ALTERNATIVE MATERIALS, TECHNIQUES AND GUIDELINES FOR LOW INCOME URBAN HOUSING IN PLAINS OF U.P.

A DISSERTATION

submitted in partial fulfilment of the requirements for the award of the degree of

MASTER OF ARCHITECTURE

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VIJAI KUMAR SINGH

DEPARTMENT OF ARCHITECTURE AND PLANNING
UNIVERSITY OF ROORKEE
ROORKEE – 247 667 (INDIA)

JANUARY, 1997

CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the thesis entitled ***ALTERNATIVE MATERIALS, TECHNIQUES AND GUIDELINES FOR LOW INCOME URBAN HOUSING IN PLAINS OF U.P.*** in partial fulfilment of the requirement for the award of the Degree of **MASTER OF ARCHITECTURE** submitted in the Department of Architecture & Planning of the University is an authentic record of my own work carried out during the period from July, 96 to Jan. 97 under the supervision of Prof. P.K. Patel.

The matter embodied in this thesis has not been submitted by me for the award of any other degree.

Place : Roorkee
Date : 30th Jan. 1997

(VIJAI KUMAR SINGH)

CERTIFICATE

This is certified that the above statement made by the candidate is correct to the best of my knowledge.

(PROF. P.K. PATEL)
Deptt. of Architecture & Planning
University of Roorkee
Roorkee - 247 667

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Roorkee
Jan. 1997

(VIJAI KUMAR SINGH)

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CHAPTER 1

INTRODUCTION

Since the advent of civilisation, housing has been recognised as one of the basic necessities for human existance, the other two being food and cloth. Housing and shelter are two distinct terms. Shelter denotes the physical structure plus the facilities provided inside it, the social infrastructure around the shelter creates habitat and constitutes housing.

In fact two types of housing problems exist in plains of U.P. First one is the shortage of houses which is being handled at every level by U.P. Housing and Development Board and other allied agencies and second one is the provision of houses within the affordable limit .

Affordable limit of low income people is very less in U.P. being more population of the state, low per capita income and unemployment. Hence this factor must be kept in mind while suggesting anything for low income group in this direction. In real sense, for economically weaker section to middle income group are struggling to get the houses in urban area within their budget. Though many Government, private agencies and research organizations are involved. But problem is still same. Housing finance is being allocated in the state budget every year. Government has invested so much amount in establishing the housing boards and development authorities with the sole aim to do something in this direction. But they are not able to satisfy the common man. Even in private sector, one does not find different picture. The basic reason for such type of problems is that neither we think about local substitutes , alternative materials and techniques, which is more socially acceptable, durable and

mically feasible nor we have enough knowledge about characteristic and

ce of substitute materials, techniques and analytical study on various cost

lements for arriving at optimum solutions.

n of my thesis is how to minimise the cost of construction and materials

heaper alternative materials, components, techniques and enhance

the labour without sacrificing the quality of construction and strength.

1.1 IDENTIFICATION OF PROBLEM

1.1.1 URBAN HOUSING SCENARIO IN PLAINS OF UTTAR PRADESH

Uttar Pradesh, the most populated state of the country. According to the Census-1991, the population of U.P. is 13.91 Crore in which 11.15 crore (80%) population lived in rural areas and 2.76 crore (20%) lived in urban area. In between 1981 to 1991, the urban annual growth rate was 3.5 % which is 0.2 % more than that of the National Growth Rate of 3.3 %.

AS PER 1991 CENSUS,

- It has the urban density of 555 persons per sq. km.
- Populationwise, the biggest city of the state is Kanpur city(20,37,333). The other two big cities whose population exceeds 10 lakhs are Lucknow city complex (17,31,224) and Varanasi city complex (13,22,248).The highest percentage of urban population is in the district of kanpur city (84.24%) followed by Lucknow (62.66) and dehradun (50.26) while the lowest percentage of urban population is in Siddharth Nagar district (3.48%)
- The highest decadal growth of urban population in the state was in Ghaziabad district (98.43%).
- The percentage of urban literacy in U.P. is only 61 %, and the proportion of urban workers in the total of the state was 32.2%.

The average number of peoples in a urban family is 6.34 in which

Density roomwise

Size of household	*% of population*
One room	33.46%
Two room	33.08%
Three room	15.40%
Four room	8.45%
More than four room	9.20%

Density familywise

Size of household (%)	Persons per family
11.30%	1-2
35.94%	3-4
32.70%	6-8
19.99%	more than 9

This shows that about 50 % family having more than average family peoples.

Type of House Holder

Type of House	*% of House holders*
Own house	75.20%
Rented	22.99%

So looking at these statistics, it can be observed that tackling of housing problems in plains of U.P. is different than other part of the country, because low income housing is directly related to the percentage of literacy, higher cost of building materials, lack of availability of good materials and skilled labour requirements, judicial use of scientific and technical knowledge etc.

In this region, housing is basically promoted by mainly two public sector agencies, i.e. development authorities and U.P. Housing and Development Board but due to lack of scientific knowledge and complete data, they are not able to provide accomodation for low income group, though these agencies are well equipped with all kinds of technical staff.

1.2 COMPOSITION OF PLAINS OF U.P.

The whole plain area of U.P. is divided into twelve divisions, i.e. Varanasi, Azamgarh, Gorakhpur, Faizabad, Allahabad, Jhansi, Meerut, Lucknow, Kanpur, Agra, Bareilly and Moradabad.

1.2.1 GEOGRAPHICAL ASPECT

Every district is surrounded by rivers, mainly- Ganga, Yamuna, Ram Ganga, Gomti and Ghaghara. Soil is very fertile in these regions. The general characteristic of the soil of these areas is alluvial soil as shown in the map enclosed.

1.2.2 CLIMATE

The climate of the state varies place to place. Although U.P. lies within the *composite temperate zone* - study of the data about the climate of some of the places in these regions impart following information :

(i) Temperature range 3.4°C to 43°C

(ii) Average rainfall between 60 -120 cm.

1.3 GOVERNMENT HOUSING POLICY IN UTTAR PRADESH

An analysis of the present situation in the cities of Uttar Pradesh reveals that the main problem of houses in the cities relates to the economically weaker sections of society. The State Housing Policy, therefore, focuses on the economically weaker sections of society in the cities as the target group and to that extent, the main objective of the government is to solve the housing problem of this group through effective intervention. The primary objective of State Government of UP policy is to make available 'maximum number of houses at affordable prices keeping in view the quality'. In prospects of this basic objective, Government is going to ensure optimum utilisation of all the sources, i.e. Government, Semi-Governmental, Cooperatives and Private, in order to bridge the gap between demand and supply of houses in the state. It is also be the objective of Government policies to remove all constraints in house construction, whether these relate to the availability of land or the sanctioning of building plans of houses. It is also proposed to reorient the role of Government and its agencies which would basically be that of 'Facilitator'.

HOUSING SHORTAGE IN URBAN AREA OF U.P.

Total housing shortage in 1991 : 11.74 lakh units

Total housing shortage by 2001 : 35.12 lakh units

Housing shortage districtwise :

Name of District	1981	1991
Kanpur	1,52,388	2,02980
Lucknow	1,01,692	1,66,204
Varanasi	92,195	-
Agra	78,111	-
Allahabad	60,756	-

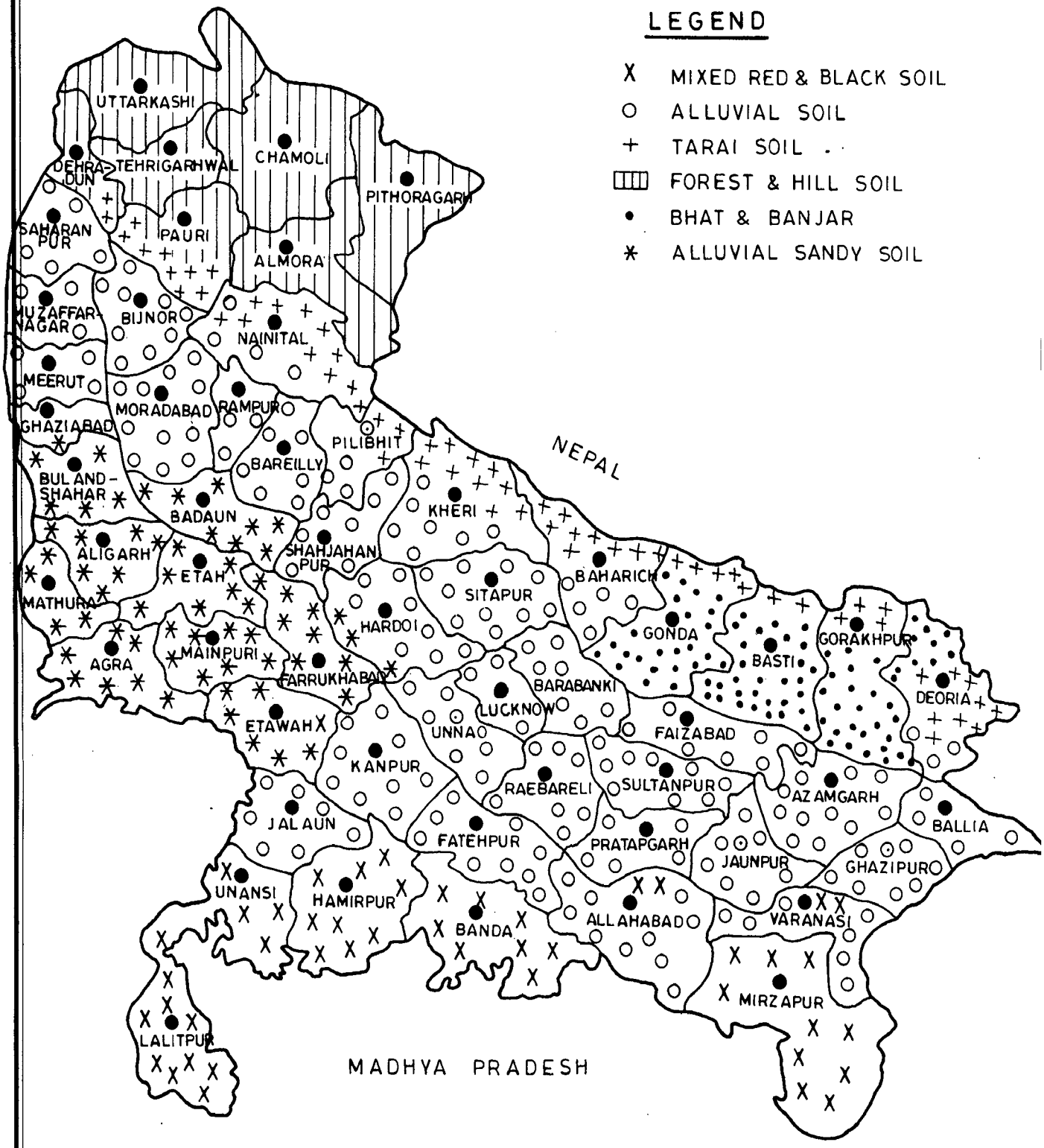
Total Urban Population in 1991 : 2.76 Crore

Total Districts : 68

Cities/Towns : 753

Density of Population in urban area of U.P. in 1991 : 555 persons/sq. km.

Source : Information and Public Relations Department, U.P., Lucknow and State Housing Policy (1995)



UTTAR PRADESH

1.4 WHAT IS LOW INCOME URBAN HOUSING

The low income urban housing may be defined as provision of housing which caters to the minimum requirements of masses within their income capabilities, without scarifying the quality of construction. So low income housing in a real sense is one which is conceived through various cost reduction measures affecting the cost of the building without sacrifying the basic needs i.e. function, comfort and quality .

INCOME LEVEL :

Category	Monthly Income(Rs.)	Cost Ceiling*(Rs.)
E.W.S.	Upto 1250	26,400*
L.I.G.	Over Rs. 1250 and upto Rs. 2650.	60,000*

* Cost ceiling applicable to E.W.S. and L.I.G. categories may be increased by 25%.

* Cost ceiling does not include the cost of land.

Sourse : HUDCO

1.5 NEED OF STUDY

With the above discussed back ground under the introduction, need of study can be seen from the following analysis :

The components of housing cost are land, services, materials and construction techniques. While the cost of land is beyond the influence of house hold, the cost of services do not show much elasticity. It is the cost of materials and the construction techniques which the construction agencies and the owner try of adjust to match the affordability. Because the price of cement which was around Rs. 25 per bag of 50 kg.

now has risen to Rs. 150 per bag in the last two decades. Similarly, the cost of steel per tonne has increased from Rs. 4,000 to Rs. 15,000 per tonne. Burnt bricks which were available in 20 paise per birck, now cost is Re.1.60 per brick. Natural timber, besides posing major ecological problems in view of the enormous deforestation, has also become extermely costly. As a result of these, four major issues arise:

1. There is a substantial shortage of conventional and traditional building materials.
2. The cost of construction using these conventional options is registering increase which is of the order of 15 to 20 per cent per annum.
3. These building materials are high in ernergy consumption and with the increasing cost of energy, the price of these materials is bound to show a still upward trend.
4. The nature of meterials like burnt brick and timber also has substatial environmental and ecological implications.

Study of characteristics and use potential of alternative material and techniques and their suitability in lowering the cost of construction, giving the tremendous task of improving availability of shelter, is necessary.

Many user agencies are either not well familiar with the potential of such alternatives or are not convinced of their effectiveness. Some of the other agencies which have adopted them have found a ray of hope in them while some others have complained of confronting problems. Study is needed to identify reasons for success or failure of alternative materials and techniques in their application and to suggest guide lines to improve their application in reducing the housing deficit of low income urban household in plains of U.P.

1.6 AIM AND OBJECTIVES

This study has been carried out with the following objectives :

(i) To understand and appreciate the significance and characteristic of building materials and techniques both conventional as well as alternative, in the context of low-income urban housing needs;

(ii) To assess the suitability of alternative techniques in selected low-income urban housing projects;

(iii) To facilitate the process of recently introduced by research organisations and projects and to meet the challenges of future urbanisation and urban growth.

(iv) Saving work effort and full utilization of materials

(v) Use of technologies which are enviornmentally appropriate and energy-efficient.

(vi) To suggest guidelines for creating conditions necessary for more effective utilisation of alternative building materials and techniques. based on case studies, survey and cost analysis.

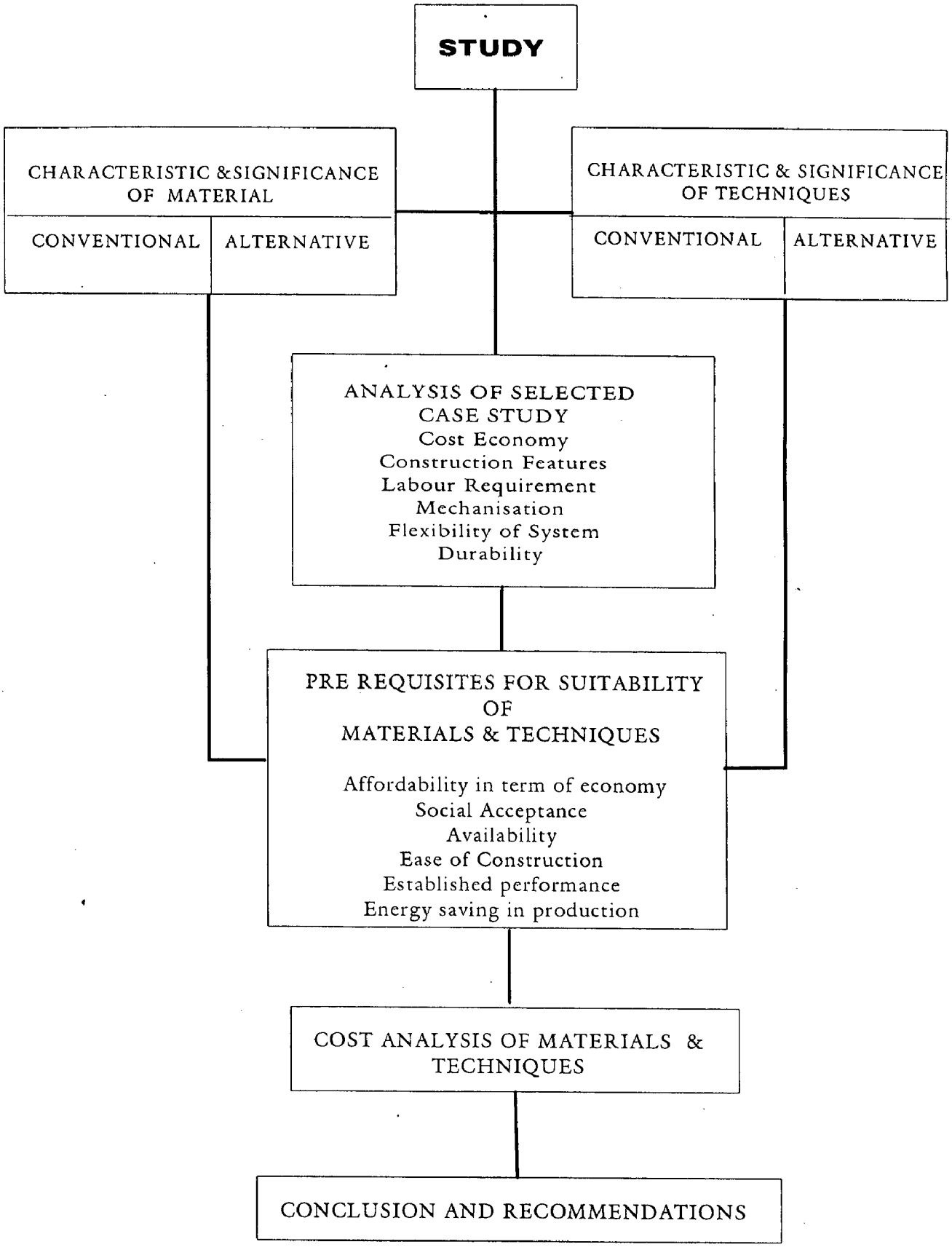
(vii) To provide energy efficient and cost effective process technologies for economical manufacture of building materials.

(viii) To suggest guidelines for low income groups on the basis of alternative materials, techniques and cost analysis of those materials and techniques whose cost is well known.

1.7 SCOPE AND LIMITATION

The scope of this study is limited mainly to subject of alternative building materials, techniques and standards which are in use in urban areas for reducing the cost of construction. Their characteristics and significance have been studied with respect to their use in low-income urban housing.

The study also includes strategy on technology transfer of such materials & techniques for there wider & wider application. Selected public housing projects in Delhi, Noida, Rishikesh and Lucknow have been taken up as case studies. The study is based on primary survey of case-studies and secondary data collected from reports, journals, research papers and observation.


STUDY
CHARACTERISTIC &SIGNIFICANCE OF MATERIAL
CONVENTIONAL
ALTERNATIVE
CHARACTERISTIC & SIGNIFICANCE OF TECHNIQUES
CONVENTIONAL
ALTERNATIVE
ANALYSIS OF SELECTED CASE STUDY
Cost Economy
Construction Features
Labour Requirement
Mechanisation
Flexibility of System
Durability
PRE REQUISITES FOR SUITABILITY OF MATERIALS & TECHNIQUES
Affordability in term of economy
Social Acceptance
Availability
Ease of Construction
Established performance
Energy saving in production
COST ANALYSIS OF MATERIALS & TECHNIQUES
CONCLUSION AND RECOMMENDATIONS

1.8 METHODOLOGY

The methodolgoy of study includes indentification and preparation of inventory of conventional and alternative building mateials and techniques available and in use in urban housing in plains of U.P. and study of individual materials and techniques, in respect of their characteristic, significance and their economic feasibility. This was followed by indentification of parameters and pre-requisites essential for low-income housing construction.

Case studies of four low-income housing projects which implemented various alternative technological options has been carried out in details. The case studies are assessed on parameters such as cost-economy, reduction in construction time, skilled labour requirements, machanisation, appearance and aesthetics, flexibility to cater to varying requirements of architecture and planning and performance with respect to thermal behaviour, resistance to impact noise and rain penetration. The case studies have been analysed and evaluated with respect to pre-requisites for suitability for low-income housing construction, such as affordability, social acceptability, availability of low-cost alternative materials and components, ease of construction and durability. Based upon these studies suitability of alternative techniques adopted in case-studies has been adjudged.

The major findings of alternative building materials, techniques from the case studies and cost analysis, conclusion and recommendations in form of guidelines have been made for more effective utilisation of alternative material and techniques.

1.9 CHOICE OF CASE-STUDY

With a view to get more realistic picture on the cost effectiveness and suitability in the field application of alternative materials and techniques four housing project have been identified for case-studies. Important consideration on the basis of which choice of case-study projects was made are:

* Project which made significant use of potentially low cost alternative materials and techniques.
* To cover up variety of alternatives, projects, making use of different technological

options have been selected.

* Information and data on the use of alternative technologies from the agencies responsible, for execution of project or extending technical guidance should be easily eccessible.

* The construction should be atleast 5-6 years old to find out performance of alternative technologies.

CHAPTER 2

ALTERNATIVE BUILDING MATERIALS

Shortage of traditional and conventional materials and compulsions and advantages of use of agro industrial wastes led to the development of substitute/ alternative materials.

Energy crisis has brought into focus the need to conserve energy in the production of materials and the need to keep the environment clean and safe and maintain ecological balance spurred innovations to develop materials with modified or special properties or altogether a class of new materials like composites.

In order to increase low income peoples' accessibility to the housing and improve quality, in plains of U.P., it is necessary to study the characteristic and significancve of conventional as well as alternative building materials. Energy saving in production and economic feasibilty.

2.1 CHARACTERISTIC AND SIGNIFICANCE OF BUILDING MATERIALS

Building materials account to 70 % of the total cost of house construction. Choice of materials and their appropriate application can greatly influence the cost of dwelling, safety, durability and performance of dwelling. The choice of materials depend upon several factors such as

* their availability.
* low energy consumed in production
* materials and techniques should be such that cost as well as energy both must be saved.
* Environmentally sound, ease of construction ans socially acceptable.
* performance should be established
* materials should be optimum utilised, and
* less need for repair and maintenence after construction.

ELEMENTAL COST ANALYSIS (%)*

THE BREAK OF COST OF HOUSING IS GENERALLY AS FOLLOWS

ELEMENT	COST(%)
Foundation & Plinth	11.4 %
Walling	32.6 %
Structural Floor & Slabs	22.6 %
Staircase	1.25 %
Doors and Windows	15.0 %
Flooring (40 mm layer skirting)	5.0 %
Roofing	5.6 %
Finishes	6.4 %

COST OF MATERIALS

CEMENT	20.0 %
IRON & STEELO	12.5 %
BRICKS	21.0 %
TIMBER	10.0 %
SAND	3.0 %
AGGREGATES	4.0 %
TOTAL	70.5 %
LABOUR COST	29.5 %

** For two storeyed building having the 23 cm thick load bearing wall and plinth area of 45 sq. mt.*

2.2 BRICKS

CONVENTIONAL

BURNT CLAY BRICK

Burnt clay brick is the most important and most extensively used building material in all over U.P. Besides being a major walling material it is also used for the floor/roof and paving. The good quality bricks at high cost are available in all parts of U.P. except in Jhansi zone and some areas of Varanasi zone.

The supply of bricks in plains of U.P. is satisfactory due to high demand. In inspite of one brick kiln in every 10-15 km. and production per kiln is about 10-25,000 bricks per day. One of the important observation in the use of bricks is find that the bricks of good quality were used public housing agencies and upper income people. While the low quality bricks for wall purpose and foundation and first class brick for roof purpose is used by low income group. The reason is that the low quality bricks are cheaper.

ALTERNATIVE OPTIONS

2.2.1 IMPROVED BRICKS FROM BLACK COTTON SOILS

Black cotton soils are expansive in nature and in many places contain modular lime. The bricks made from such soils shows poor strength of 20-30 kg/sq. cm , high water absorption of about 20 %. They exhibit expansion and contraction characteristics during firing. Lime bursting occurs in fired bricks contributing to further loss of strength. These soils as such cannot be used for the manufacture of bricks. It requires the use of some opening materials like grog, coal, flyash,cinder etc. to reduce the moisture content and excessive shrinkages.

Manufactring process :

For the manufacturing of better quality. bricks from black soils, a process is developed which consist of following steps :

(a) wasing the raw clay to make it free from kankar and lime nodules.

(b) addition of 20-30 % of grog/finely ground calcined clay (fired at 500-600°C), 20-40 percent flyash, cinder, rice husk-ash, stone dust etc. into the washed clay.

(c) addition of 0.5 percent sodium chloride (common salt) to avoid lime bursting.

(d) Instead of clamp kiln, bull's kiln should be used for firing the bricks to attain better temperature profile.

Black soil ----------> weathering soil and removal by coarser lime nodules ----------> Mixing of opening material ----------> moulding and drying of bricks ----------> Firing of bricks in Bull's kiln.

Important Properties :

Compressive strength	:	70-100 kg/sq. cm
Water absorption	:	15-20 percent
Energy saving in making bricks	:	10-30 percent

Economic feasibility

The techniques of making such types of bricks is economical in Mirapur and Sonebhadra district and Jhansi division.

Minimum Economic Unit :

25 to 30,000 bricks per day.

Consumer's acceptability

Since there is no difference in the physical properties of modular bricks as compared to conventional bricks, there is no resistance from consumers to accept them for use in buildings.

2.2.2 IMPROVED BRICKS FROM RED SOILS

These soils do not make good bricks due to the presence of high proportion of ferranginous, aluminous and siliceous constituents, clay minerals in varying proportions, cracking during drying, lime bursting and fall in strength during firing in the temperature range of 950-1060 °C.

Manufacturing Process :

According to the investigations on red soils it is observed that good quality of bricks can be manufactured by the following process :

(a) the addition of flyash 10 to 40 percent or rice husk ash 20 to 40 percent or cinder to the soil.

(b) Blending of plastic soil with murrum or red soil passing 1 mm size in the ratio of 30:70

(c) removal of kankar nodule if present and the addition of 0.5 to 1 percent common salt

(d) hard burning in the temperature range of 950 to 1050°C.

Important Properties :

Compressive strength	:	70-150 kg/sq. cm
Water absorption	:	10-20 percent
Energy cost	:	low energy consumed in burning process.

Economic feasibility :

This type of bricks are economical in Mirzapur and Sonebhadra district.

Minimum Economic Unit :

25 to 30,000 bricks per day.

Consumer's acceptability :

Established performance of material and socially acceptable due to no difference in physical properties.

2.2.3 BURNT CLAY FLYASH BRICKS

Flyash is obtained as a waste product from thermal power stations due to high percentage of ash content present in coal, the generation of flyash is also very high. It creates a lot of environmental problems such as air and water pollution, wastage of large tracts of land which could be utilized for useful purposes. It has been estimated that about 12 million tonnes flyash is being produced annually in plains of U.P.

The possible areas of uses are as follows :

(a) As pozzalanic material for manufacture of Portland pozzolana cement.

(b) For manufacturing of flyash based bricks and blocks.

(c) As part replacement of cement in ready mix concrete.

(d) For manufacture of cellular concrete building blocks and slabs.

(e) For preparation of base and subbase course for roads, highways and runways for airports, etc.

(f) For manufacture of lightweight aggregate.

(g) As a structural filler material.

(h) As filler for low grade refractory bricks.

(i) For recovery of metals.

(j) For soil conditioning and improvements for agricultural purposes.

COAL CONSUMPTION AND FLYASH PRODUCTION AT THERMAL POWER STATIONS IN PLAINS OF U.P.

STATION	*CAPACITY (mwS)*	*COAL CON. (M.Ts)*	*ASH (%)*	*ANNUAL ASH PRODUCTION (M.Ts)*
1. Singrauli Sonebhadra	5 x 200+2 x 500	9.4	23.0	2.2
2. Anpara Sonebhadra	5 x 210+ 2 x 500	9.5	23.0	2.25
3. Obra Sonebhadra	5 x 200 + 3 x 100 + 5 x 50			1.65(L.S.)
4. Vindhyachal Mirzapur	6 x 210	5.45	27.0	1.50
5. Renusagar Sonebhadra	250			0.45
6. Rihand Sonebhadra	2 x 500	3.54	31.0	1.20
7. Unchahar Pratapgarh	2 x 210	1.48	40.0	0.60
8. Tanda Faizabad	2 x 110			0.40
9. Dadri Ghaziabad	4 x 210	1.80	41.0	0.74
10. Panki Kanpur	300			
11. Harduaganj Aligarh				
APPROXIMATE TOTAL PRODUCTION				10.99 MT

Source : NTPC REPORT

Manufacturing Process :

A process for the manufacture of clay flyash brick has been developed which involves addition of 10 to 40 percent flyash on the dry weight of the soil, depending on the physico-chemical and ceramic characteristics of the soil.

(a) Mechanical or manual mixing and processing.

(b) Manual moulding of bricks or shaping by extrusion process.

(c) Firing of bricks in continuous type Bull's kiln or intermittant type of kilns, conventionally adopted in the state.

(d) Firing temperature range, 950°C to 1050°C.

Casting

Clay + flyash ----------> mixing of clay, flyash 10 to 40 percent ----------> Sun drying-

Firing

----------> Burnt clay flyash brick

Important Properties :

Strength	:	75 to 220 kg/sq. cm
Water absorption	:	8 to 16 percent.
Energy cost in production	:	553.0 x 10^3 k/cal

per 1000 Nos. which is half of the energy consumed in conventional burnt bricks and fuel saving in the range of 15 to 30 % or coal saving upto 3 to 5 tonnes per lakh bricks.

* The bulk density of clay flyash bricks is reduced which provides better heat thermal insulation property to the masonry walls and reduces dead load on the brick masonry structure.

Economic feasibility :

Within economic distance of thermal power stations.

For large production : Change from manual to semi-mechanised production is needed.

Minimum Economic Unit :

25 to 30,000 bricks per day.

Consumer's acceptability :

Since there is no difference in the physical properties of bricks as compared to conventional bricks, there is no resistance from consumers to accept them for use in buildings.

Applications :

Bricks conforming in the range of grade 50 to 300 as prescribed in IS:3102-1971 can be manufactured. These bricks can be used for all types of brick masonry, pavings and soiling purposes.

2.2.4 STONE MASONRY BLOCKS

They are simply made by mixing of stone block, cement and sand mortar.

Mix and cast

Cement + sand + stone ----------> *Stone block*

1:5:8

The blocks are normally manufactured to the following sizes :

Length	Width	Height
300 mm	200 mm	150 mm
300 mm	150 mm	150 mm
300 mm	100 mm	150 mm

Important Properties :

Strength : depends upon conc. mix.

Water absorption : zero

Energy cost in production : very low

Economic Feasibility :

All parts of Jhansi, Lalitpur, Mirzapur and Sonebhadra districts.

2.2.5 MASONRY BLOCKS FROM WASTE LIMESTONE OF SUGAR MILLS

Stone grit is a waste part of quick lime, which is produced by sugar mills at a rate of 300 kg./day or 60,000 kg. per year per mill* and

Total annual production of stone grit in U.P. is 100 x 60,000 = 60,00000 kg.

It is available free of cost in every sugar mill of U.P.

Manufacturing Process :

mix & cast

Cement + Sand + Stone Grit ----------> Masonry Blocks

1:5:8

Important Properties :

All physical properties are same as Stone Masonry and no technical difficulties during costing of blocks.

Economic Feasibility:

Application within the economic distance of sugar mills.

** Mahalaxmi Sugar Mill, Iqbalpur, Hardwar.*

2.2.6 MASONARY BLOCKS FROM JHAWA (O.B.B.) OF BRICK KILNS

300 to 400 Nos. over burnt bricks (Jhawa) per day/bhatta is available in plains areas of U.P. which can be utilised for making masonry blocks.

Manufacturing Process :

Mix and cast

Cement + Sand + Jhawa (O.B.B.) ----------> Masonry block

1:5:8

2.2.7 PERFORATED BURNT BRICKS

The perforated bricks are good alternate of solid burnt brick. Conventional solid bricks suffer mainly from three disadvantages :

(1) They are more expensive today than any other waaling materials.

(2) The heat insulation of a wall made of solid bricks is poor and

(3) The resistance to rain penetration is low.

These difficulties can be overcome by using, 20 to 25 percent perforated bricks.

Manufacturing Process :

Alluvial soil ----------> *Casting* *semimechanised plant* ----------> *drying* ----------> *burning* ----------> *Perforated brick*

Important Properties :

*	Thermal and fire resistant	
*	Stabilised life span	
*	Crushing strength	60 to 75 kg/sq.cm.
*	Water absorption	10-18 %
*	Energy cost	very low.

Economic feasibility :

This type of bricks are economical both cost and energy consumption wise.

* saving in clay.
* dry faster
* require less fuel for burning as compared to solid bricks.
* large size bricks help to increase the mason output, the number of joints are less and mortar consumption further reduced.

Minimum Economic Unit :

20 to 25,000 bricks per day.

Consumer's acceptability :

There is no resistance from consumers to accept them for use in buildings.

Applications :

As per IS:2222-1979, such types of bricks can be used for all types of masonry work upto 2 storeyed buildings.

2.2.8 CLAY RED MUD BURNT BLOCKS

Red mud is an industrial waste product of aluminium producing plant (HINDALCO IN SONEBHADRA) which can be used for manufacturing of construction blocks and solve the problem of disposal of the waste produced.

Manufacturing process:

Mixing(50:50)

Clay + Red Mud ----------> Block ----------> sundry ----------> 1000°C Firing----------> High strength block

They have good architecture value as compared to bricks due to their pleasing hues of red.

Important Properties :

Compressive strength	about 500 kg/sq.cm
Water absorption	12-14 percent

Other Potential Uses :

* Red mud + PVC --------> Corrugated Plain Roofing Sheet

* Red Mud + Fibre(Khoi, Mooj, Rice Husk) + Resin or Polymer ------> Roofing Sheet

Economic feasibility:

Application and production within the economic distance of HINDALCO in Sonebhadra district.

TABLE : COST OF DIFFERENT TYPES OF BRICKS/BLOCKS.

S. No.	Name of Material	Size	Cost of each block (Rs.)	Economy(Rs)	
				As per UP.P.W.D. schedule of rate 1996	Market Rate
1.	Conventional burnt Brick	9"x4.5"x3"	1.4		
2.	Improved brick from black & cotton soil	"	0.85	0.55	0.75
3.	Improved brick from flyash	"	0.75	0.65	0.85
4.	Stone masonry block	30x20x15 cm	5.65	one block =4.6 bricks 0.80	1.70
5.	"	30x10x15 cm	3.00	0.25	0.70
6.	25% perforated block	30x20x15 cm	2.5(L.S.)	one block = 4.6 bricks 3.94	4.66

2.3 BINDERS

CEMENT

Cementing materials form one of the basic items required in any construction activity. Among the various cementing materials ordinary portland cement is most popular in plains of U.P. The other frequently used general purpose cement in the buildings are portland pozzalana and portland slag cement. All these types of cement are produced in bulk in Uttar Pradesh.

The annual production of cement in U.P. during 1995-96 33,17 LTPA

Out of the total production of the cement in plains of U.P. nearly 50 % is consumed

by large non-housing construction work such as bridges, canals, dams, power houses etc., and therefore shortage of cement for housing remains almost a permanent feature.

LIST OF CEMENT PLANTS IN PLAINS OF U.P.*

S.No.	*Name of Plant*	*Location*	*Capacity(LTPA)*
1	U.P. State Cement Corp. Ltd.	Chunar	16.80
2.	U.P. State Cement Corp. Ltd.	Churk	4.75
3.	U.P. State Cement Corp. Ltd.	Dalla	4.32
4.	U.P. State Cement Corp. Ltd.	Dalla	Clinkerisation Unit
5.	Diamond cement	Madora, jhansi	5.00
MINI CEMENT PLANTS			*Capacity(TPD)*
1.	Nirmal Cement factory	Moradabad	30
2.	Ashish Cement Pvt. Ltd.	Meerut	30
3.	Vikram Cement (P) Ltd.	Kanpur	50
4.	Indra Steels (P) Ltd.	Ghaziabad	30
5.	R.A. Cement (P) Ltd.	Kanpur	50
6.	Indus laminators (P) Ltd.	Kanpur	40
7.	Brahmavarta Cement (P) Ltd.	Kanpur	30
8.	Jagdishpur Cement (P) Ltd.	Jagdishpur	30
9.	Krishna Fertilizers (P) Ltd.	Kanpur	30
10.	Arpit cement (P) Ltd.	Muzaffarnagar	50
11.	Sonu Udyog	Kanpur	50
12.	Vikrant Cement (P) Ltd.	Meerut	50
13.	Delta Erectors (P) Ltd.	Kanpur	50

** SOURCE : NATIONAL COUNCIL FOR CEMENT & BUILDING MATERIALS.*

ALTERNATIVE OPTION

2.3.1 LIME

Lime is produced locally all over U.P. in small scale units in unorganised sector and its quality is unreliable. A few plants for production of standard quality dry hydrated lime have been set up in U.P. Lime is the potential material to meet the shortfall in binders and posseses certain unique properties which results in better quality construction and makes its use as a useful building material. The outstanding characteristics of lime mortars are better workability and good plasticity, low shrinkage on drying which makes for durability, resistance to moisture and avoidance of cracking. Further, due to its excellent adherence to masonary units and as a result of slow-setting it adjusts to stresses in course of time. The lime mortar improves its strength continuously with lime.

When lime is mixed with portland cement and sand in suitable proportions, it gives valuable properties of strength, moisture resitance and plasticity and replaces cement. Lime is cheap surface coating material used in white/colour washing for low cost costruction.

Scope of Application in building :

Lime concrete with broken bricks oftenly used in buildings for foundations

* floor sub-base and roof teracing
* for making composite mortar for masonry work and plaster
* As a surface coating material used in white/colour washing.

2.3.2 BUILDING LIME FROM WASTE LIME SLUDGE OF SUGAR MILL

Sugar industry produces about 100 T of waste lime sludge per day per mill and the cost of waste sludge is Rs. 7.0 per quitel. These lime sludge is in form of calcium caronate ($CaCO_3$) or calcium hydroxide. Some of these sludge is already being used as a fuel for the manufacturing of bricks, but most of it is thrown as waste.

Manufacturing Process :

Investigations carried out show that building lime could be manufactured by the process out lined below :

Lime sludge ----------> Sundrying ----------> grinding----------> Briquetting (with 10-12% water) ----------> Calcination in kilns $\xrightarrow{950\text{-}1000^{\circ}C}$ *Lime*

$$CaCO_3 \xrightarrow{950\text{-}1000^{\circ}C} CaO + CO_2$$

Lime Sludge *calcium oxide*

Important Properties :

Compressive strength of Hydrated Lime ----------> 12.5 kg/sq cm after 14 days

2.3.3 ACTIVATED LIME POZZALANA MIXTURE

Calcined clay , rice husk and lime sludge are extensively used as pozzalana in making lime pozzalana (quick setting cementitious material) which could be mixed with surkhi or flyash for use as a mortar. The mortars conform to the I.S. specification -4098.

Manufacturing process :

Clay+Rice husk + Lime sludge $\xrightarrow[grinding]{burning}$ *good lime pozzolana.*

In this process, no extra fuel is required and rice husk provides the entire source of energy to raise the temperature to the required level. The only equipment required is a simple grinder (Ball mill).

Important Properties:

Ground to fineness	2500 sq cm/gm
Setting time	90 minutes
Strength	40-60 kg/sq.cm. in 28 days
Water retention	64 %
Shrinkage	0.015 %

It is 20 % cheaper to use masonry cement than portland cement for mortar work.

2.3.4 SURKHI

Surkhi is good substitute of cement and obtained from the grinding of 2nd class broken bricks. Today 300 to 400 Nos. broken bricks per day is produced by every Bhatta which could be mixed with lime for use as a mortar in building construction.

Manufacturing Process :

grinding

2nd class broken bricks ----------> *Surkhi*

Important Properties:

Manufacturing energy cost/kg 0.33 x 10^3 kcal.

2.4 RICE HUSK

Rice husk is an important agricultural waste materiual in plains of U.P. about 18 quintel* rice husk is produced per day per rice mill. The calorific value of rice husk is about 3300 kcal/kg which is about 15 % less the calorific value of coal.

Application in Building Industry

- Rice husk board doors : It is superior in quality and lower in price compared to products made from wood based board and also substitutes of wood.
- Alternate fuel for firing brick : It is used as fuel in rick kilns with coal, resulting 15-25% overall saving in coal consumption.
- Lime pozzolana

** Raja Rice Mills, Bahadarabad, Hardwar.*

TABLE : COST OF DIFFERENT TYPES OF BINDERS

S. No.	Name of Binder	Cost/bag(50 Kg) (Rs)	Cost Economy/50 kg
1.	Portland cement	135.00	
2.	Masonry Cement	80.00	55.00
3.	Market lime	75.00	
4.	Lime from lime sludge	68.75	6.25
5.	Surkhi	12.50	
7.	Rice Husk	30.00	

2.5 AGGREGATES

NATURAL AGGREGATES

Aggregate in its general term are inert materials which when bound together by cementing material from concrete. A proper mix of both fine and coarse aggregate is required to make good concrete. Naturally occuring sand, gravel and crushed hard stone are most commonly used aggregates for structural concrete.

In many areas such aggregates have to be bought from long distances and are costly. Artificial aggregates from some industrial wastes and also made from clay may form an alternative to naturally occuring aggregates.

2.5.1 ARTIFICIAL AGGREGATES

The artificial aggregates can be made by crushing of overburnt bricks (Jhawa) which is available at a rate of 300-400 numbers per day per Bhatta*.

* *Star Bhatta, Luxar, Hardwar.*

Manufacturing process :

crushing

High burnt brick ----------> Aggregate

TABLE : COST OF AGGREGATES

S.No.	Name of Aggregates	Cost /cu.mt. (Rs)	Cost economy per cu.mt. (Rs)
1.	Natural Aggregate	425.00	
2.	Artificial Aggregate From over burnt bricks	200 to 300.00	225 to 125.00

2.6 ROOFING MATERIALS

BURNT CLAY TILES

In areas where rainfall is high generally sloping roofs with burnt clay tile covering are widely used. Clay roofing tiles of several designs are manufactured in various part s of the state. These may be flat, interlocking or curved tiles. Some of them are called after the name of the town where they were originated like Mangalore pattern tile, Allahabad tiles and Guna tiles.

2.6.1 CORRUGATED COIR CEMENT SHEETS

The corrugated roofing sheets are made from a mix of coir fibre and cement and hydraulically pressed. After carring when the sheets gets hardened it is given cement wash and on drying trimmed to the required sizes.

The special features of the sheets are :

* The requrement of cement in these sheets is 30 % less as compared to A.C. sheets.
* The sheets are light and tough. These can be carried over hilly and rough roads without any breakage.
* These sheets are strong and posseses good bending strength. A man can safely walk over it.
* The sheets have good thermal insulation properties as compared to A.C. or G.I. sheet. These are expected to provide greater comfort in tropies.
* Their preparation needs neither heavy machinery nor high capital investment.
* No further finishing or water proofing treatment is required on the roofs made with

these sheet.

* These sheets are lighter in weight with 11/12 Kg/m as compared to 13.5 Kg of A.C. sheets.

2.7 SERVICES

ALTERNATIE OPTION

2.7.1 PIPES AND FITTING

The conventionally used materials for pipes are galvanised iron, cast iron, asbestos, cement and steel. Some of them have foreign exchange components in one form or the other and are becoming scarce and expensive.

Plastic pipes on the other hand are indigenous light weight (1/6 the of metal pipes), corrosion resistant, having low frictional resistance(40% lower than metal pipes). It is easy to maintain, handle and transport.

Saving:

The energy requirement for production of PVC pipes in 1/5th of that required for GI/CI pipes.

22-40% economical as against the use of metal pipes.

2.7.2 ELECTRICAL CONDUITS

Conduits are a rigid or flexible tubings through which cables are drawn for the purpose of offering these an added protection.

They are available in the diameter from 16 mm -63 mm. Rigid PVC is inert to most of the chemicals and is not affected by corrosion like mild steel and also about 1/6th in weight of M.S. and are easy to transpor, install and handle, besides being economical.

ALTERNATIVE CONSTRUCTION TECHNIQUES

Conventional construction technologies used in housing greatly rely on the use of high cost and scares materials, do not make their efficient use, are low productive, slow and costly. in urban areas where large population belonging to low income category is to be adequately housed within the limited resources, continuance of such technologies cannot be afforded as such, if solution to housing problem is to be found.

Low cost alternative technolgy are essential to increase housing stock. In the waker of this, several alternative technologies ranging from the improvement in conventional technology to a highly mechanised technology are available. The conventional techniques are labour oriented while fully prefabricated techniques requiring industrialisation rely on high mechanisation. The past experince with several mechanised technologies has not been encouraging. As an alternative to the two extremities there is an emphasis on partial prefabrication techniques. These techniques also fall in tune with govt. policy of employment oriented production as well as tend to speed up production.

In order to find appropriate solution to low income urban housing problem in plains of U.P., it is necessary to study characteristics and significance and understand applicability of both conventional as well as alternative techniques.

3.1 FOUNDATION

Foundations are considered to be the footing for a building. Study reveals that more than 11% of total cost is spent on foundation due to lack of knowledge. In private sector where individuals construct their houses under own supervision invest a lot of money in foundation.

There are three main factors which should be considered while designing the cost effective foundation in plains of U.P.

1. Soil condition.
2. Total load on the wall.

3. Span of the building.

The soil condition factor will determine the depth of foundation where a total load on the walls and span will lead to the size of foundation. Though the C.B.R.I., Roorkee has recommended the minimum depth of foundation for load bearing wall as 45 cm. for single storey houses in Virbhadra Yojna in Rishikesh, and E.W.S. Housing at Noida, U.P., under normal type of alluvial soil in which 10-20% houses are converted into double storeyed by the incremental growth, and foundation is properly functioning.

The above parameter must be considered while suggesting the depth of foundations for low income urban housing in plains of U.P.

ALTERNATIVE OPTIONS

Based on analysis observation, and bearing capacity of soils, in plains of U.P.. Following are the alternative options for the low income urban housing.

FOR E.W.S. HOUSING FOUNDATION : Width as per design, 45cm below ground level to load bearing walls and 30cm below ground for the non load bearing wall.

FOR L.I.G. HOUSING FOUNDATION :

(i) 60 x 60 cm for single storey

(ii) 75 x 75 cm for double storey

(iii) 90 x 90 cm for 3 to 4 storeyed building with 15 cm thick base concrete of 1:6:12 with 40 mm aggregates

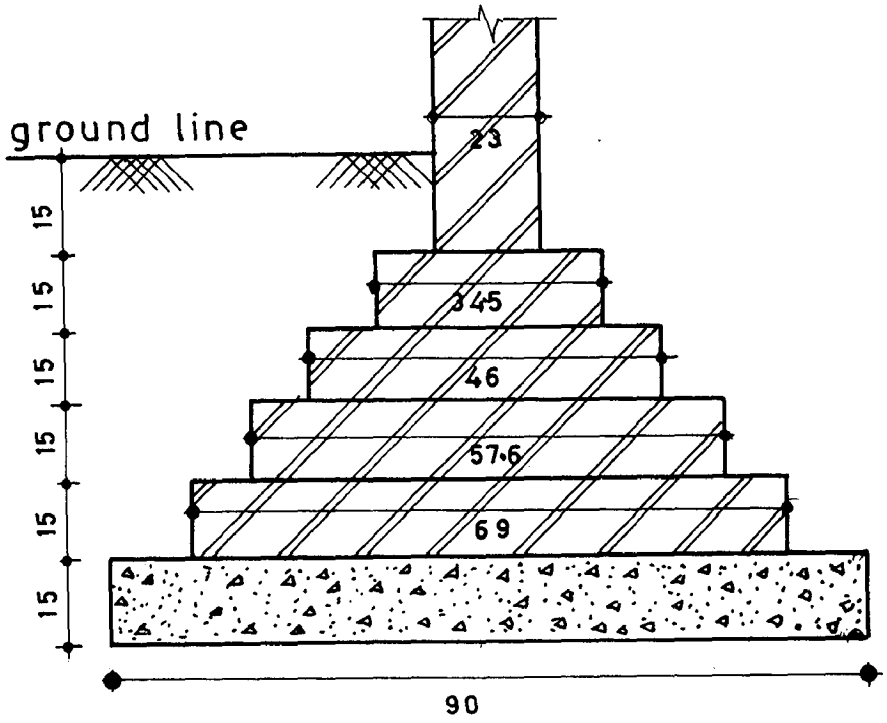
The offset for widening of the foundation masonry are to be concentrated in the lower regions of the foundation only. As against the Normal practice of taking them upto ground/plinth level.

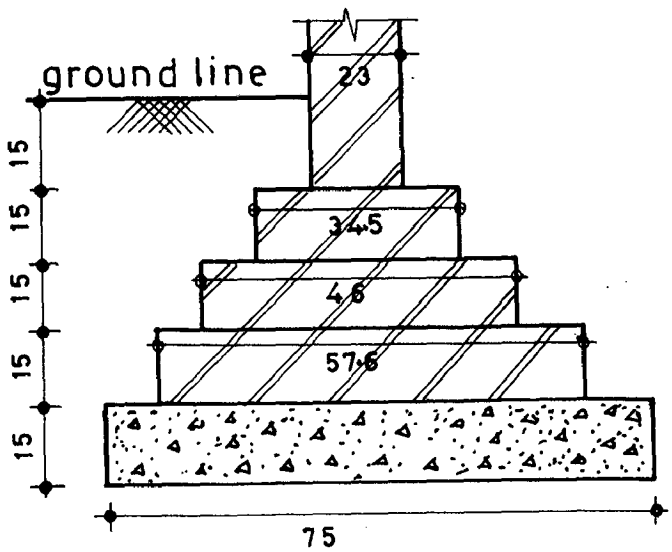
Table 1

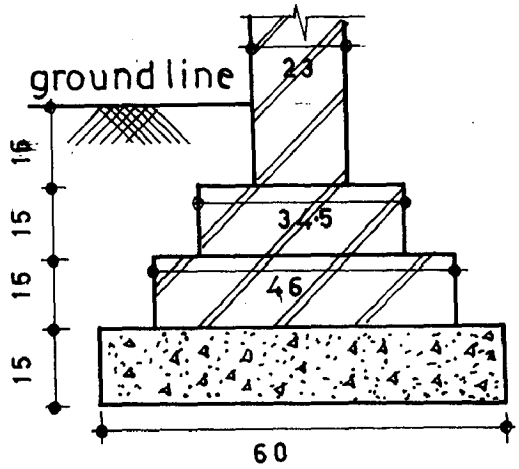
S. No.	Size cm	Length cm	Mortar	Quantity			Overall % growth
				Bricks	Mortar	Base	
				Nos.	*cu-m-*	*conc(cu.m)*	
1	60 x 60	100	1 : 6	74	0.04	0.09	
2	75 x 75	100	1 : 6	119	0.06	0.12	25 %
3	90 x 90	100	1 : 6	170	0.09	0.14	36 %

The Table 1 clearly shows that size of foundation chosen without deisgn can affect the cost of foundation upto 36%. So keeping this factor into mind, while you are going to suggest foundation.

This will ultimately help in optiming the cost of dwelling.







ALTER NATIVE OPTIONS IN FOUNDATION

3.2 PLINTH HEIGHT

The function of raised Plinth is:

(i) To avoid the entry of rain water into building.

(ii) To prevent the building from getting damped.

(iii) To provide suitable slope for drainage of ground water.

(iv) To prevent the entering of outside creatures like snakes, frogs etc.,

Out of above four functions (i) and (iii) are the primary functions. It has been observed through various case studies that minimum plinth height should be 15cm and optimum plinth height should be 30cm. Any height above 30cm will simply increase the cost of the house.

Table - 2

S. No.	*height of plinth (cm)*	*Thickness of Wall (cm)*	*Height of wall (cm)*	*Quantity (cu-m)*	*Overall % saving*
1	15	23	100	.04	
2.	30	23	100	.07	42%
3.	45	23	100	.1	60%
4.	60	23	100	.14	71%
5.	75	23	100	.17	76%

From the above table, clearly shows that 15cm height of plinth for economically weaker section is enough for cost consideration.

It is obvious from the table that saving upto 76% in plinth can be done for e.w.s. and upto 60% in case of L.I.G. If optimum plinth height is adopted.

3.3 DAMP PROOF COURSE

The D.P.C. is provided in the building at plinth level.

The main function of D.P.C. is to check the dampness from rising into the wall

above plinth level.

It has been obsrved. through survey that 25mm thickness of D.P.C. course is sufficient for their function.

3.4 WALLING

The walls are basically vertical members forming an enclouser or defining a space. In a building, they perform many functions like.

(i) To carry the load of floor/root and wall itself.

(ii) To keep out rain, heat and sound.

(iii) To resist fire and to give protection to the men and materials from the theft.

They account more than 32% of the over all cost of a building. So efforts should be made to minimize the cost of walls taking the consideration of following parameters

(i) Thickness of wall

(ii) Height

(iii) Ratio and type of mortar used.

(iv) Percentage of shaved wall.

(v) Selection of material.

ALTERNATIVE OPTIONS

By the adoptions of designed masonary walls substantial saving in material cost can be achieved like.

3.4.1 DESIGNED BRICK MASONARY WALLS

Burnt bricks is the most common building material used for the construction of walls. In plains of U.P., the thick ness of brick walls is still governed by to thumb rule rather than on any rational design as thus uneconomical construction.

Based on the research work done elsewhere and in this country and IS:1905-1980.

In areas where bricks of strength 10N/mm (101.9 kg/cm^2) or first class bricks are available, it is possible to construct 4 or more storyed residencial buildings using single bricks with 1:6 cement mortar in walls of all floors

Saving :

The use of designed brick masonry concept in case of 4 storyed building give a saving of about 20% in materials and cost of wall and increases the 10% usable area of rooms compared to walls designed by thumb rule and optimum utilization of materials

3.4.2 NINETEEN C.M. THICK MASONARY WALL WITH NON-CONVENTIONAL BONDS

In the common practice, 23cm thick load bearing wall are used for different types of construction work. The 19cm thick wall with non conventional bonds consists of three bricks laid flat on one face with two bricks laid on edge at the other face. The faces with flat bricks and bricks on the edge are alternated after every 230mm height. The technique is suitable upto double storyed building.

Advantage :

This type of wall is superior to the conventional wall in resisting moisture penetration.

* Thicknes is reduced by 40mm.
* 17 percent saving in the consumption of bricks and motor implies reduction in cost of construction.

This type of bond pattern provides even surface on both of faces, it emplies less thickness of plaster.

Disadvantage :

Load bearing capacity is reduced 10% than the conventional wall of 23cm thick.

3.2.3 11.5 CM THICK INTEGRATED THIN LOAD BEARING WALL SYSTEM

This type of load bearing wall is made in Z form by the using of burnt bricks with 1:4 (cement : sand) mortar and is suitable for two stroyed building.

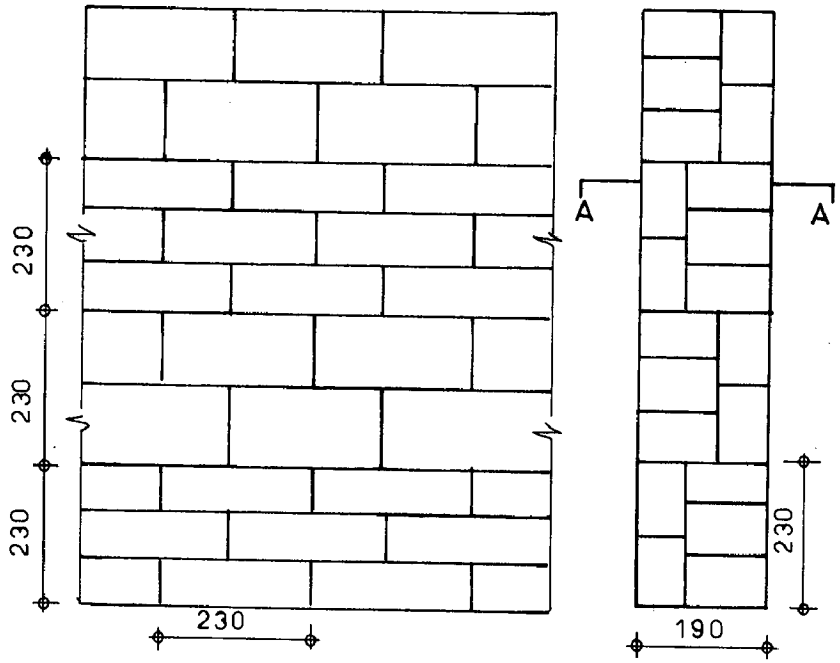
Advantage :

35 percent saving in brick as compared to 23cm thick wall.

* 20 to 25 percent saving in overall cost of construction.

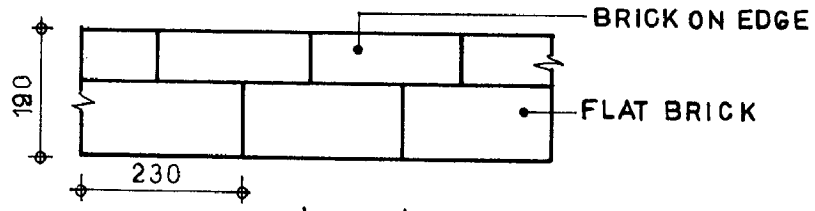
Suitability :-

This technique is simple and easily acceptable.



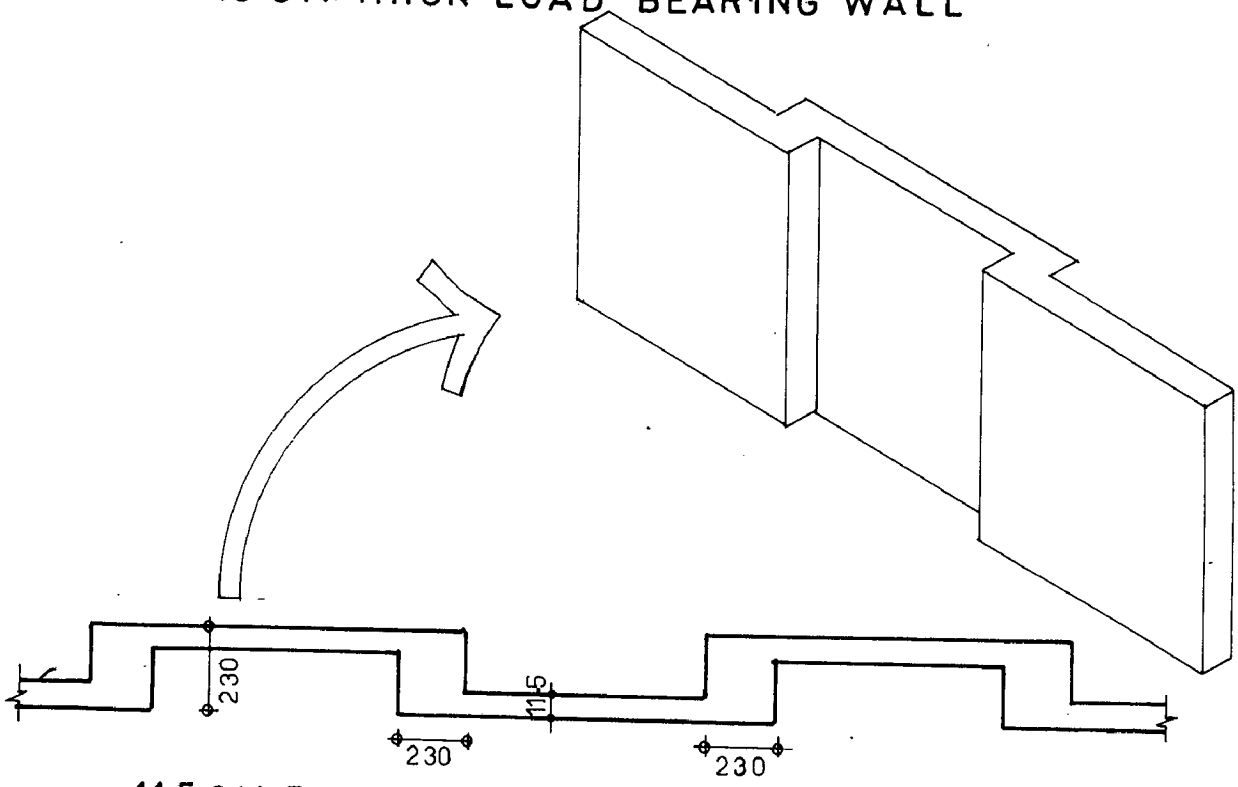
front elevation

End elevation



plan at-AA

19 C.M. THICK LOAD BEARING WALL



11.5 C.M. THICK LOAD BEARING WALL SYSTEM

3.4.4 PRE-FABRICATED BRICK PANEL FOR WALLS

It is a prefabricated low-cost construction techniques for walls. The pre-cast wall panels are unreinforced of size 515 x 1050 mm or 500 x 865 mm with a thickness of 75mm only. The first type of panel is made of 18 bricks and weight 75Kg while the second type panel is made of 16 bricks and weight 65 kg. with the combination of two panel, it is possible to built houses of different configurations and sizes. No mechanisation is envolved. The panels are cast on leveled ground with top layer of sand in timber moulds. The bricks are kept in the mould with staggered joints leaving in requiste gap between the bricks for laying mortar 1:4 cement : sand mortar is filled in the joints and compacted by using trowel. Two 6mm dia lifting hooks are embedded in the centre of the flat bricks thickness, while casting the panels. The mortar is cured by sprinkling water for one week after words the panel are lifted and stacked vertically and allowed to dry for 3 weeks, before using them is any construction. One 6mm dia bar is provided vertically in the joint between the panels. After keeping timber planks on both sides of the joint, it is filled with 1:2:4 concrete.

This techiques of construction is suitable for E.W.S. single storey houses.

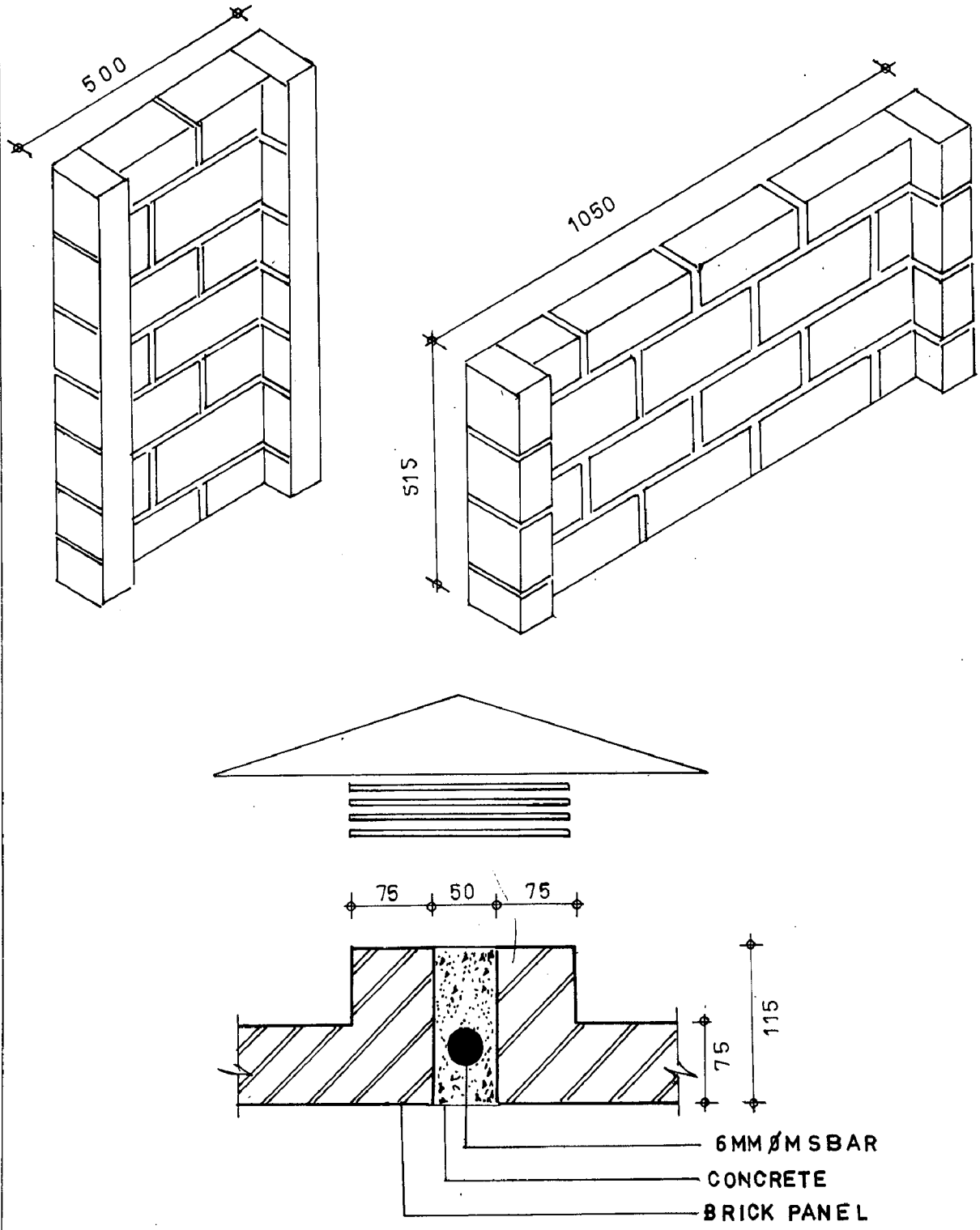
Advantages :-

There is considerable saving in the quantity of bricks required compared to a 230mm thick solid bricks wall in mud mortar, the bricks panel scheme will give an economy of about 30 percent in cost and fast construction implies saving in labour cost.

Suitabiltiy :-

This techniques is socially acceptable and durable.

PRE FABRICATED BRICK PANELS FOR WALL



JOINT DETAIL

3.4.5 PRE-CAST STONE MASONRY BLOCK WALLS

In some parts of state of U.P. like Varanasi division and Jhansi division, good quality of stone is avialable in abundance and forms the main building materials. Pre-cast stone block masonry is an economical alternative to 300 to 450 mm thick random rubble masonry wall. The blocks can be easily cast at site. It is also economical to bricks masonry wall. Pre-cast stone masonry blocks are normally produced with cement concrtete mix 1:5:8 (1 cement : 5 sand : 8 graded coarse aggregate of size 10mm). The blocks have a compressive strength of about 71.3 kg/sq cm.

The blocks are normally manufactured to the following sizes

Length	Width	height	Weight
300 mm	200 mm	150 mm	18.0 kg
300 mm	150 mm	150 mm	13.5 kg
300 mm	100 mm	150 mm	9.0 kg

200 mm thick single block wall can be used as a loud bearing wall upto 3 to 5 storyed building depend upon the conc mix used to produce the blocks.

Advantages:-

Compared to 300 mm thick randum rubble masonry wall, the technique save 26 percent in cement consumption

* About 20% saving in the cost of construction of walls.

Suitability :-

Neither sophisticated techniques or equipment is enolved nor skilled laboure is required hence this technique is socially acceptable and economically feasible.

3.4.6 RAT-TRAP-BOND WALL SYSTEM

This type of wall is made by the using of rat-trap bond in 23cm thick wall. It is as strong as the ordinary solid nine-inch thick bricks wall.

This type of wall system is suitable for two storeyed building.

Advantages:

It saves 25 percent of the total number of bricks as compared to 23cm thick solid wall and has a better insulation properties.

* 25% saving is cost as compared to 9" thick wall

Suitability:-

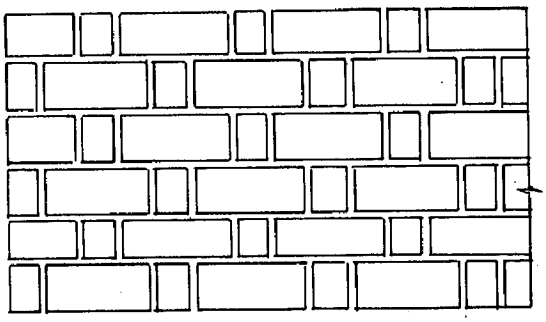
No special technique or, equipment or skilled labours is required hence it is socially accpetable.

3.4.7 PRE-CAST O.B.B. BLOCK WALLING

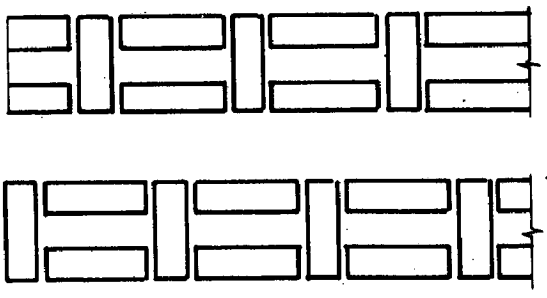
In all plains of U.P., over burnt bricks are available in abundance at lower cost. It can be used as main material for making blocks of different sizes like 30x20x15cm, 30x10x15 cm etc. which is economical alternative to brick mansonry wall.

TABLE - 3 COST COMPARISION

S.No.	Name of item	size	Cost of each block	Relation	saving
1.	Brick	23x7.5x11.5cm	Rs.1.40	one block = 4.5 bricks	Rs .65 in each block
2.	O.B.B. block	30x20x15cm	Rs. 5.65		



ELEVATION



PLANS OF ALTERNATE COARSE

RAT-TRAP BOND WALL SYSTEM

3.5 LINTEL

The cost in situ R.C.C. and R.B. Lintels are the conventional type of techniques used for spanning the opening is walls.They are costly is sense of shuttering base making setting, curing and delay in progressing of masonry work over it.

The flat brick arches are note economical because they require shuttering, More labour and more time to set.

STONE LINTEL

The economic feasibility of stone lintels is only in those areas where good quality of stone is available like in U.P. varanasi division and Jhansi divisions. It is the most economical lintel, for low income urban housing in these two divisions.

ALTERNATIVE OPTIONS

3.5.1 THIN PRE-CAST R.C. LINTELS

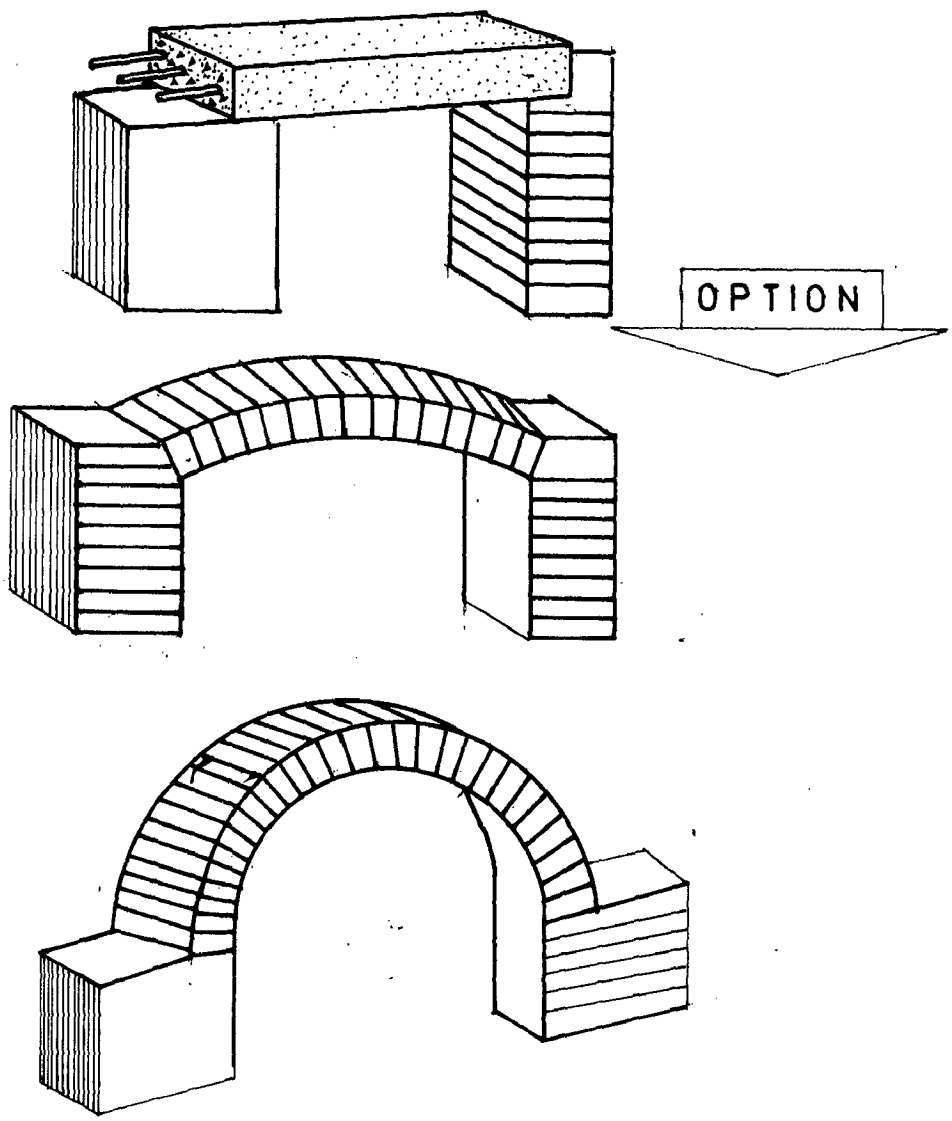
The thin R.C. Lintels are designed on the basis of calculation of bending movement equal to Wl/6 for a trangular portion of masonry. The composite action of masonary over it is not taken into account which can result in 50% of saving in steel and cement. Another option is that the R.C.C. lintel could be readily pre-cast and handled manually resulting is saving by cutting down delay involved in cast in situ.

Further more, where good bricks are available in U.P. like lucknow division reinforced masonry lintel cum chajja should be used to econmize the cost of cement (25% to 30%).

3.5.2 CONCEALED LINTEL

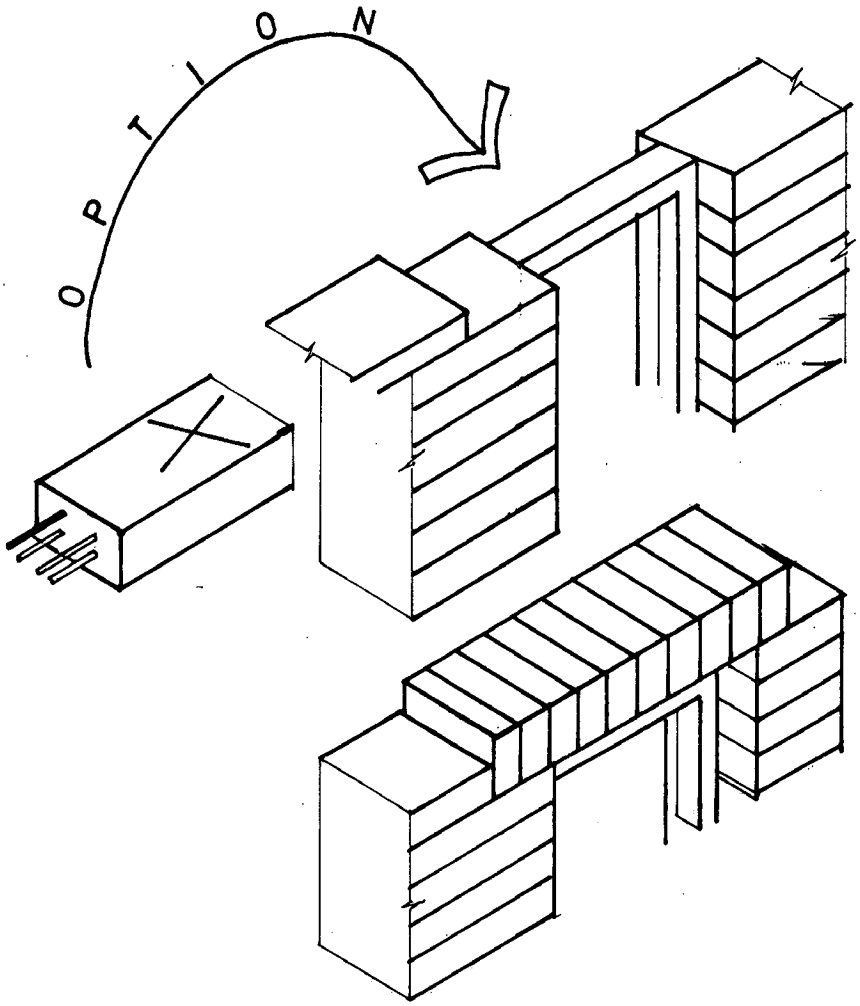
It is a hollow arrangement of bricks on edge filled with over two steel bars in concrete can carry the weights of wall and roof above it.

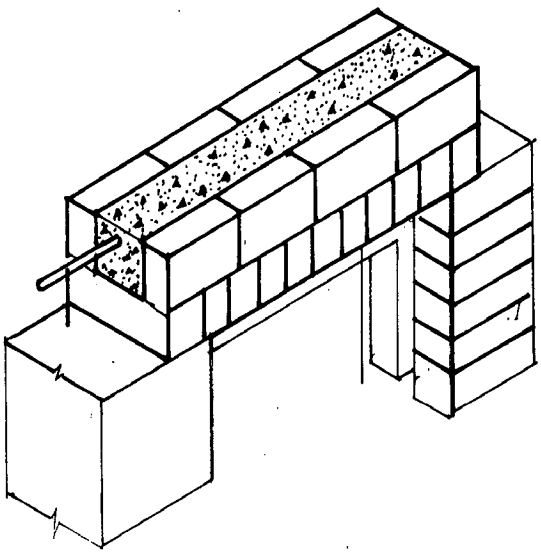
This type of lintel is less than half in the cost of the orthodox reinforced concrete lintel.



ALTERNATIVE OPTION FOR LINTEL

OPTIONS IN LINTEL





3.6 ROOF

Roof may be defined as covering provided over the top of a building with a view to keep out rain, snow, sun, wind and to protect the building from the adverse effects of these elements. and it is the most important structural element of building which cost of 22.6% of the total cost of the building. When it is R.C. slab. which needs specials attentions for low income housing R.C.C. provides a very durable structure but it is very costly for low income housing and their construction techniques is time consumming and it also requires expensive shuttering, laying ,casting and more energy consumption.

Some construction techniques have been made for low income people which is suitable for low income housing in plains of U.P. though some of the techniques, I.S. specification have not been strictly followed but tests on them have proved the structural/ functional efficiency of the system.

3.6.1 PRE-FABRICATED BRICK PANELS AND R.C.C. JOIST

It consists of pre-cast reinforced bricks panels 530 cm wide, 75cm thick and 1040 to 1200mm long, placed over pre-cast R.C. joists 100 x 130 mm in section and upto 5.0 mt long, spaced at 1.1 to 1.25 mt c/c 35mm thick structural deck concrete with nominal reinforcement is provided over the panels. The brick panels are cast manually on levelled ground. Bricks are arranged in the form with the joints in adjacent row of bricks staggered. Two 6mm dia bars are provided in the longitadinal joints. The joints are either filled with 1:4 cement: sand mortar or concrete of grade M15. The bricks panels are cured by sprinkler water for two weeks then allowed to air dry for two weeks.

The joists are designed as T beam with deck concrete acting as flanges.

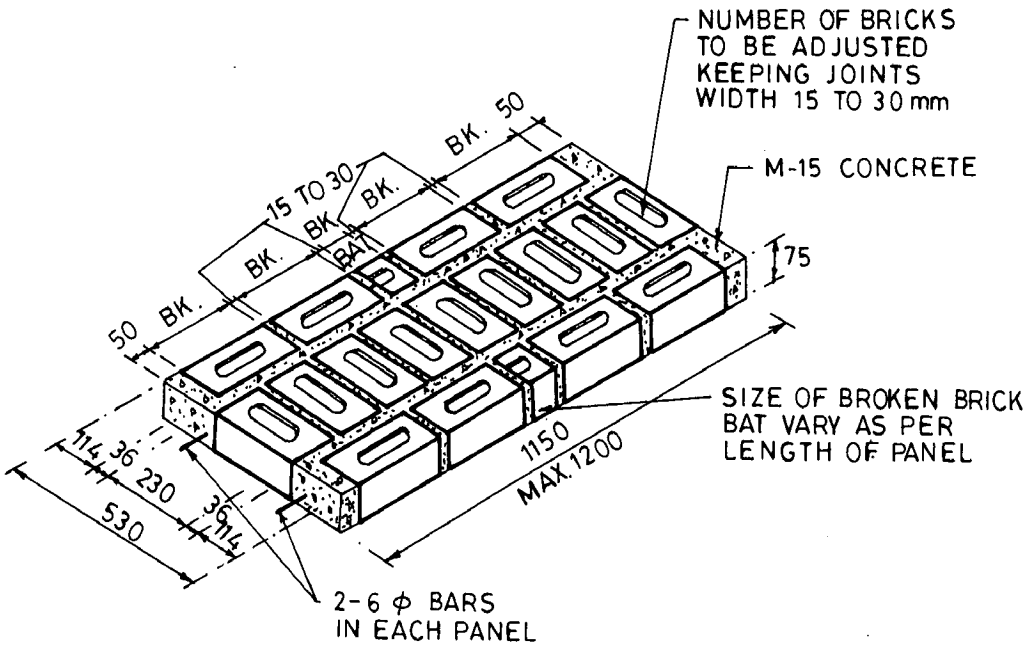
Advantage:-

* 25 percent saving in over all cost as compare to traditional R.B. slab.

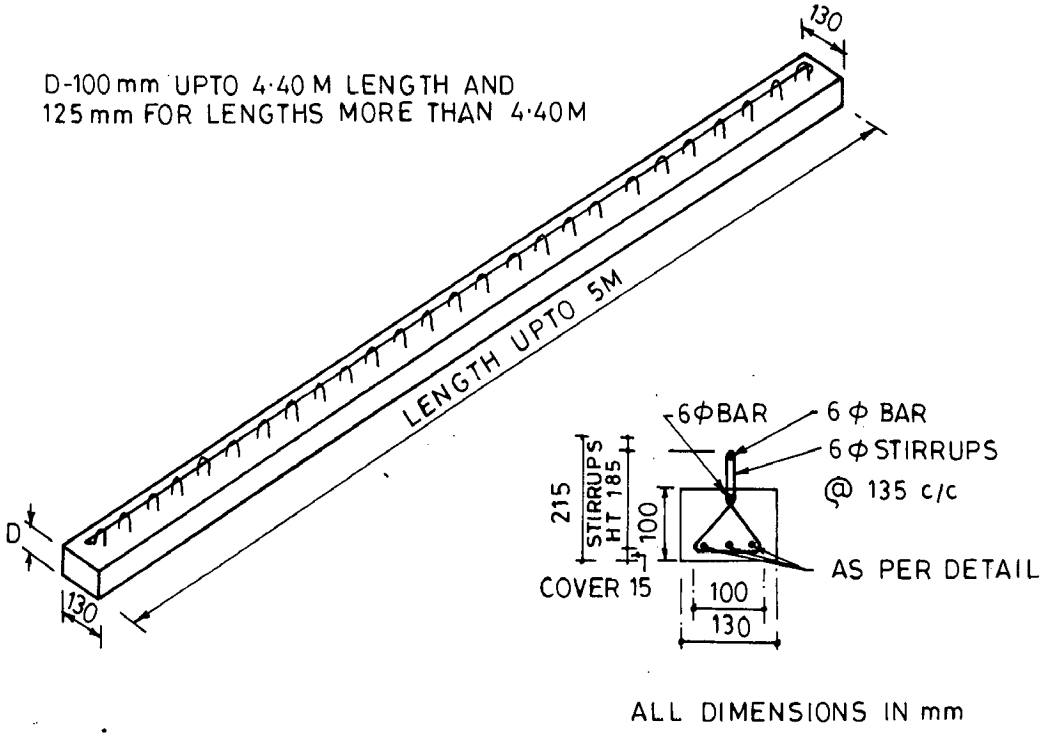
* Consumption bricks and mortar and 25 percent in steel besides saving of about 25% in over all cost.

SUITABILITY :-

The techniques is idealy suited for the construction of low income urban housing in plains of U.P.



ISOMETRIC VIEW OF BRICK PANEL



ALL DIMENSIONS IN mm

PARTIALLY PRECAST JOIST

3.6.2 PRE-CAST R.C. PLANKS AND JOISTS

The techniqes consists of pre-cost R.C. planks supported over prarically precast R.C. joists. To provide for T-beam effect with in joist, the plank is made partly 30mm and partly 60mm thick. The planks are 300mm wide with a miximum length of 1.5 mt. They are made of concrete of grade M15 and are reinforcent with 3 of 6mm bars at 200 mm c/c across the span. The partically pre-cast joists are 150 mm wide and 150mm deep with stirrups projectry out on the top side.

MECHANISATION :-

Simple timber/steel mould can be used by casting the planks and joists.

Advantage:-

Compared to conventional R.C. slabs, use fo this technique for Roof/floor will result in saving of about 14% in steel.

27% in concrete and 21% in overall cost.

Suilabity:-

The economic feasibility of this techniques is where natural aggregate are available is lange quanlity.

3.6.3 PRE-CAST JOISTS AND STONE PATTI

This technique is similer to the pre-cast planks and joists system. The only difference is that in this technique stone patti is used in place of R.C.C. planks.

Advantage:-

Saving is cost of construction of planks.

Suitability :-

This teching is suitable in jhansi and varansi divisions because good quality of stone patti (2' to 3' long and 1' wide) are available in abundance.

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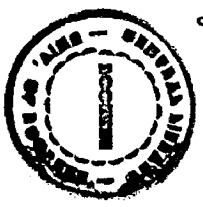
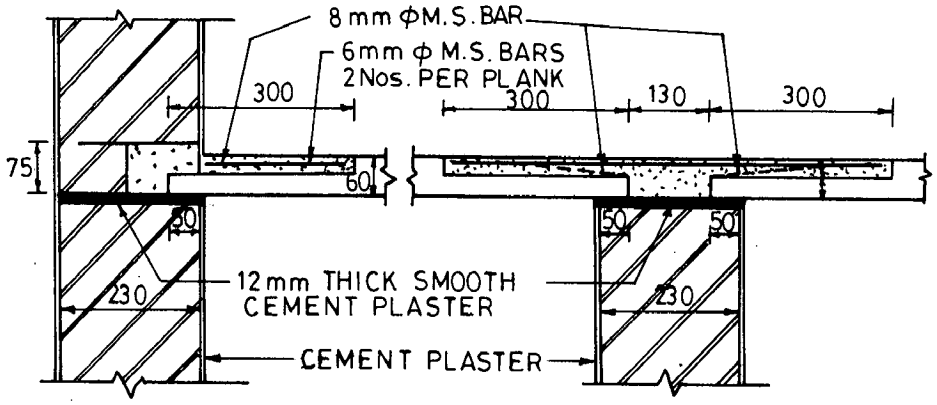
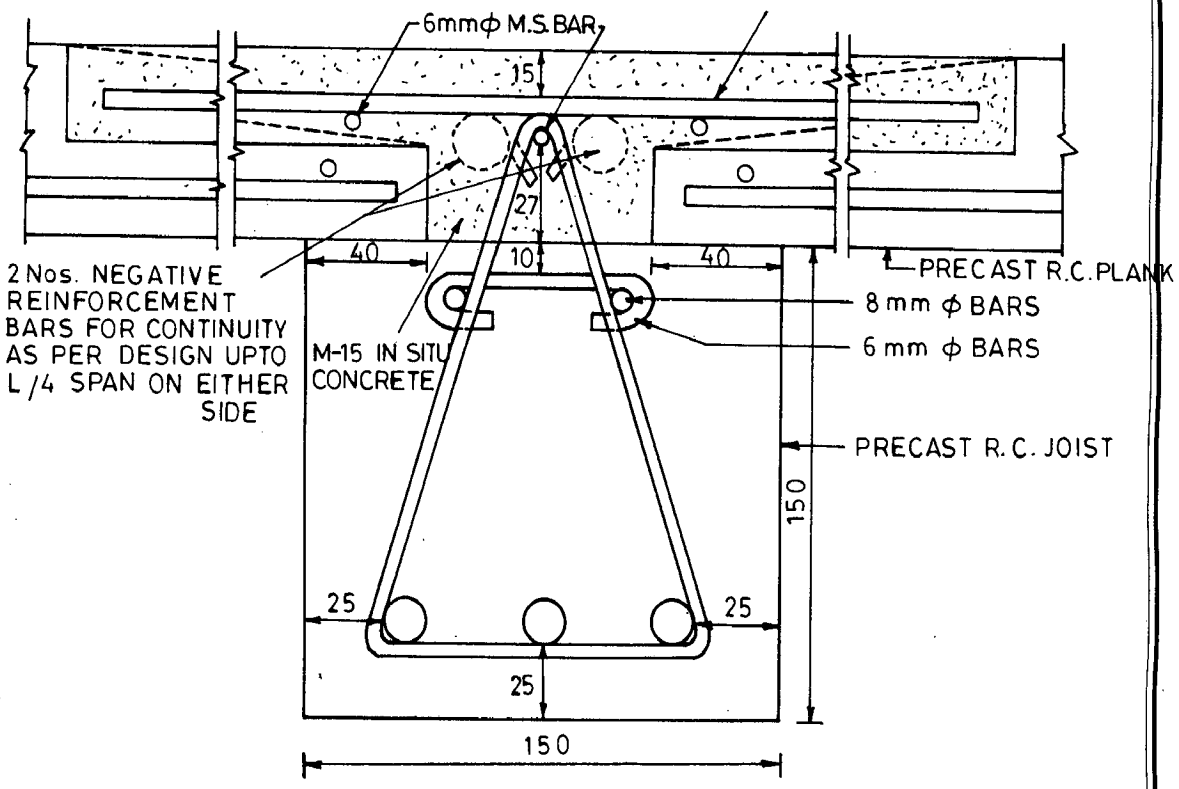


CONSTRUCTION DETAIL OF R.C. PLANK & JOIST



DETAIL AT END WALL

DETAIL AT INTERMEDIATE WALL



DETAIL AT BEAM SUPPORT NEAR WALL

DETAIL SHOWING DIFFERENT BEARING POSITIONS

3.7 DOORS/WINDOWS

Doors and windows serve as a media to distribute light and ventilation into the building. More than 15% of the building cost is shared by this element alone. A lot of wastage in term of quality and quantity has been observed. So special attention is needed on the following parameters:-

(i) Opening size

(ii) Location

(iii) Selection of material

Optimum size of doors and windown as per functional requirement should be provided in a building.

ALTERNATIVE OPTIONS

Under these circumstances, use of other alternative which can be considered are

3.7.1 FRAMELESS DOORS AND WINDOWS

Elemination of door and windows frames in low income housing can results in saving of about 2 percent of the over all cost of a dwelling apart from reducing the comsumption of timber which is becoming scare and costly. Two types of fixture are developed i.e. pivot system and fork system for frameless shutters which are suitable for both vertically and horizontally movable shutters..

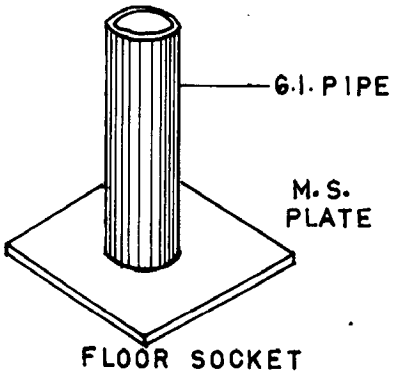
Advantages

This is strong, simple, unexpensive requires very little labours, No iron mongery, lets in light air and provides security.

Suitabiltiy :-

These fixtures (system) have been in use for a long period in buildings and have given satisfactory performance.

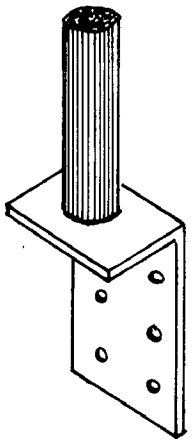
FRAMELESS DOOR



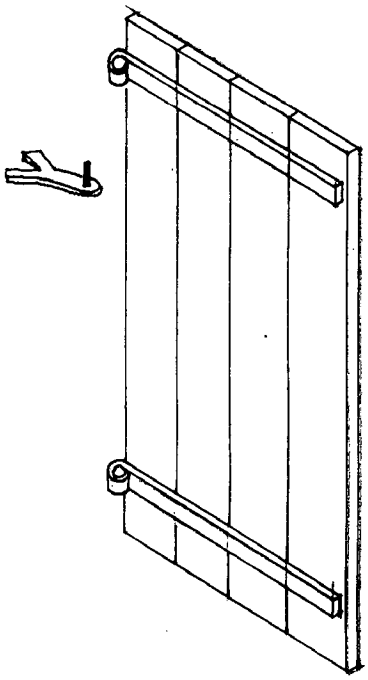
FLOOR SOCKET

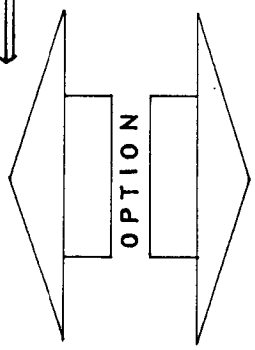
TOP SOCKET

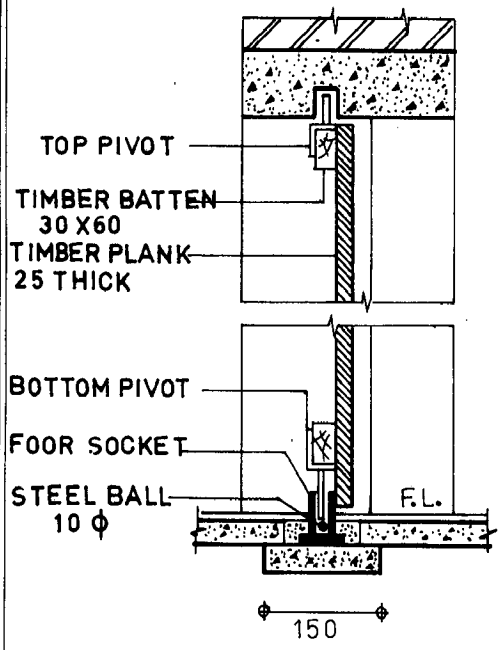
M.S.BAR

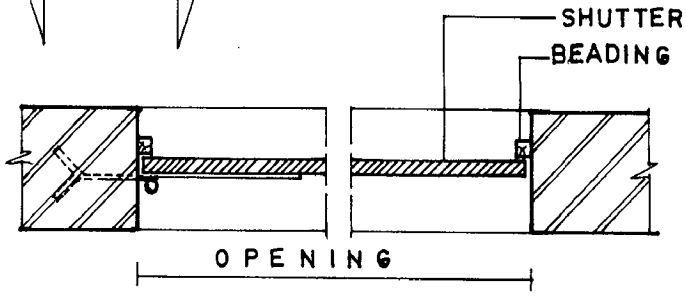


PIVOT





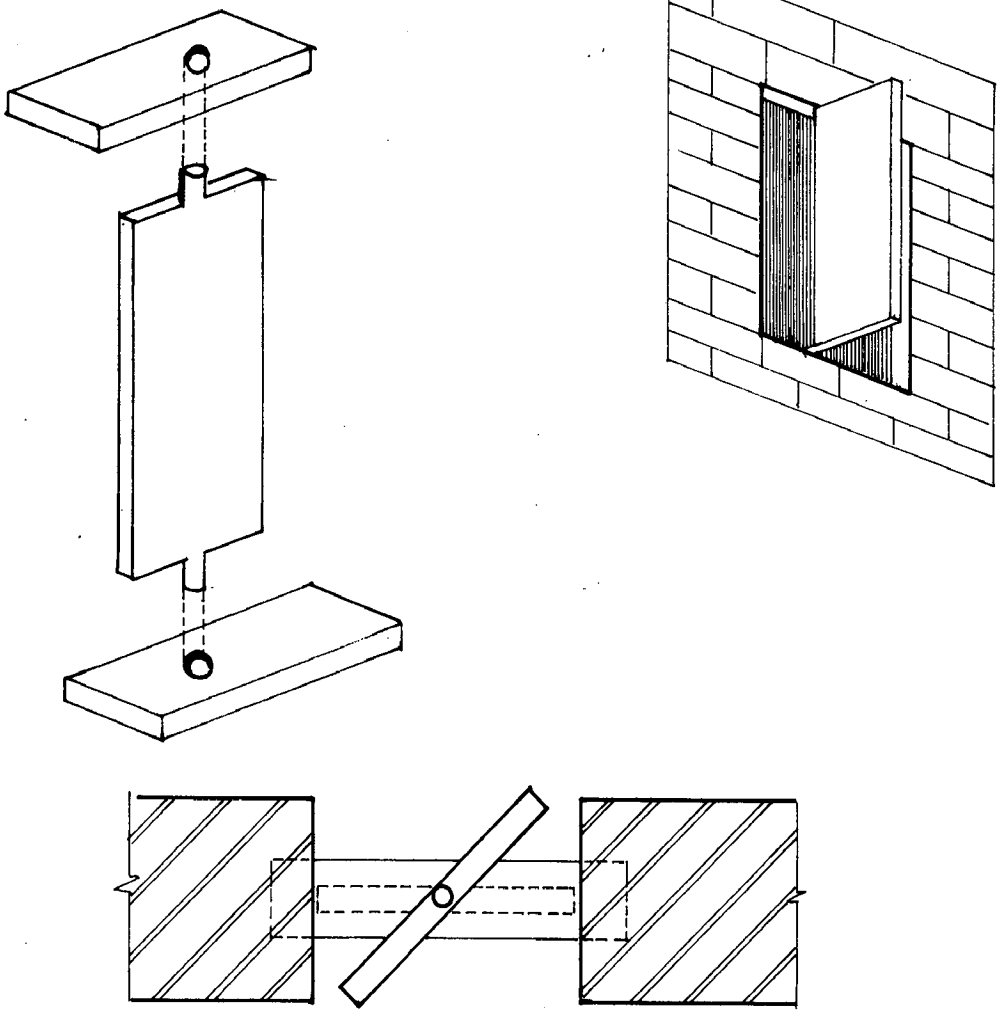




TYPICAL DETAIL OF PIVOT SYSTEM

TYPICAL DETAIL OF FORK SYSTEM

DETAILS OF FRAMELESS WINDOW



FRAMELESS WINDOW

3.7.2 FERROCEMENT DOOR SHUTTERS

Ferro cement shutters for doors are the most economical alternative of traditional timber door.

They are manufactured by the chiken mess and concrete mix.

The thickness of shutters varries between 2.5cm 3 cm depending upon confirguration and size.

The techiques is successfully used in low income housing at lucknow by krishna coloniser, Lucknow.

Advantages :-

50% saving in overall cost in compare to traditional timber door.

* Structure can be thin light.

* They can be easily pre-cast at site

3.8 SERVICES

3.8.1 ELECTRICAL

The use of wood conduit for electrification has become out of age costly and more energy oriented. Under this circumstances, plastics is the most economical solution for electrification of low income housing. It is available in market in different diameter i.e. 10mm to 63mm at very low cost.

Advantage :-

* easty to transport
* corrosion resistant

3.8.2 DRAINAGE (RAIN WATER PIPE)

The conventional system of rain water pipes which is provided from terrace to bottom of the building, consume more cost to avoide the cost of this R.W.P.

We can simply provide projected U.channel which will serve the function of Rain water pipe and also provide the Aesthetic look.

3.8.3 PLUMBING

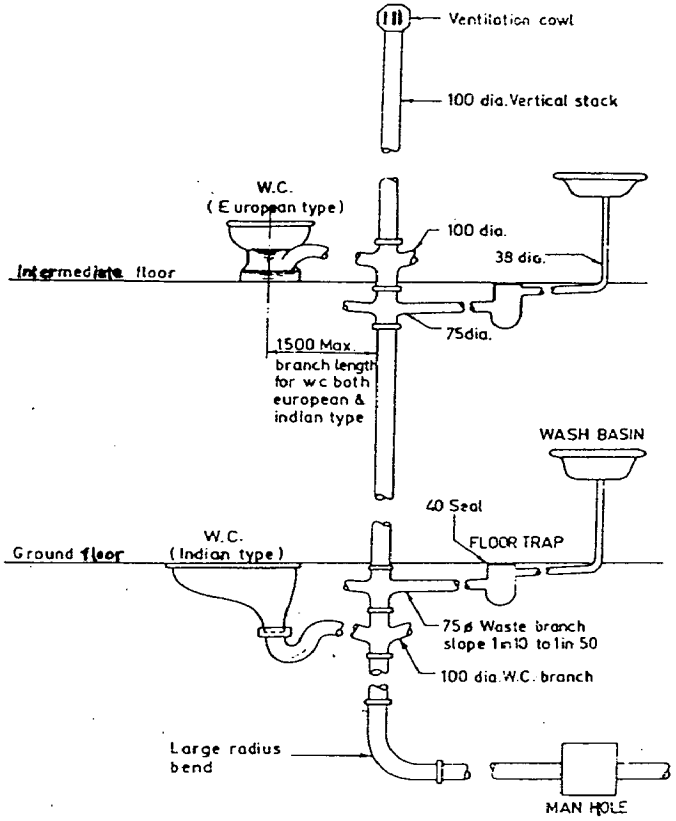
The conventional drainage systems recommended is municipal by laws for buildings involve use of two seprate pipes and in addition vertilation pipes are fitted with both the stacks. which consume more cost i.e. uneconomical.

ALTERNATIE OPTION

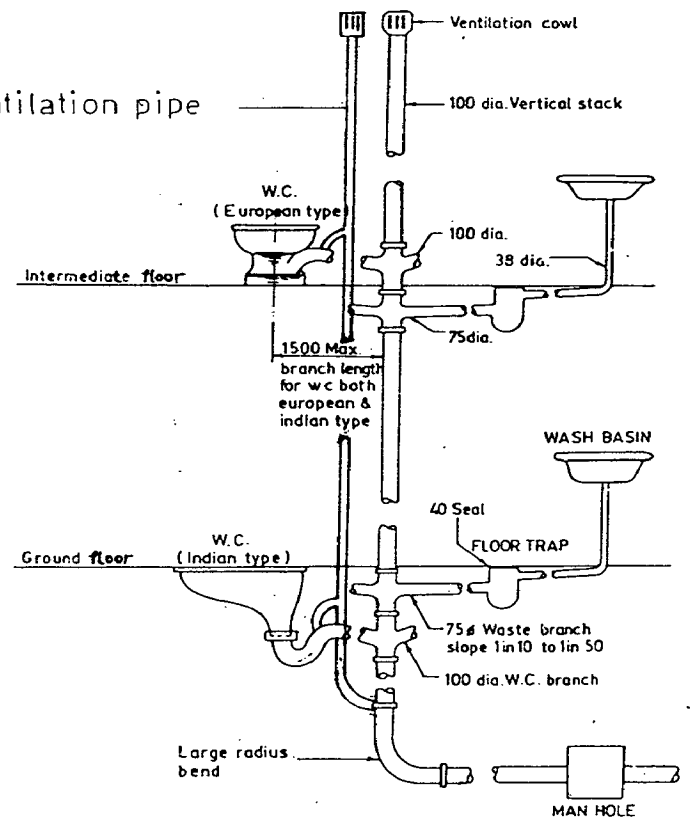
3.8.3 SINGLE STACK SYSTEM

In this system, all the appliances are connected to one pipe (stack) which itself acts as the ventilation pipe also. Single stack systems in simple, economical and functionally efficient for low income urban housing.

PLUMBING SYSTEM



SINGLE STACK SYSTEM



MODIFIED ONE PIPE SYSTEM

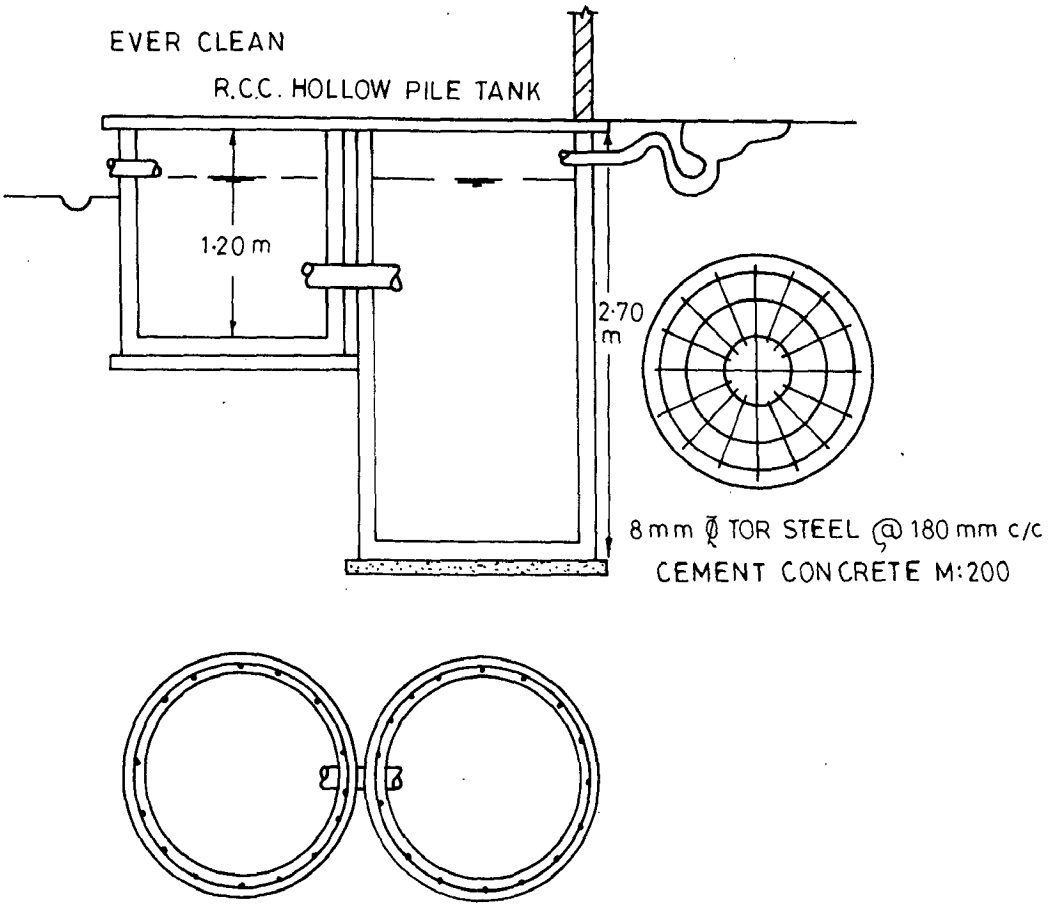
3.8.4 R.C.C. HOLLOW PILE TANK (LATRINE)

Which is easy to construct occupies lesser space and very low cost than old model septic tank latrine. It is ever lasting and does not require re-cleaning.

Following are the special features of this type of tank:

* Everlasting for life long
* Eco-friendly
* Does not require recleaning forever
* needs litle space
* Does not require soak pit Ever Clean
* Leak proof
* Water tight
* No danger to foundation
* Most hygeinic
* Outlet pipe can be installed in general drain
* Bathroom water & Fennel can be digested
* Suits all soil conditions

Users	Rate (Rs.)
50	10,000/-
100	12,000/-



R.C.C. HOLLOW PILE TANK

CHAPTER 4

VIEW OF TWO STOREYED E.W.S. HOUSING AT NOIDA

CASE STUDIES

4.1 CASE STUDY - 1

E.W.S HOUSING SECTOR 12, POCKET Y, NOIDA (U.P.)

Economically weaker section housing was taken up by New Okhla Industrial Development authority to provide houses to the workers working in Noida. Since large number of houses were to be built within the limited financial resources it was decided by the authority to make use of alternative construction techniques with a view to reduce the cost of dwelling and complete the construction faster.

The construction of these units was completed in 1988. It took six months to complete the construction. The plot size for EWS unit was 31.97 sq. mt. and the plinth area is 21.65sq. mt. The total number of dwelling unit is about 500 out of which 50% are single storey and 50% double storey. The total cost of construction of a dwelling unit is Rs. 19,845/-. The per sq.mt. construction cost works out to be Rs. 886.75. Prefabricated brick panel and integrated thin wall system of construction was adopted for the construction of single as well as double storeyed houses. The work was executed on contract. A demonstration of fabrication and handling of prefab components and construction of integrated thin wall was adopted.

During the construction technical assistance was provided by CBRI, Roorkee who developed the techniques and designed the housing project.

4.1.1 CONSTRUCTION FEATURES

In the construction of houses of Noida scheme commonly available conventional materials i.e. bricks, cement, aggregate have been used in innovative manner. Their has been to reduce consumption of materials by optimum utilisation of their strength through technological innovations and bring down the cost. The cost limit fixed by the Noida Authority was a maximum of Rs. 20,000/-. The actual average cost of dwelling came to Rs. 19,845/-.

VIEW OF ONE STOREY E.W.S. HOUSING AT NOIDA

Important features of construction are:

FOUNDATION :

Strip foundation in Brick Masonry for rational loading, the depth of the foundation for load bearing wall is 45 cm below ground level with a width of 60cm. The foundation concrete is 15cm thick. The masonary above footing and upto plinth level is 20cm thick.

CONSTRUCTION OF WALLS:

The wall system mainly is made of 11.5 cm thick burnt brick wall integrated with 23cm masonary pier for supporting the joists to carry roof load. The wall in other direction is 11.5 cm thick except where any floor joists comes 23 thick pier is provided.

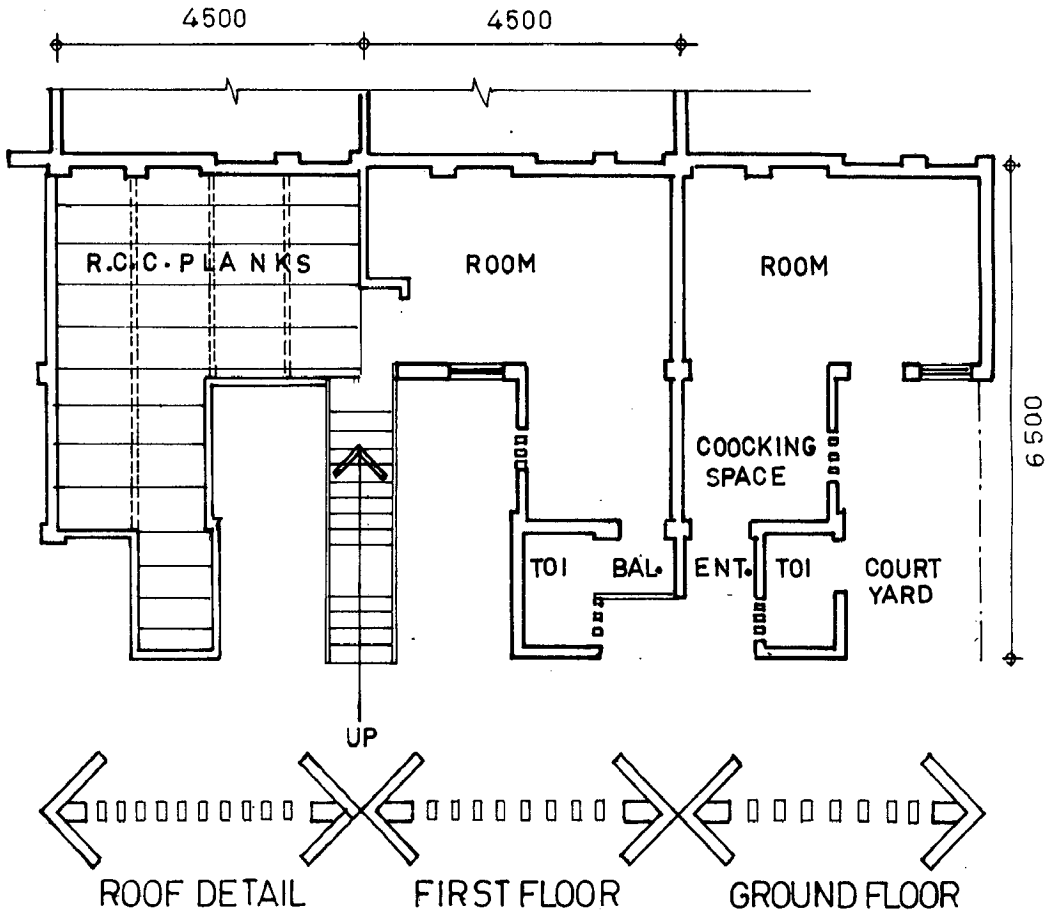
Thus, in a way, the wall system is a designed masonary work. The mortar used in the construction of walls is 1:4 cement coarse sand mortar. In this system of wall construction, apart from reduction in the consumption of bricks, substantial reduction in consumption of mortar is also achieved.

FLOOR/ROOF:

The roof is made of prefabricated reinforced brick panels and partially precast reinforced concrete joists. The brick panels which were used of two sizes i.e. 53 cm by 110 cm and 53 cm by 120cm. with a thickness of 7.5 cm. For the construction of one dwelling 28 panels of 53x110 cm and 3 panels of 53x120 cm were used. The partially precast joists of 295 cm length and one joist of 220 cm length were used for one unit. The weight of the longer panel was about 55 kg and the weight of the longer joists was 90 kg.

DOORS/WINDOWS:

Frameless doors of 75 cm and 92 cm width and 200 cm height have been used. The only one window provided in the room is 75cm x 195cm and has three sides steel frame. The ventilation and light in the toilet and the cooking portion is provided by the provision of brick jali. The shutters of doors and windows are made of local wood.


4500
4500
R.C.C. PLANKS
ROOM
ROOM
6500
COOCKING SPACE
TOI
BAL.
ENT.
TOI
COURT YARD
UP
ROOF DETAIL
FIRST FLOOR
GROUND FLOOR

LINTELS/SUNSHADES:

Precast R.C. thin lintels over door, window and ventilator openings have been used. Sun shades are integrated with lintles. Use of these precast components avoids delay in the progress of masonary work and is economical compared to cast-in-situ practice.

PLUMBING:

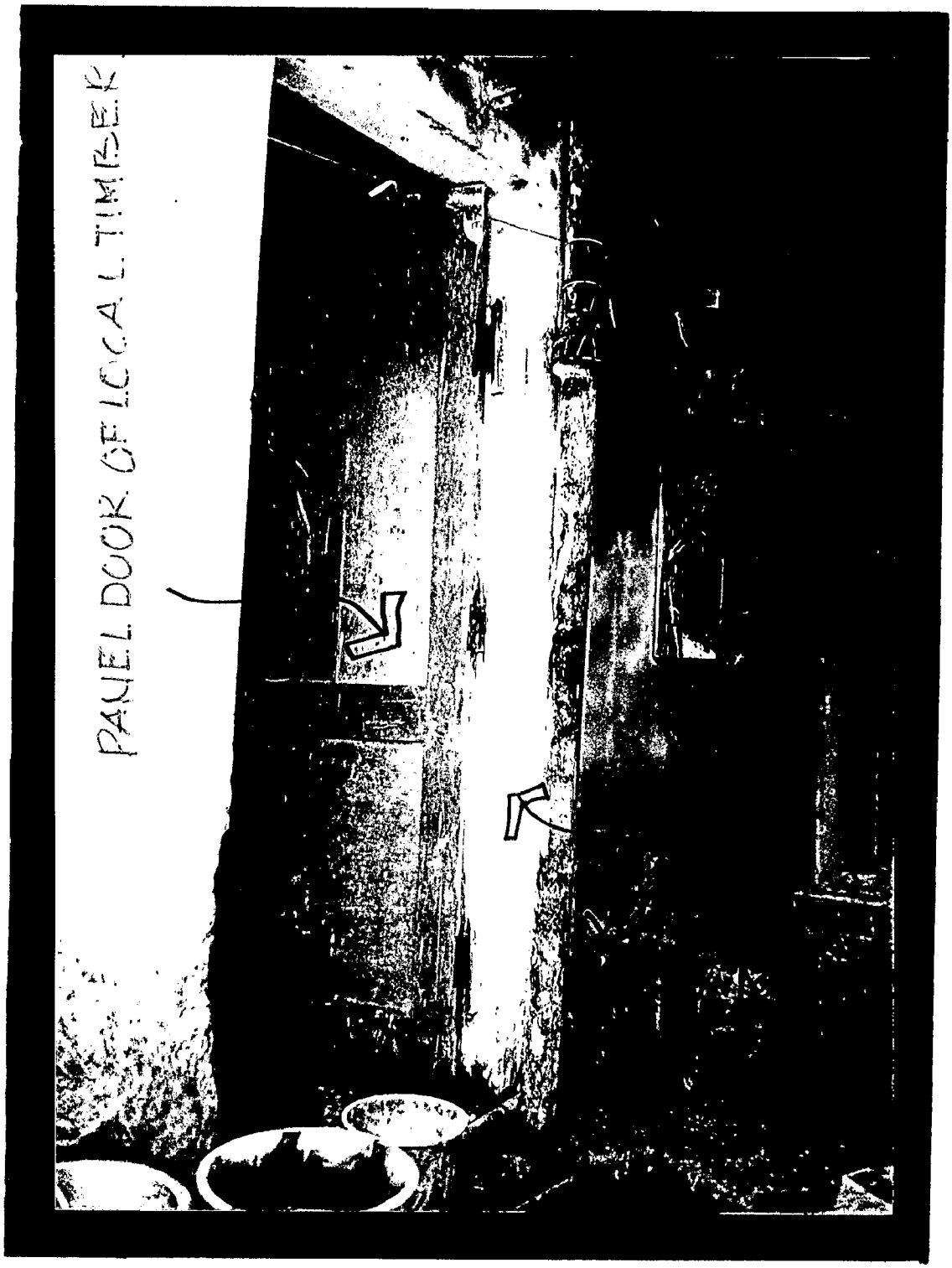
Single stack system has been used for two storeyed construction. keeping living habits of the EWS families in view flushing cistern for W.C. has not been provided. In practice it has been found that cisterns very often get out of order and remain unrepaired by the EWS house holds. As a result cistern often start leaking. Instead, of reparing the cistern they use bucket for flushing the toilet. In order to reduce cost, precast ferro-cement water tanks have been provided.

4.1.2 ASSESSMENT OF CASE STUDY:

COST ECONOMY:

The economy in cost has been computed vis-a-vis conventional construction. In the conventional construction practiced in the area the minimum foundation depth is 90 cm below ground and width is 90 cm with 15 cm thick foundation concrete for 23 cm thick brick wall upto 2 storey, construction. All the walls are kept 23 cm thick. The walls are plastered both internally and externally with cement sand mortar.

The conventional roof considered for the comparison is 11.5 cm thick reinforced brick cast-in-situ slab. Door and window used in conventional construction have wooden frames and shutter of secondary species of timber. Single stack plumbing system has been.



VIEW SHOWING THE CONSTRUCTION OF DOOR & WINDOW

Cost Economy Table, EWS Housing Noida, U.P.

Items/elements	Cost of conventional elements(Rs)	Cost of alternative elements(Rs)	Elemental saving(%)	Cost Economy(%)
Foundation	1862.79	1080.42	42.00	0.37
Walls	4778.47	3044.36	36.24	6.41
Roof	7289.19	5241.02	28.00	7.56
Flooring	1268.86	1290.43	-1.70	-0.07
Doors/Windows	5120.43	2638.07	48.57	0.22
Finishing	2078.77	2245.07	-8.00	-0.61
Internal Services	4589.49	4306.29	6.17	1.04
Total	Rs. 26,597	Rs. 19,845	-	24 %

Source : NEW OKHLA INDUSTRIAL DEVELOPMENT AUTHORITY, NOIDA.

Considered a conventional practice for double storey units. Similar flooring for conventional as well as alternative system has been considered.

The economy achieved in the Noida scheme as compared to the conventional construction is due to use of alternative techniques leading mainly to saving in material through rational design and specifications. Major savings have been contributed by prefab brick panel and precast joist roof, thin integrated walling and due to frameless doors. However, the items of flooring and finishes have come out marginally expensive. It is observed that the economy achieved due to alternative techniques of prefab brick panel and joist roof is 28% compared to conventional R.B. slab roof whereas this saving in roofing is 7.6% of the overall construction cost of conventional building. The saving reflected in walling due to the use of integrated thin wall system is of the order of 36% when compared to 23cm thick conventional wall. The economy contribution due to integrated thin walls is about 6.5% of the total conventional construction cost of dwelling.

The maximum saving in the elemental cost is seen in doors and windows. The overall saving in the cost of construction as a result of use of alternative techniques and rationalisation is to the tune of 24% which is a considerable saving particularly for an EWS household.

4.1.3 REDUCTION IN CONSTRUCTION TIME:

In the conventional construction the project was expected to be completed in 9 months. The cast-in-situ work in conventional system takes considerable time. The first stage where time is saved by the use of precast components is at lintel level of doors and windows. By the use of precast intels further masonary work need not undue wait. The next stage when the progress of construction work is delayed is in laying of roof slab. The erecting of shuttering and centring, laying of bricks and binding of reinforcement and filling voids with mortar in R.B. work takes away considerable time. By the use of prefabricated joist and brick panel the construction time of roof is reduced by about 30% compared to conventional RB slab. the reduced masonary work, use of precast lintels and prefabricated roofing components have given an overall reduction in construction time of 30%. Whereas the the production of prfabricated components had to start two week in advance to avoid any delay in the progress of construction.

4.1.4 SKILLED LABOUR REQUIREMENT:

The skilled labour availabe in the market has no experience of working with precast roofing components. But as the techniques are simple the available skilled labour with some initial training and constant supervision did the work of fabricating, handling and assembling of these components efficiently without difficulty. The skilled and unskilled manpower requirement for prefabrick panel and joist roof and integrated thin wall system, viz-a-vis conventional construction are given in the table below.

Labour requirement per sq.mt. of roof: (man days)

S. No.	Labour	Conventional RB slab	Prefab brick panel and joist roof
(i)	Mason	0.12	0.20
(ii)	Carpenter	0.44	0.035
(iii)	Barbinder	0.08	0.12
(iv)	Labour/Bhisti	1.00	1.20

Source : CENTRAL BUILDING RESEARCH INSTITUTE, ROORKEE.

Labour requirement in walling per sq. mt. (man days)

S. No.	Labour	Conventional wall 23 cm thick	Thin integrated wall
(i)	Mason	0.40	0.40
(ii)	Labour/Bhisti	0.70	0.64

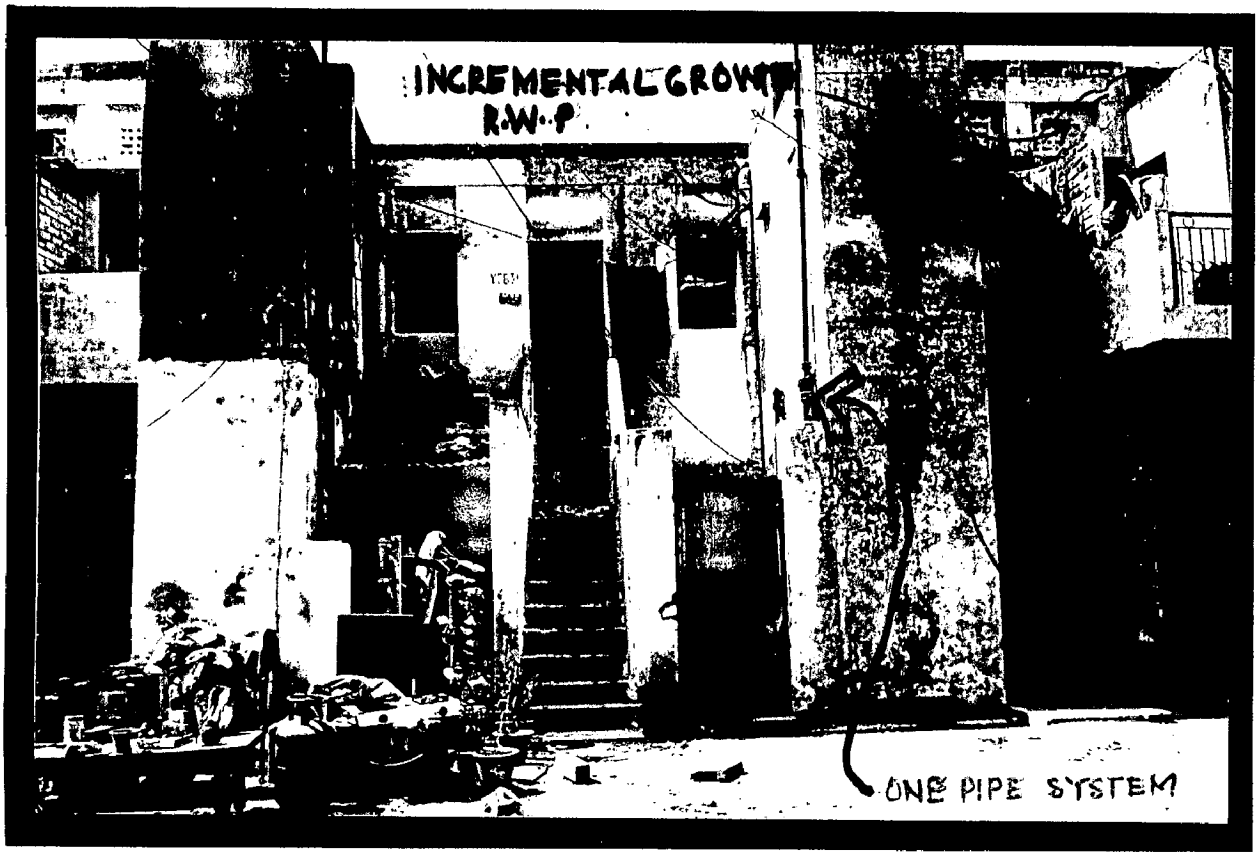
Source : CENTRAL BUILDING RESEARCH INSTITUTE, ROORKEE.

From the above table it is seen that the requirement of mason, bar binder and labour have increased whereas the requirement of carpenter has reduced, in the alternative roofing technique of prefab brick panel and joist compared to conventional RB slab.

In walls the requirement of mason does not show any variation but the requirement of labour has decreased in the case of new technique compared to 23 cm thick conventional wall the due to handling reduced quantity of materials.

MECHANISATION :

As the alternative techniques used in the Noida project was simple they required only simple tools besides mixture and vibrator required for concreting work. All other operations including handling and hoisting of components in position were done manually.



VIEW SHOWING THE INCREMENTAL GROWTH

4.1.6 MAINTENANCE:

The materials used for the alternative techniques of walling and roofing are the same durable materials i.e. bricks, cement and steel which are used in conventional construction and the building elements satisfy structural safety requirements as per building code. The walls are plastered both externally and internally with the cement sand mortar of conventional proportions of 1:6 With this the maintenance is not expected unusual than the conventional construction.

4.1.7 FLEXIBILITY OF THE SYSTEM :

By flexibility of the system we mean its ability to satisfy varying planning requirements from functional to architectural considerations. In case of conventional construction unlimited variety in the room sizes and plan configuration can be achieved, which is neither necessary nor economical. Certain degree of standardisation is necessary for rationalisation in planning and reduction in the cost of construction. The integrate thin wall system offers limitation in respect of room sizes and is suitable for two storey constructions only. However, considering the requirement of dwelling spaces for low income housing, the integrated thin wall system does not impose limitation.

From practical and economical considerations the recommended width of prefabricated brick panel is 53 cm whereas its length can vary from 90 cm to 120 cm. The maximum recommended length for partially precast joist is upto 3.5 m. It can be seen from the size limitations of roofing components that encloser sizes with increments of 53 cm and 90 to 120 cm. can be achieved to cater to various house hold functions. The system offers adequate planning flexibility.

4.1.7 APPEARANCE OF AESTHETICS:

The integrated thin wall system provided certain lengths of wall recessed which does not give an appearance of continuous plain wall. But the recessed space has been utilised usefully for hanging clothes and making use for other storage purposed. The flat roof surface with projecting joists at regular intervals makes an interesting pattern. The occupiers of these house did not make any adverse remarks when specially asked

VIEW SHOWING THE CONSTRUCTION OF THE ELECTRIC WIRING AND DOOR/WINDOW

for their view about aesthetics.

4.1.8 PERFORMANCE:

The performance of alternative technique with respect to conventional constructions has been studied in terms of thermal performance, resistance to impact noise, fire resistance and rain penetrations.

THERMAL PERFORMANCE:

The thermal performance idex (TPI) of prefabrick panels for roof is 143 against 116 of RB roof.

The termal performance of 11.5 cm thick wall is poor compared to 23 cm thick wall but this deficiently has very little disadvantaged in the dwellings due to the fact that only about 10% of 11.5 cm thick externals wall of living space is exposed.

RESISTANCE TO IMPACT NOISE:

The impact noise ratings (INR) which indicates the degree of impact noise. The insulations provided by the floor is 16 db for 10 cm thick R.C.C. slab. The INR for 11.5 cm thick R.B. slab is 12 db while that of R.B. panel roof with deck concrete is 14 db. The noise transmissions through a floor does not depent on its thickness. The desired value of INR which is +5 db as recommended by Bureau of Indian Standards for satisfactory performance can be achieved only by putting a layer of resilient material between the slab and floor finish.

SUITABILITY OF ALTERNATIVE TECHNIQUES:

AFFORDABILITY:

The cost of dwelling with alternative construction is considerably less than the estimated conventional cost. The construction under the case study is considerably economical with in the afordable limits.

SOCIAL ACCEPTABILITY:

The houses are built with durable conventional materials and satisfy space provision for EWS households. By the expectation of allotties the houses are of good standard and are well accepted.

AVAILABILITY OF LOW COST COMPONENTS:

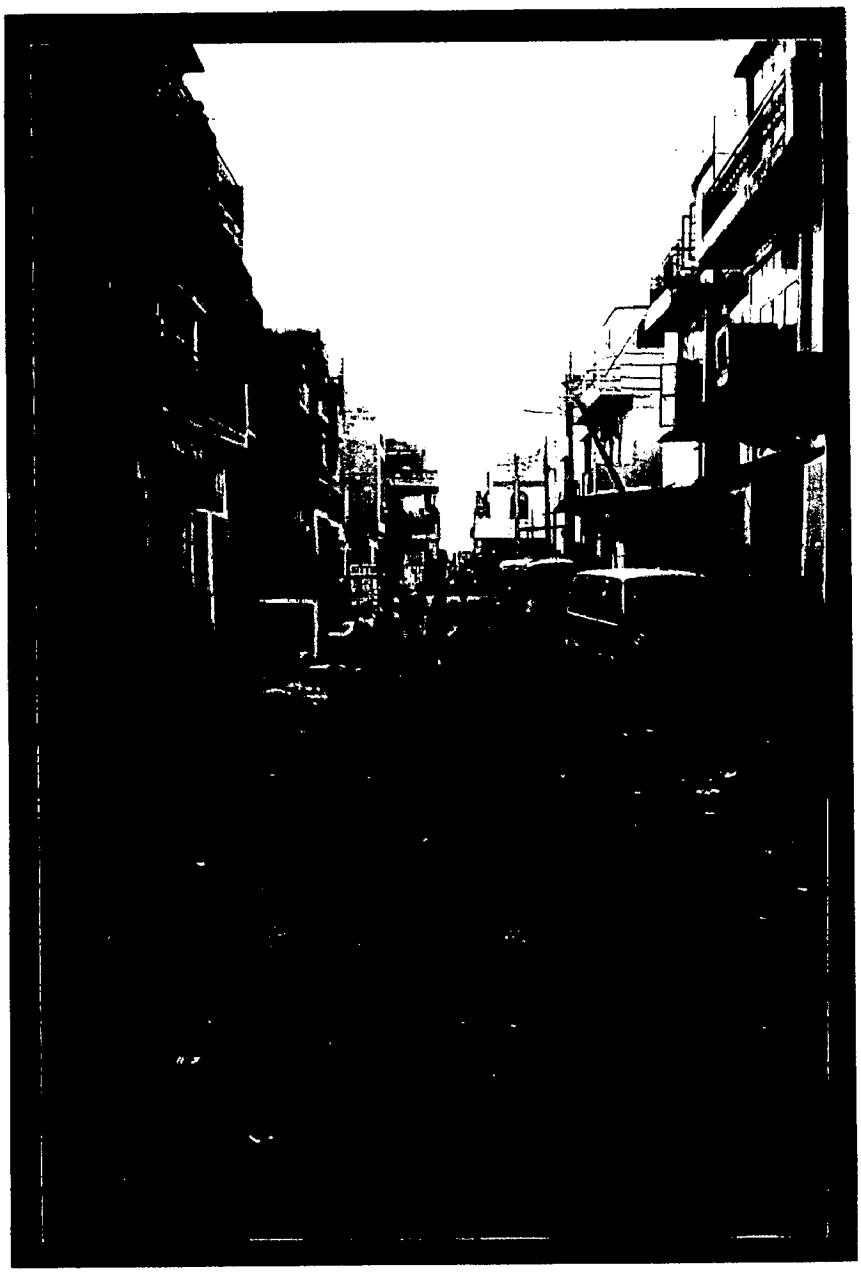
Locally available materials are used in the construction as well as in fabrication of components. The prefab brick panels can not be transported for long distances. The techniques is essentially a on site fabrication technique.

EASE OF CONSTRUCTION:

The alternative techniques involve more operations and require attention of all workers and alert supervision. Since the contractor and mason are not familer with such techniques they require technical guidance. However, no special equipments are required, the construction can be done with simple tools and devices. All operation are manual.

DURABILITY:

The Techniques make use of durable materials such as bricks, cement, aggregate and steel. The resultant constructions are durable compare to convectional costruction.



TWO STOREY E.W.S HOUSING AT ROHINI

4.2 CASE STUDY - 2

E.W.S. HOUSING, SECTOR 5, BLOCK-C, PACKET-2 ROHINI, DELHI.

Delhi Development Authority assigned the construction of 1952 EWS dwelling units, in *Sector 5, Block-C Pocket-2* in Rohini township of Delhi to Hindustan Prefab Limited. (Jungapura New Delhi) a Public Sector Undertaking. One of the consideration to award the work to Hindustan Prefab Limited was to complete the construction faster with its capability for large-scale prefabrication and long standing experience. The construction work was completed in 1988. It took two years to complete the project against the initial schedule of one and half year. The completion of project was delayed by six month by slow downing the work due to delay in supply of cement and steel by D.D.A. which were to be supplied by them as per the agreement. The plinth area of each delling is 22.814 sq. m. The cost of construction per dwelling is Rs. 36,000/-. The per sq. mtr. construction cost works out Rs. 1579/-.

The Hindustan Prefab Limited adopted room size precast RCC floor/roof slab, Staircase flights, landings and lintels. A casting yard for fabricating components was establishied at site and necessary equipment for casting, transporting and hoisting such as steel moulds, concrete mixtures, creanes, tractors etc. were brought in.

4.2.1 CONSTRUCTION FEATURES:

The construction of dwelling was in two storey flats, conventional materials such as brick, cement, agregate were used. The conventional 23 cm thick walls, which supported precast RC roof components of room size.

Important feature of construction are:

FOUNDATION:

Strip foundation in brick masonary for rational loading was employed, 10 cm. thick foundation concrete was used with stepped footings in single brick courses.

WALLS:

The load bearing external walls were of single brick thickness, with burnt clay bricks.

Where at the intermal walls use of 41/2 thick. The walls are in cement sand mortar of 1:6 proportions.

FLOOR/ROOF:

The roof is made of precast reinforced concrete slabs of 10 cm thickness. Each dwelling unit has 5 sizes of roof components, one each for, a room, balconey, kitchen, bath and W.C. In stair-case two precast flight units and the two landings have been used.

DOORS/WINDOWS:

Door frames are made of angle iron, shutters in secondary species of Hallock wood with ply-board panels.

LINTELS:

Conventional lintels of precast reinforced concrete are used over door and window openings.

PLUMBING:

Single stack system of plumbing has been used for the two storey construction. A single pipe carries water of kitchen, bath and water closet. W.C. has no facility of cistern only earth pot is used for flushing the toilet.

4.2.2 ASSESSMENT OF CASE STUDY:

COST ECONOMY:

The walls, flooring, finishing and external services do not give economy as the conventional practice has been used in them. The economy has been achieved in foundation, doors and windows. The elemental cost saving is 4.9% and 9.35% in foundations and door/windows respectively. The roof/floor is costly by 7.86% over the conventional roof slab. As such no economy has been achieved in the overall cost of the building.

4.2.3 REDUCTION IN CONSTRUCTION TIME :

Originally D.D.A. assured to Hindustan Prefab Limited to give construction work of 10,000 dwelling units with an initial lot 1952 units. The Hindustan Prefab Limited, planned for their equipment etc. considering the total size of the scheme. The first phase was estimated to be completed in three years time. however, the construction agency proposed to complete the work in one and half years with their prefab techniques. The DDA had to supply cement and steel for the construction but the work was suspended due to delay in supply of cement and steel. This resulted in late completion of the project and the project took two years.

4.2.4 SKILLED LABOUR REQUIREMENT:

The large size perecast roofing differs significantly from that of conventional cast-in-situ RC slab construction. The skilled and unskilled man-power requirements also very in trade and skill. The skilled labour requirement of mason and bar binder as well as labourer is substantially less, compared to conventional R.C. slabs. However, additional labour component of welder fitter and crane operator is essentially required.

COST ECONOMY TABLE, EWS HOUSING ROHINI, DELHI.

Items/elements	Cost of conventional elements(Rs)	Cost of alternative elements(Rs)	Elemental saving(%)	Cost Economy(%)
Foundation	2484	2360	4.99	0.34
Walls	6372	6372	-	-
Roof	9720	10484	-7.86	-2.11
Flooring	1692	1692	-	-
Doors/Windows	6840	6200	9.35	3.77
Finishing	2772	2772	-	-
External Services	6120	6120	-	-
Total	Rs. 36000	Rs. 36000	-	-

Source : HINDUSTAN PRE-FAB, DELHI

4.2.5 MECHANISATION:

The Hindustan Prefab Limited employed a higher degree of mechanisation for the pre-fabricated building components used in construction. Steel mouldes of precise dimensions were used for casting of components. Transportaion of components from casting yard to construction place and their hoisting made use of trolleys, tractors and cranes. The system required high capital investment in equipment and machines and a large establishment.

4.2.6 MAINTENANCE:

The components produced with the techniques were of excellent quality. Due to fewer number of joints restricted to only over the supporting walls give minimum problem of maintenance.

4.2.7 FLEXIBILITY OF THE SYSTEM:

The components are cast as per the specific size of individual space/enclosure. The components produced are suitable for the very particular design and may not be possible to use for different planning options. The system gives a poor planning flexibility.

4.2.8 APPEARANCE AND AESTHETICS:

The techniques give a plain ceiling with a better finish than other manual techniques and conventional construction. No plastering on ceiling is required.

PERFORMANCE:

RESISTANCE TO IMPACT NOISE:

The roofing technique gives INR of 16 db equal to conventional RCC roof slab.

RAIN PENETRATION:

Better quality achieved through mechanised production of components with joints only coming supporting walls gave no problem of rain penetration.

4.2.9 SUITABILITY OF ALTERNATIVE TECHNIQUES:

AFFORDABILITY:

The actual cost of construction is much higher than the ceiling price recommended by HUDCO. The cost of construction is beyond the reach of EWS and highly unaffordable, the scheme is not suitable for EWS.

SOCIAL ACCEPTABILITY:

By all standards the components with alternative construction techniques are of very high quality but costly. The technique is failed in achieving the objective of economical housing for EWS.

AVAILABILITY OF COMPONENTS:

The components are not readly available, these are fabricated at site with mechanised process. They do not meet the requiremement of availability of components due to their large size and machanisation involve at high cost.

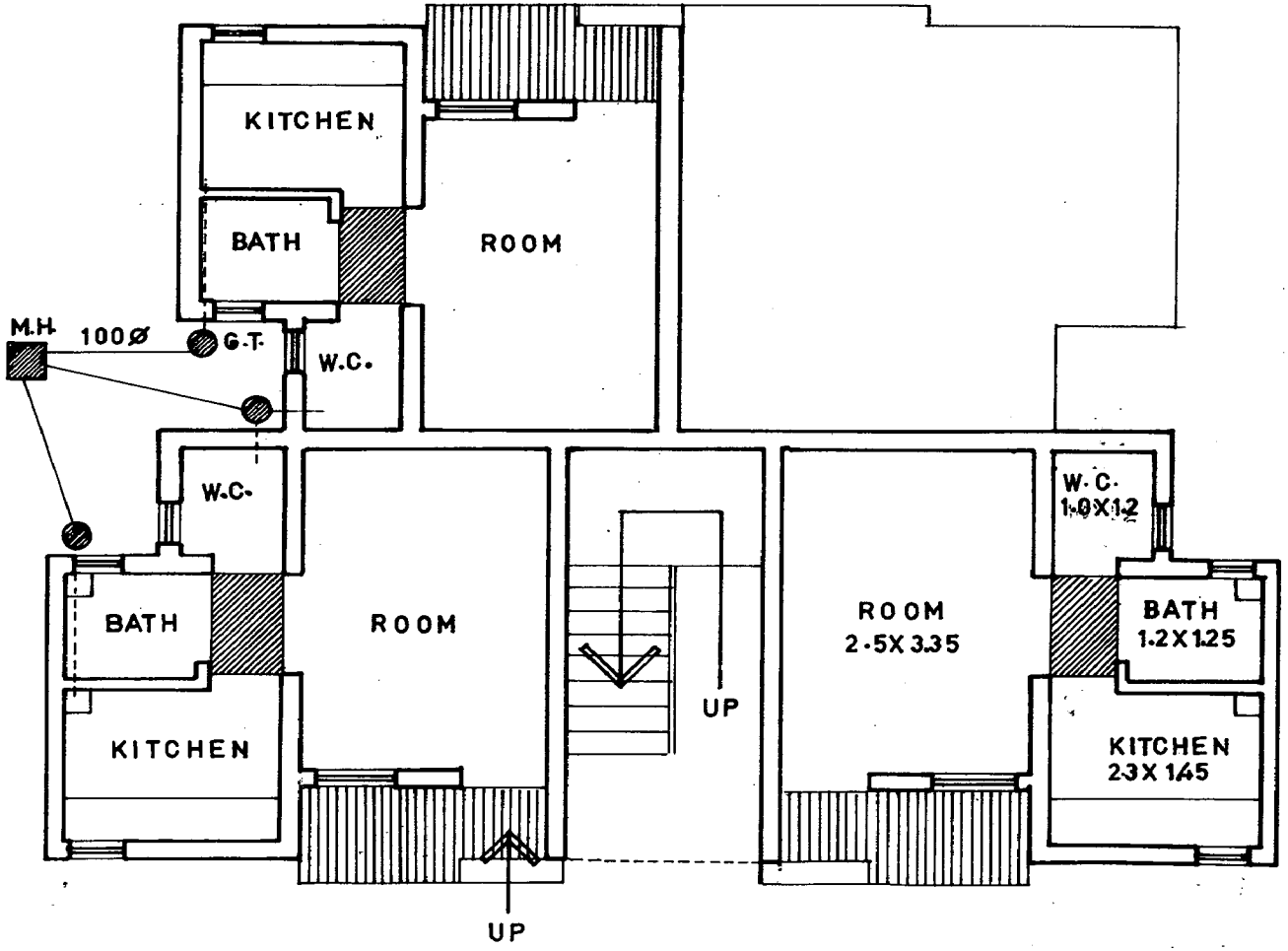
EASE OF CONSTRUCTION:

The production and assembly of components requires machanisation and high skilled supervision. The technique to unsuitable for easy and simple construction.

DURABILITY:

The components are highly durable as they are produced from durable materials and with machnised process. Such a high degree of durability is not essential requirement of EWS housing.

GROUND FLOOR PLAN



NOTE

WINDOWSARE 230MM FROM WALL JUNCTION

STAIR W.— 100 CM
T.— 25
R.— 20

E.W.S. HOUSING AT VIRBHADRA

CASE STUDY -3

4.3 E.W.S. HOUSING AT VIRBHADRA, RISHIKESH (U.P.)

This E.W.S. housing was taken of by U.P. Housing and Development Board, Meerut (U.P.) to provide houses for economically weaker sections in semi-hilly areas of Rishikesh. It was decided by the U.P.H.D.B. to make houses with the help of local materials and alternative techniques to save in the cost by saving transportation charges as well as being cheaper than the materials arranged from other far off places.

With this in view, the U.P.H.D.B., Meerut approached the C.B.R.I., Roorkee to suggest use of local materials along with other economical specifications so as to restrict the cost of project to the minimum possible.

The construction of these units was completed in 1990. It took one year to complete the construction. This plots sizes for E.W.S. are 25 and 40 sq. m. and plinth areas are 15 and 18 sq.m. respectively.

The total cost of construction of a dwelling unit is 27,175.

4.3.1 CONSTRUCTION FEATURES

Important features of the construction are :

FOUNDATION

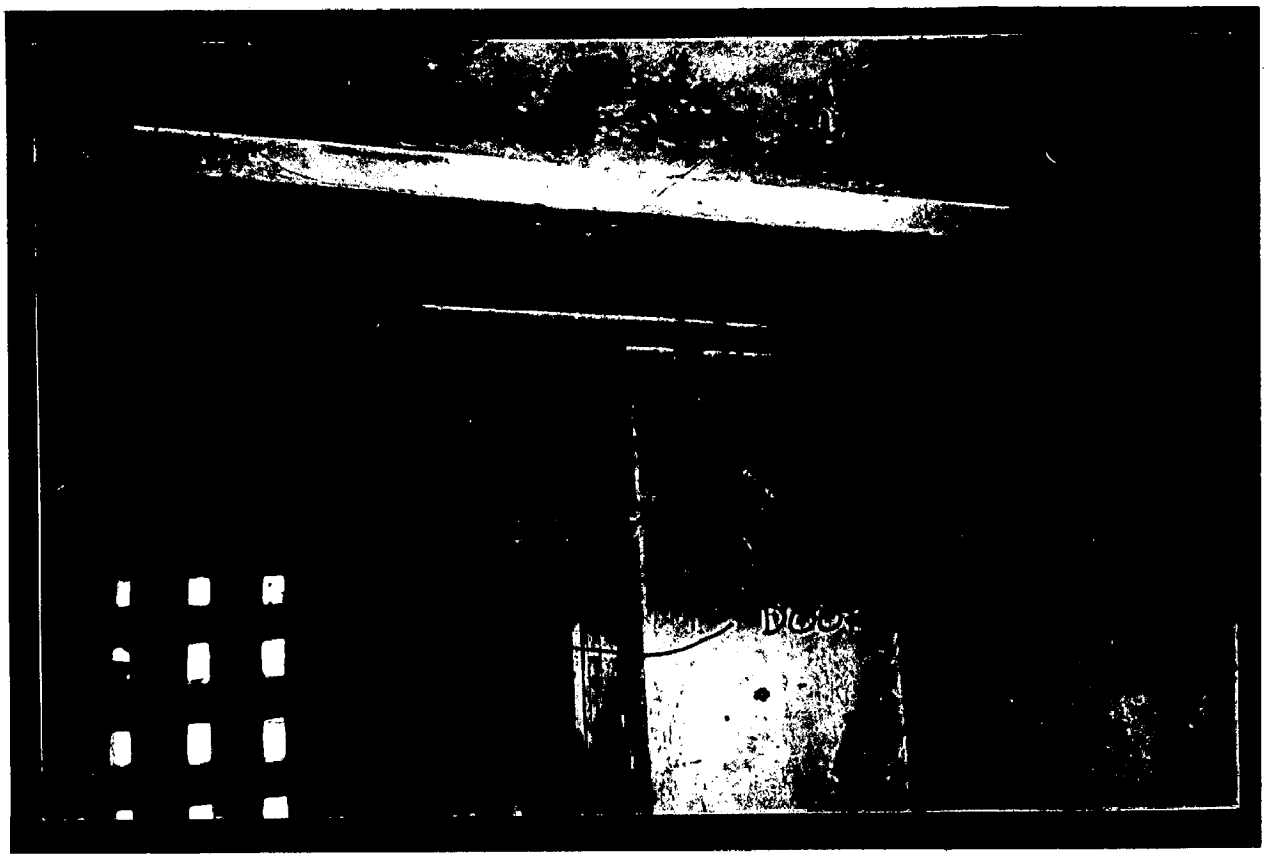
Strip foundation of R.R. masonry block, depth of the foundation is 45 cm below the ground level for load bearing walls and 30 cm below the ground for non load bearing walls. The foundation concrete is provided 1:5:10 with 40 mm aggregate.

D.P.C.

18 mm thick cement plaster is provided in 1:4 cement and coarse sand with water proofing compound and covered by 2 coats of hot bitumen at a rate of 1.7 kg/ sq.m.

WALLING

10 cm thick staggered stone masonry block are used in walling in cement sand



INTERIOR VIEW OF E.W.S. UNIT

mortar 1:6 with 20 cm x 20 cm columns at intervals.

In this system of wall construction, following things are reduced - consumption of Stone block, mortar and labour time.

LINTELS

Pre fabricated thin R.C.C. Lintel-cum chajjas are used over the openings.

ROOF

Pre fabricated brick panel roof covered with 30 mm screed concrete 1:2:4 with cement:coarse sand: 12 mm stone aggregate.

DOOR/WINDOWS

Angle/Tee iron frame fixed with appropriate hold fasts in cement concrete. Blocks embedded in jambs. Shatters of seasoned country wood.

For windows brick jali is used.

PLASTERING/POINTING

12 mm thick 1:2:9 (cement:lime:sand or 1:6 (cement:sand) Plaster.cement pointing 1:1/s:4.5 composite mortar or cement sand mortar (1:3) are used.

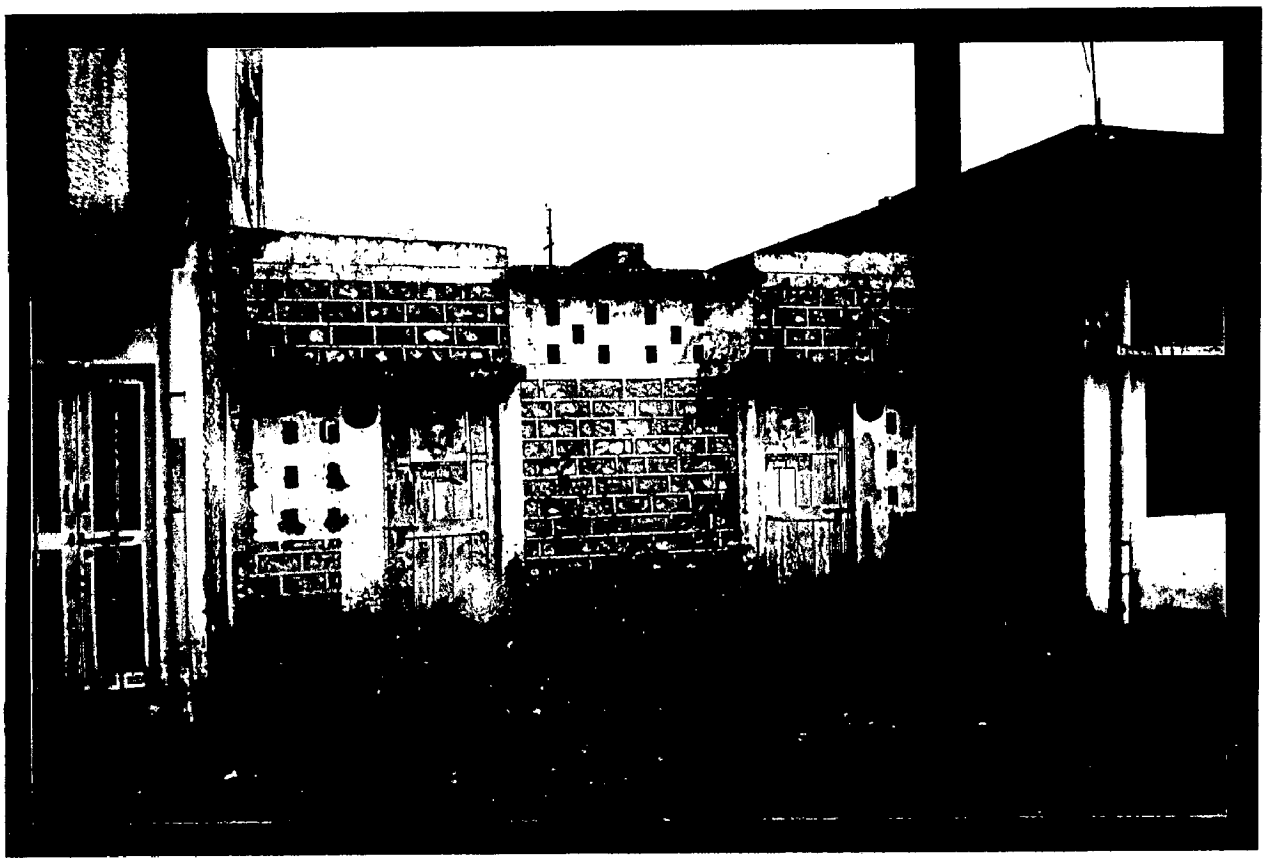
balance items of work like painting, W.wash/colour wash etc. as per traditional practice.

ASSESSMENT OF CASE STUDY

4.3 COST ECONOMY

The economy achieved in this project after the construction of 468 houses of two categories.

In following places economy is achieved.



VIEW SHOWING THE INCREMENTAL GROWTH

Items/elements	Conventional	Alternative techniques
Foundation	75 x 90 cm	45 x 75 cm
Walls	23 cm brick wall	10 cm thick staggered
Windows	timber frame and panels	brick jali
Roof	11.5 cm thick RCC	Brick panels 75 mm thick

Comparison of cost of 23 cm thick brick wall in cement sand mortar 1:6 with stone masonry block walling in cement sand mortar 1:6.

Type of walling		Cost/sq.m. of wall
(i)	23 cm brick wall in cement sand mortar 1:6	Rs. 139.38
(ii)	20 cm stone masonry block walling in cement sand mortar 1:6	Rs. 97.70
(iii)	Staggered stone masonry block walling in cement in cement sand mortar 1:6(10 cm thick wall with 20 cm columns at intervals)	Rs. 61.34
(iv)	Staggered brick wall in cement sand mortar 1:4	Rs. 86.65

Comparison of cost has been worked out on the basis of a full length wall in a house actually constructed at site.

VIEW OF CLUSTER SPACE

COST ECONOMY TABLE : E.W.S. HOUSING, RISHIKESH, U.P.

Item/element	Cost of conventional elements(Rs)	Cost of alternative elements(Rs)	Cost Economy
Walling	3438.11	1964.20	42.86 %
Roof	197.32	154.64	21.60 %
Door/Windows	-	-	30 %

Source : C.B.R.I., ROORKEE

Overall saving: 30 % per house in comparison to conventional system.

SKILLED LABOUR REQUIREMENT :

The skill labour available in the market has no experience of working with precast components. But as the technique are simple, the available skilled labour with some initial training and constant supervision did the work of fabricating, handling and assembling of these components efficiency without difficulty.

4.3.4 MECHANISATION

The techniques which are used in Rishikesh is very simple and requires simple tools. All other operations include handling and hoisting of componnts in position were done manually.

MAINTENANCE

The materials, techniques of walling and roofing are used as per buildings code hence satisfy structural requirements.

4.3.6 FLEXIBILITY OF THE SYSTEM

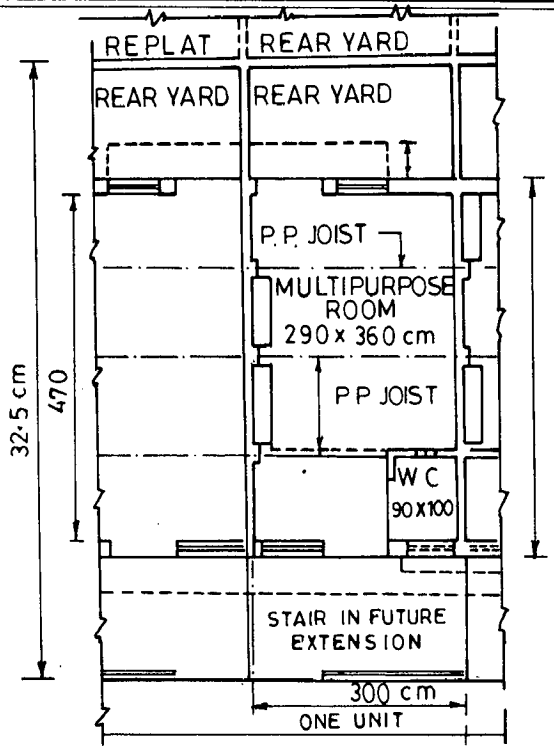
The adopted system offers adequate planning, flexibility in roofing, walling and incremental growth.

4.3.7 APPEARANCE OF AESTHETICS

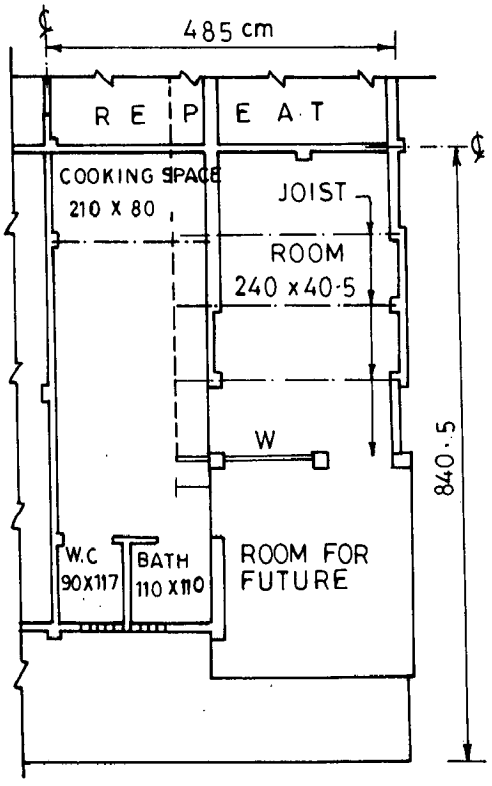
Natural texture of stone, projected P.P. Joist give an appearance of aesthetics.

4.3.8 THERMAL PERFORMANCE

Thermal performance index (TTI) of fabricated panels for roof is 143 against 116 db of R.B. roof.



TYPE 15/25 S



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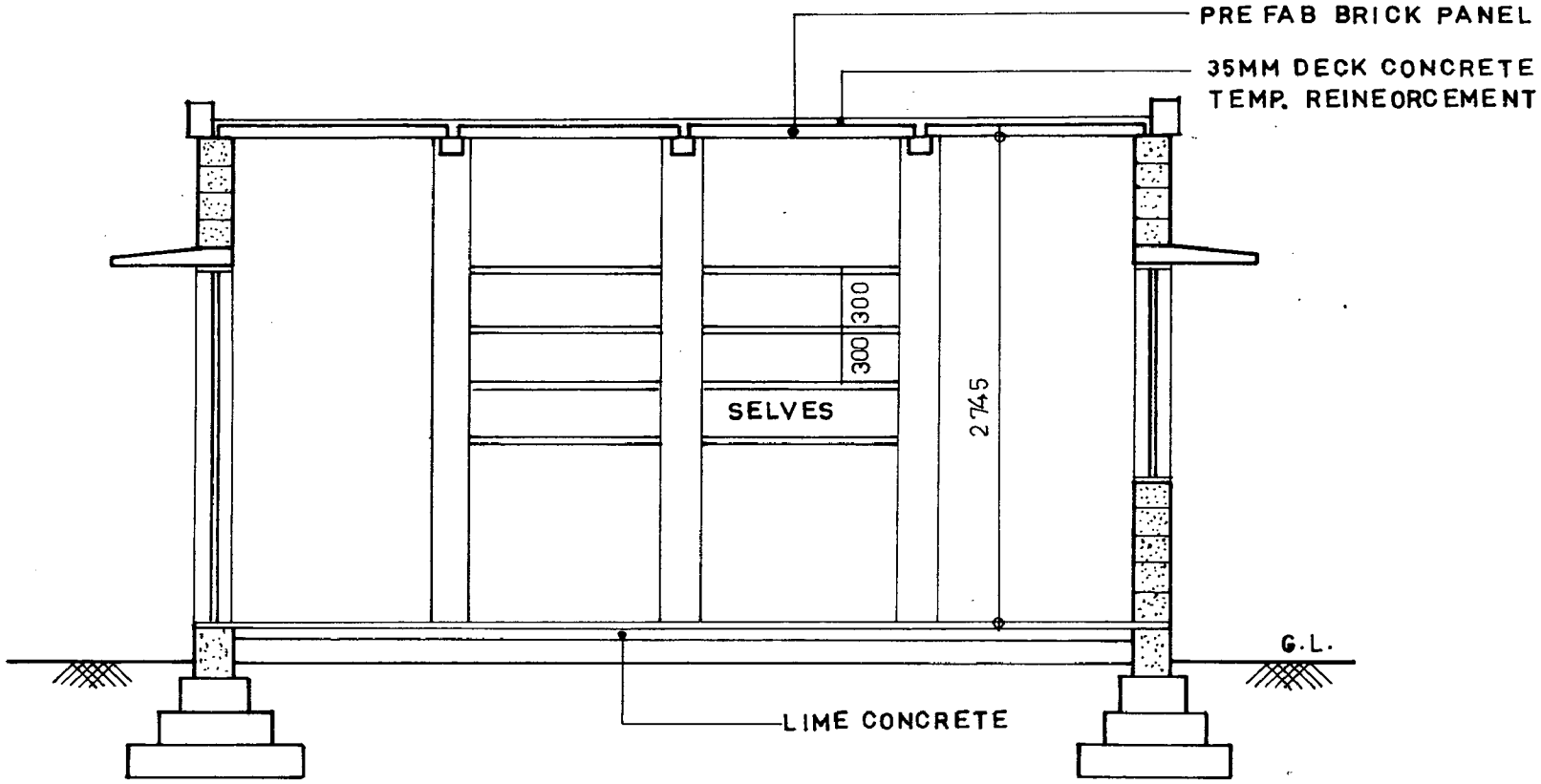

PRE FAB BRICK PANEL
35MM DECK CONCRETE
TEMP. REINEORCEMENT
300
300
SELVES
2745
G.L.
LIME CONCRETE

SECTION A A

4.4 CASE STUDY- 4

DEMOSTRATED L.I.G. UNITS AT INDIRA NAGAR, LUCKNOW

This demostrated L.I.G. units was designed and constructed by U.P. Housing and Development Board, Lucknow (U.P.).

The main aim of this demostrated unit is to provide economical house of low income group of U.P.

The construction of these units was completed in 1990. The plot size for L.I.G. was 60 sq.mt. and plinth area 29 sq.mt. The total cost of a dwelling unit was 92,000.

4.4.1 CONSTRUCTION FEATURES

Important construction features of the demostrated L.I.G. units are

FOUNDATION

Conventional foundation of burnt brick, depth of the foundation is 90 cm below the ground level. For all Load beasing walls foundation concrete is provided 1:5:10 with 40 mm aggregate in this system of foundation constrution no-economy is achived in neitherin materal nor in contruction techniques.

D.P.C.:

18 mm thick cement plaster is provided in 1:4 (1 cement : 4 sand) with water proofing compound and covered by 2 coats of hot bitumen at a rate of 2 kg/sq.mt.

WALLING :

23cm thick all load bearing walls and 4-inch partition wall in W.C. & bath room are used in walling in cement sand mortar of 1:6.

No economy is achived in wall construction neither in material nor in labour time.

LINTELS :

Cost-in-situ lintels over doors & windows is used.

ROOF :

Pre-fabricated R.C.C. planks of 115.0 x 30.0 cm supported over 23 cm thick walls and pre-cast R.C.C. beams of 15.0 x 20.0 cm is used and covered with 45mm dec concrete.

DOOR/WINDOWS:

All main doors, W.C. and bath room doors are of Ferro-cement concrete. For windows-bricks jali is used.

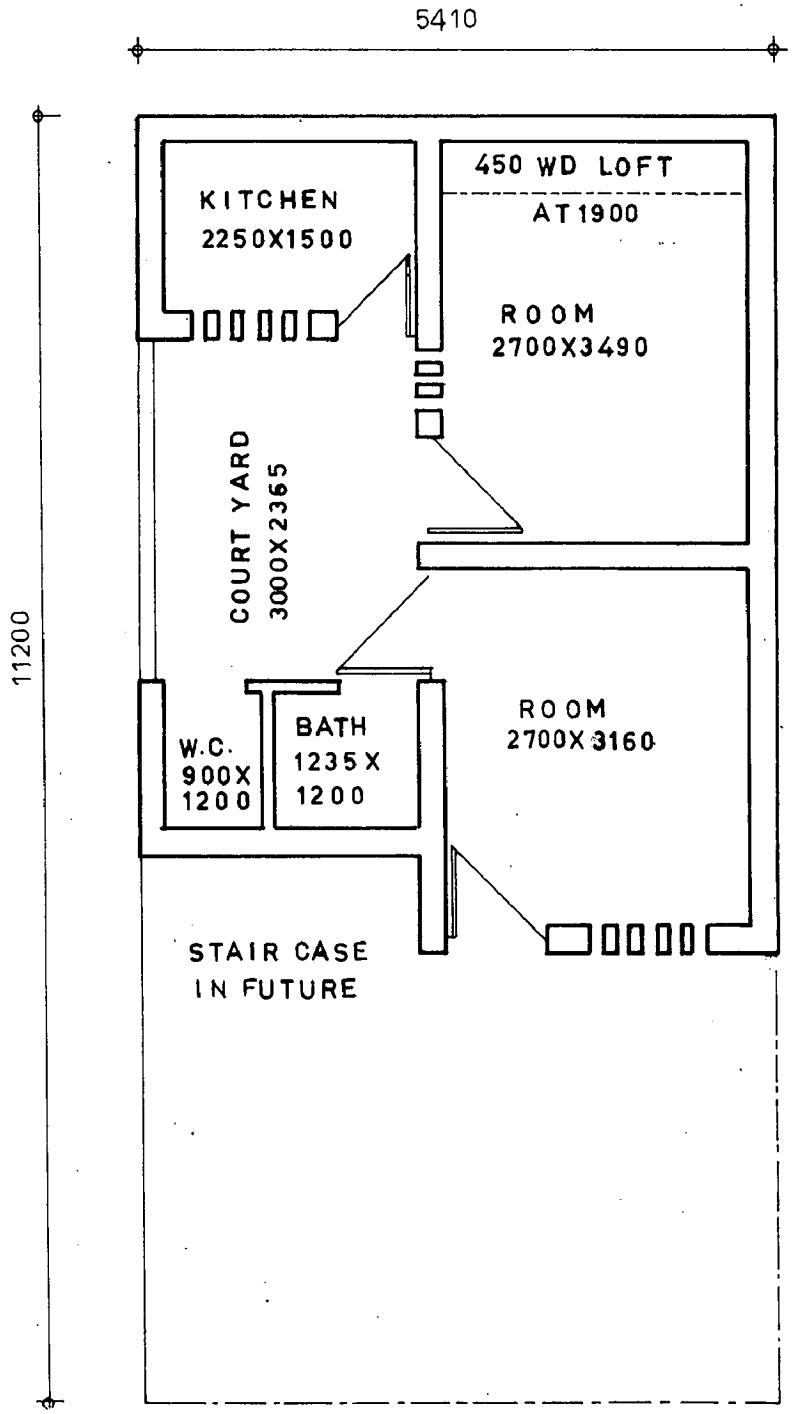
12 mm thick plaster is used balance. Items of work like painting White washing/ colour wash etc as per traditional way.

4.4.2 ASSESSMENT OF CASE-STUDY

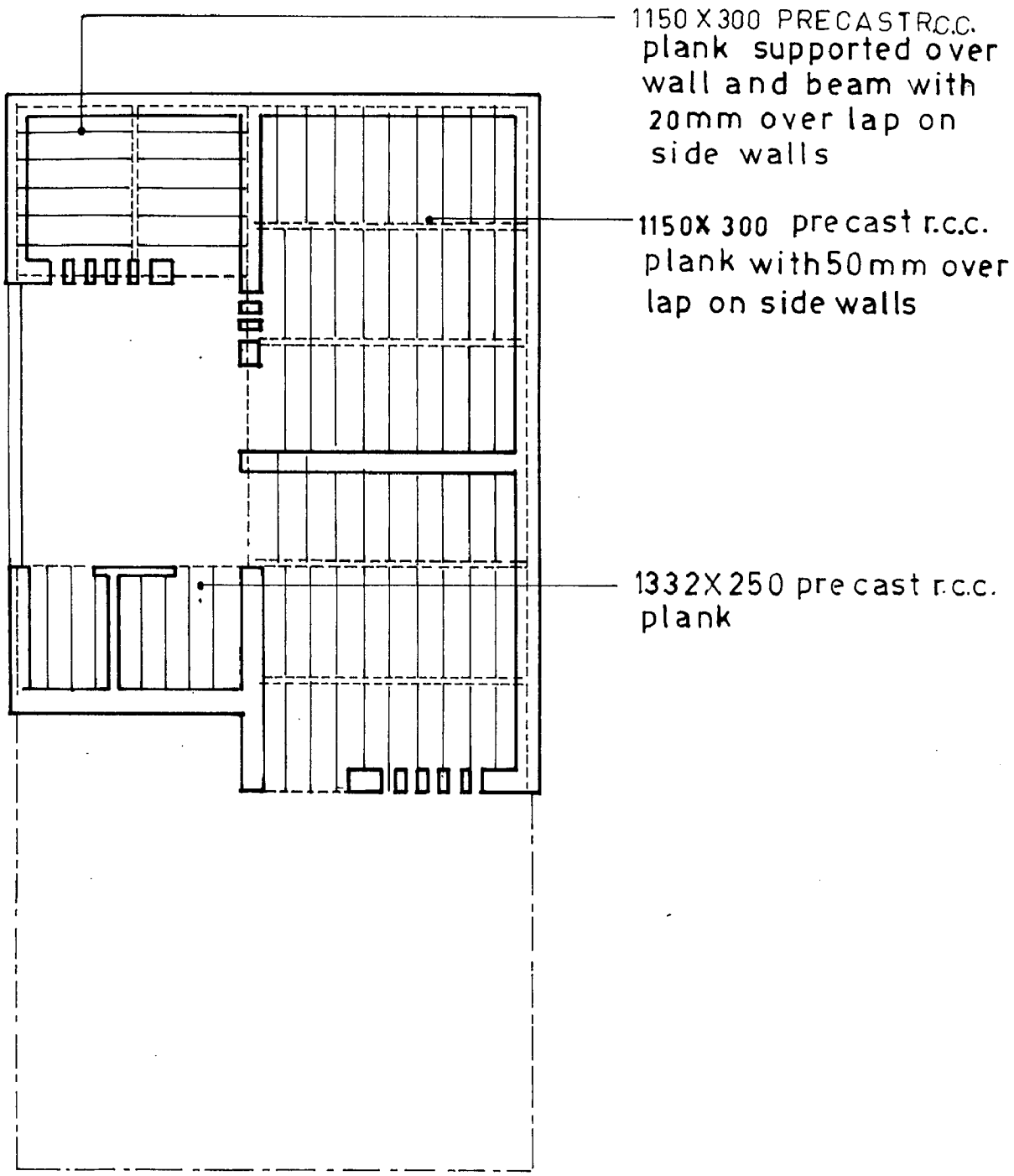
COST ECONOMY

Over all saving is 30% per housing in compare to conventional system in following place economy is achieved.

Elements/Item	Conventional	Alternate
1. Doors/window	Timber frame	Brick jali and ferro cement shutters
2. Roofs	11.5 cm thick	Pre-fabricated planks & joist system R.C.C. slab


5410
11200
KITCHEN
2250X1500
450 WD LOFT
AT 1900
ROOM
2700X3490
COURT YARD
3000X2365
W.C.
900X
1200
BATH
1235 X
1200
ROOM
2700X 3160
STAIR CASE
IN FUTURE

G. F. PLAN



L.I.G. TYPE 29/60

ROOFING PLAN

CHAPTER 5

COST ANALYSIS OF MATERIALS AND TECHNIQUES

NOTE : Taking cost of all materials as per U.P.P.W.P. 1996 Schedule of Rates of Lucknow Zones

5.1 DIFFERENT TYPES OF BLOCKS

(A) FOR PRECAST OVER BURNT BRICK (O.B.B.) BALLAST MASONRY BLOCK

Taking size 30 x 20 x 15 cm.

MIX 1:5:8

(A) MOULD (Gang mould of 6 Nos.)

(i) Materials :

* M.S. Angle (35 x 35 x 6 mm)

  4.5 mt. @ Rs. 3 kg/mt = 13.5 kg @ Rs. 18.00/kg = Rs. 243.00

* M.S. Plate (4 mm thick)

  0.85 mt^2 @ Rs. 31.4 kg/mt^2 = 26.6 kg. @ Rs. 17.00/kg. = Rs. 452.20

* 12 mm dia bolts (3 cm long) = 8 Nos @ Rs. 1.50/bolt = Rs. 12.00

(ii) Labour

* Fitter	1.5 m. days	@ Rs. 60	= Rs. 90.00
* Welder	1 m. days	@ Rs. 60	= Rs. 60.00
* Helper	3 m. days	@ Rs. 45.00	= Rs. 135.00

Taking the consideration of that one mould can be used 500 times.

HENCE COST OF MOULD PER 100 BLOCKS = (100 x 992.2)/(6 x 500)

= Rs. 33.00

(B) CASTING OF BLOCKS (taking 100 Nos.)

(i) Materials :

* Cement	1.55 bags	@ Rs. 135/bag	= Rs. 209.25
* Sand	0.28 mt^3	@ Rs. 115/cu.m.	= Rs. 32.20
* Brick Ballast	0.81 mt^3	@ Rs. 200/cu.m	= Rs. 162.00
			Rs. 403.45

(ii) Labour

* Mason	0.30 m. days @ Rs. 90	= Rs. 27.00
* Unskilled Labour	2.12 m. days @ Rs. 43.00	= Rs. 91.16

(C) SUNDRIES :

Cost of casting platform and mould oil etc.

L.S.	= Rs. 10.00
Cost of mould	= Rs. 433.00
	Rs. 564.60

∴ COST OF EACH BLOCK = Rs. 5.64 say Rs. 5.65

(B) FOR PRECAST BRICK BALLAST (OVERBURNT BRICK) MASONRY BLOCK

Size 30 x 10 x 15 cm

MIX 1:5:8

(A) MOULD (Taking Gang mould of 6 Nos.)

(i) Materials :

* M.S. Angle 35 x 35 x 6 mm = 4.15 mt. @ 3 kg/m = 12.45 kg @ Rs. 18/kg
  = Rs. 224.10

* M.S. plate 4 mm thick = 0.45 m^2 @ 31.4 kg/m^2 = 14.13 kg @ Rs. 17/kg
  = Rs. 240.21

* 12 mm dia m.s. bolts, 3 cm long = 8 Nos @ Rs. 1.5/bolt = Rs. 12.00

(ii) Labour

*	Fitter	1.1 m. days	@ Rs. 60	= Rs. 66.00
*	Welder	1 m. days	@ Rs. 60	= Rs. 60.00
*	Helper	2 m. days	@ Rs. 45	= Rs. 90.00
				Rs.692.31

Let us assume that one mould can be used 500 times

THE COST OF MOULD PER 100 BLOCKS = (100 x 692.31)/(6 x 500)

= Rs. 23.00

(B) CASTING OF BLOCKS (Taking 100 Nos.)

(i) Materials:

*	Cement	0.78 bags	@ Rs. 135/bag	= Rs. 105.30
*	Sand	0.15 cu.m.	@ Rs. 115/cu.m.	= Rs. 17.25
*	Brick ballast	0.38 cu.m.	@ Rs. 200/cu.m.	= Rs. 76.00
				Rs.198.55

(ii) Labour

*	Mason	0.2 m. days	@ Rs. 90	= Rs. 18.00
*	Unskilled Labour	1.4 m. days	@ Rs. 43	= Rs. 60.20

(C) SUNDRIES

*	Cost of casting platform and mould oil etc.	L.S.	= Rs. 10.00
*	Cost of mould used		= Rs. 23.00

∴ COST OF EACH BLOCK = Rs. 3.00

5.2 ANALYSIS OF RATE FOR DIFFERENT TYPES OF MORTAR MIX

(A) CEMENT MORTAR OF 1:6 FOR 1 CU. M.

(i) Material :

*	Cement	5 bags	@ Rs. 135/bag	= Rs. 675.00
*	Finesand	1.07 m^3	@ Rs. 115/cu.m.	= Rs. 123.05
*	Hire and Running Charges of mixture		L.S.	= Rs. 5.00
*	Sundries		L.S.	= Rs. 10.00

Rs. 805.00/cu.m.

COST/CU.M OF MORTAR = Rs. 805.00

(B) MASONRY CEMENT MORTAR (Dry) OF 1:4 (M. Cement : Sand) FOR 1 CU.M.

Materials

Masonry cement	= 4.2 bags	@ Rs. 135	=	567.00
Sand	= 0.8 Cu.m.	@ Rs. 115/cu.m.	=	92.25
Mixing and Hire charges of				
Mixer		L.S.	=	5.00
Sundries		L.S.	=	10.00

COST/CU.M OF CEMENT SAND MORTAR Rs. 674.00/cu.m.

(C) LIME, SURKHI AND SAND MORTAR OF 1:1:1 FOR 1CU.M.

Materials

Lime	3.1 Quintel	@ Rs. 150	=	465.00
Surkhi	0.475 cu.m.	@ Rs. 300	=	142.50
Sand	0.475 cu.m.	@ Rs. 115	=	54.60
Hire & running charges of mixture	L.S.		=	5.00
Sundries			=	10.00
COST/CU.M OF MORTAR (1:1:1)			=	677.10

(D) LIME SURKHI MORTAR OF 1:2 FOR 1 CU.M.

Materials

Lime 3.1 Quintel	@ Rs. 150	=	465.00
Surkhi 0.95 cu.m	@ Rs. 300 /cu.m..	=	265.00
Hire & running charges of mixture		=	5.00
Sundries		=	10.00
COST /CU.M. OF MORTAR		=	765.00

TABLE

COMPARATIVE COST OF VARIOUS MORTAR FOR 1 CU.M. MORTAR*

			Cost /cu.m (Rs.)			
Material	Bulk Density kg/cu.mt.	Rate Rs./tonne	Cement:sand (1:6)	Masonry cement: sand (1:4)	Lime:Surkhi 1:2)	Lime : Surkhi: Sand (1:1:1)
Portland	1450	2700	813			
Hydrated lime	720	1500		674		
Sand	1200	96			765	
Masonry Cement	1050	1600				677

BASIS : Equal strength of all mixture and reactivity strength of 40 kg/cm2.

5.3 ANALYSIS OF RATES FOR DIFFERENT TYPES OF FOUNDATION

ANALYSIS OF RATE FOR BRICKWORK IN FOUNDATION

Taking 1 cu.m. masonry work and mortar of 1: 6

(i) Materials :

Bricks (Ist class)	494 Nos.	@ Rs. 1.40/brick	= Rs. 691.60
Mortar	0.25 cu.m.	@ Rs. 800/cu.m	= Rs. 200.00

(ii) Labour

mason	0.70 m. days	@ Rs. 90	= Rs. 63.00
U.S. Labour	1.5 m. days	@ Rs. 45	= Rs. 67.50

COST RUNNING/CU.M. = Rs. 1022.10

ANALYSIS OF RATE FOR BASE CONCRETE

Taking 15 cm thick base concrete of 1:6:12.

(i) Materials

cement	2.2 bags	@ Rs. 135/bag	= Rs. 297.00
Sand	0.47 cu.m.	@ Rs. 115/cu.m.	= Rs. 54.05
Brick aggregate	0.89 cu.m.	@ Rs. 200/cu.m.	= Rs. 178.00

(ii) Labour	Skilled	0.1 m. days	@ Rs. 90	= Rs. 9.00
	U.S.	1.77 m. days	@ Rs. 43	= Rs. 76.11

∴ COST /CU.M = Rs. 614.16 say Rs. 614 /cu.m.

A. SIZE OF FOUNDATION 90 x 90 cm and plinth height 30 cm

Taking mortar 1:6 and length of foundation = 1 mt.

(i) Material

Quantity of base concrete = 0.14 cu.m. @ Rs. 614/cu.m. = Rs. 82.90

Quantity in brick work upto plinth level

= 0.41 cu.m. @ Rs. 1022.10 /cu.m. = Rs. 419.00

TOTAL COST OF FOUNDATION/ MT. LENGTH = Rs. 501.90

B. SIZE OF FOUNDATION75 X 75 CM

(i) Materials:

Quantity of base concrete

= 0.75 x 1.0 x 0.15 = 0.11 cu.m. @ Rs. 614/cu.m. = Rs. 69.00

Quantity of brick work upto plinth level

= 0.31 cu.m. @ Rs. 1022.10 /cu.m. = Rs. 316.85

TOTAL COST OF FOUNDATION PER MT. LENGTH = Rs. 385.85

C. FOUNDATION SIZE : 60 X 60 CM

(i) materials :

Quantity of base concrete = 0.60 x 1.0 x 0.15 = 0.09 cu.m

= 0.09 cu.m.@ Rs. 614/cu.m. = Rs. 55.26

Quantity of brick work upto plinth level = 0.22 cu.m.@ Rs.1022.10/cu.m.

= Rs. 246.86

TOTAL COST OF FOUNDATION PER MT. LENGTH = RS. 302.12

Table

Comparison of Cost of Foundation

S.No.	Size of foundation (cm)	Cost per mt. length (Rs.)
1	60 x 60	302.12
2.	75 x 75	385.85
3.	90 x 90	501.90

As is clear, the saving of 40% in foundation only on adopting 60 x 60 cm size of foundation in comparison to conventional 90 x 90 cm foundaion.

5.4 ANALYSIS OF RATES FOR DIFFERENT TYPES OF WALL

TAKING WALL AREA 1 SQ.MT.

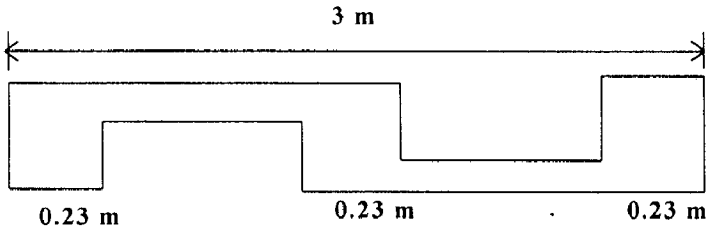
A. 23 CM THICK WALL WITH 1:6 MORTAR

Quantity of brickwork = 0.23 cu.m.@ Rs. 1147.00/cu.m = Rs. 263.81/sq.m.
in superstructure

B. TAKING 19 CM THICK BRICK MASONRY WALL

Quantity of brickwork in superstructure for 1 sq.m. area
= 0.19 cu.m.@ Rs. 1147.00/cu.m. = Rs. 217.93/sq.m.

C. STAGGERED WALL OF 11.5 CM THICKNESS



Taking wall of size 3m x 3m = 9 sq. m.

Quantity of brickwork = 2.31 x 0.115 x 3.00 = 0.80 cu.m.
3 x 0.23 x 0.23 x 3.00 = 0.48 cu.m.

1.28 cu.m

1.28 cu.m. @ Rs. 1171.00/cu.m. = Rs. 1498.88

COST/SQ. MT. = (1498.88)/(9) = RS. 166.54/SQ. MT.

D. 20 CM THICK WALL WITH 1;6 CEMENT SAND MORTAR OF PRE CAST BRICK BALLAST BLOCK MASONRY IN SUPER STRUCTURE

Taking 10 sq. m. wall area

(i) Materials :

Precast brick ballast blocks = 222 Nos. @ Rs. 5.65/block = Rs. 1254.30

Mortar 1:6 (Cement:sand) 0.20 sq. m @ Rs. 800/cu.m. = Rs. 160.00

(ii) Labour

Mason 1.50 m. days @ Rs. 90 = Rs. 135.00

U.S. 3.10 m. days @ Rs. 43 = Rs. 133.30

Add 10 % for contractor profit and overheads = 168.00

THEREFORE COST/SQ.M. FOR 20 CM THICK WALL = 185.00

E. COST OF WALLING OF 10 CM. THICK PRECAST BRICK BALLAST BLOCK WITH 1:6 IN SUPER STRUCTURE

Size = 30 x 10 x 15

Taking 10 sq. m. area

(i) Materials :

Brick ballast blocks = 222 Nos. @ Rs. 3 /block = Rs. 666.00

Mortar 1:6 = 0.10 cu.m.@ Rs. 800/cu.m. = Rs. 80.00

(ii) Labour

mason 1 m. days @ Rs. 90 = Rs. 90.00

U.S. 2 m. days @ Rs. 43 = Rs. 86.00

Add 10 % contractor profit + overheads = Rs. 92.00

COST /SQ.M. FOR 10 CM. THICK WALL = Rs. 101.40

Taking staggered wall of size 3 m x 1.2 m = 3.6 sq.m.

Quantity of work = 3.0 x 1.2 + 0.2 x 1.2 x 3 = 4.32 sq.m.

Cost = 4.32 sq.m. @ Rs. 101.40 = Rs. 438.00

HENCE COST/SQ.M. = 438/3.6 = 121.68

F. RAT TRAP BOND WALLING

Taking 23 cm. thickness of wall and mortar 1:5 and wall area 1m x 1m

(i) Materials :

Cement	= 7.2 kg	@ Rs. 2.7/kg	= Rs. 19.45
Sand	= 0.03 cu.m.	@ Rs. 115/cu.m	= Rs. 3.45
Bricks	= 90 Nos.	@ Rs. 1.90/brick	= 126.00

(ii) Labour

Mason	0.46 m. days	@ Rs. 90	= Rs. 41.40
Majdoor	0.23 m. days	@ Rs. 45	= Rs. 10.35
U.S.	0.23 m. days	@ Rs. 43	= Rs. 9.90
			Rs. 210.55

COST OF BRICK WORK/SQ. M. = Rs. 210.55

TABLE

COMPARISON OF COST OF 23CM THICK BRICKS WALL IN 1:6 CEMENT MORTAR WITH O.B.B. BLCOK AND OTHER TYPES OF WALL.

S No.	Type of walling	Cost/m^2 of wall (Rs.)
1.	23cm brick wall in 1:6 mortar	263.81
2.	19cm thick wall in 1:6 mortar	217.93
3.	23cm thick rat-trap bond wall in 1:5 mortar	210.55
4.	20 cm thick (O.B.B.) block wall in 1:6 mortar	185.00
5.	10 cm thick (O.B.B.) block wall in 1:6 mortar	121.68
6.	11.5cm thick brick staggered wall in 1:4	166.54

5.5 RATE OF ANALYSIS FOR DIFFERENT TYPES OF ROOFS

A R.C.C. ROOF :

Taking 10 cm thick slab

M15 grade concrete

Cost of R.C.C. slab/sq.m = 0.1 cu.m @ 2677.00/cu.m = Rs. 267.70

Reinforcement taking 1% of R.C.C, i.e 7.85 kg @ Rs. 16/kg = Rs. 125.60

Rs. 393.30

Based on rates as per U.P.P.W.D. 1996 schedule of rates.

B R.B.C. ROOF :

Taking thickness of slab 11.5 cm. Conc : M15

The cost of material for 1 sq. m.

(i) Materials

*	Bricks	35 NOS	@ Rs. 1.40 /brick	= Rs. 49.00
*	Cement	0.30 bags	@ Rs. 135/bag	= Rs. 40.50
*	Coarse sand	0.02 cu.m	@ Rs. 425/cu.m	= Rs. 8.50
*	Fine sand	0.04 cu.m.	@ Rs. 115/cu.m	= Rs. 4.60
*	Steel	0.7% of cubical content	= 0.7 x 78.5 x 0.115 kg/sq.m	
			= 6.3 kg/sq.m @ Rs. 16/kg	= Rs. 100.80

(ii) Labour

*	Skilled	0.11 m. days	@ Rs. 90	= 9.90
*	Barbender	0.05 m. days	@ Rs. 45	= Rs. 2.25
*	U.S.	0.28 m. days	@ Rs. 43	= Rs. 12.00

(iii) Shuttering	Rs. 80/sq.m.	= Rs. 80.00
Sundries	Rs. 1/sq.m.	= Rs. 1.00

COST /SQ.M. Rs. 308.59

C R.C.C. PLANK AND JOIST ROOF :

A. MOULDS

(A) Precast R.C. Plank (1.5m x 0.3 m x 0.06 m)

Wooden Mould

(i) Materials :

Timber (Deodar)	= 0.016 cu.m.	@ Rs. 2400/cu.m	= Rs. 38.40
M.S. tie rods 10mm dia	50 cm long with washer and nut		= 2 Nos
		@ Rs. 1.5/nut	= Rs. 3.00
7.5 c. hinges	= 4 Nos.	@ Rs. 2.0 each	= Rs. 8.00
Sundries for nails	= Rs. 5.00		

(ii) Labour

Carpenter	1 m. days	@ Rs. 85	= Rs. 85.00
Majdoor	1 m. days	@ Rs. 45	= Rs. 45.00

NOTE : 1 mould can be used for 60 castings.

COST OF MOULD PER PLANK = Rs. 184.40/60 = Rs. 3.00

(B) CASTINGS OF COMPONENTS :

(A) Taking R.C. Plank (150 x 30 x 6 cu.m.) Conc : M15 grade

(i) Materials :

Cement	6.95 kg	@ Rs. 2.7/kg	= Rs. 18.76
Coarse sand	0.0093 cu.m.	@ Rs. 425/cu.m.	= Rs. 4.00
Stone aggregate 10mm gauge	= 0.0186 cu.m	@ Rs. 600/cu.m.	= Rs. 11.16
Reinforcement 6 mm dia	1.54 kg.	@ Rs. 16/kg	= Rs. 24.64
G.I. Binding wire 24 gauge	0.012 kg	@ Rs. 25/kg	= Rs. 0.30

(C) LABOUR FOR CASTING AND STACKING

Mason	1/18 m. days	@ Rs 90	= Rs. 5.00
majdoor	1/9 m. days	@ Rs. 45	= Rs. 5.00
Bhisti	1/200 m. days	@ Rs. 45	= Rs. 0.25
Barbender	1/30 m. days	@ Rs. 45	= Rs. 1.50
Helper	1/60 m. days	@ Rs. 43	= Rs. 0.75

(D) MISCELLANEOUS :

Costing of plateform	= Rs. 0.60
Oil	= Rs. 0.60
Vibrator and electric charges	= Rs. 1.00

	Rs. 73.00

+ 3 casting + 7.3 (erection charges)

(A) PARTIALLY PRE-CAST R.C. JOIST

Taking size 3.5 x 0.15 x 0.15

MOULD :

(i) Materials :

Timber (Deodar)	0.05 cu.m.	@ Rs. 2400/cu.m	= Rs. 120.00
M.S. tie rods 10 mm. dia 30 cm with washer and nuts		2 Nos @ Rs. 1.5	= Rs. 3.00
M.S. Angle iron	25 x 25 x 3 mm = 3 Nos.	@ Rs. 3.00 each	= Rs. 45.00

(ii) Labour

Carpenter	0.5 m. days	@ Rs. 90	= Rs. 45.00
Majdoor	0.5 m. days	@ Rs. 45	= Rs. 22.50

NOTE : 1 mould can be used for 100 castings.

HENCE COST OF MOULD FOR EACH BLOCK= 195/100 = Rs. 1.95

B. CASTING : PRECAST R.C.C. JOIST

Taking size 3.5 x 0.15 x 0.15

(i) Materials:

Cement	27.0 kg	@ Rs. 2.7/kg	= Rs. 72.90
Coarse sand	0.036 cu.m.	@ Rs. 425/cu.m.	= Rs. 15.30
Stone aggregate 20mm grade	= 0.072 cu.m	@ Rs. 380/cu.m.	= Rs. 27.36
Reinforcement 6 mm-10mm dia	19.65 kg.	@ Rs. 16/kg	= Rs. 314.40
G.I. Binding wire 24 gauge	0.10 kg	@ Rs. 25/kg	= Rs. 2.50

(ii) Labour for casting and stacting

Mason	1/18 m. days	@ Rs 90	= Rs. 5.00
majdoor	3/18 m. days	@ Rs. 45	= Rs. 7.50
Bhisti	1/100 m. days	@ Rs. 45	= Rs. 0.45
Barbender	1/4 m. days	@ Rs. 45	= Rs. 11.25
Helper	1/8 m. days	@ Rs. 43	= Rs. 5.37

(C) MISCELLANEOUS :

Costing of plateform	= Rs. 1.00
MouldOil & old paper	= Rs. 1.00
Vibrator and electric charges	= Rs. 0.80

	Rs.464.83

(III) ERECTION AND ASSEMBLY :

Partially Precast Joist & Materials Rs. 5.00

(i) Labour

Mason	1/20 m. days	@ Rs. 90	= Rs. 4.50
Majdoor	1/5 m. days	@ RS. 45	= Rs 9.00
Carpenter	1/20 m. days	@ RS. 90	= Rs. 4.5

			Rs. 23.00

(II) PRECAST R.C. PLANK

Material :

Cement	0.06 kg	@ Rs. 2.7	= Rs. 0.20
Sand	0.003 cu.m.	@ Rs. 115 /cu.m	= Rs. 0.35

.Labour

Mason	1/40 m. days	@ Rs. 90	= Rs. 2.25
Majdoor	1/10 m. days	@ Rs. 45	= Rs. 4.5

			Rs. 7.30

(IV) IN SITU CONCRETING BETWEEN PLANKS AND OVERBEAMS

Taking 10 sq. m. roof area

(i) Materials :

Cement	53.3 kg		@ Rs. 2.7/kg	= Rs. 144.00
Coarse sand	0.072 cu.m.		@ Rs. 425/cu.m.	= Rs. 30.60
Stone aggregate 10mm gauge		= 0.144 cu.m	@ Rs. 600/cu.m.	= Rs. 86.40
6 mm dia M.S. bar	9.4 kg		@ Rs. 16 /kg	= Rs. 150.40
G.I. Binding wire 24 gauge		= 0.1 kg	@ Rs. 25/kg	= Rs. 2.5

(ii) Labour (upto 6 m lift)

Mason	1/4 m. days	@ Rs 90	= Rs. 22.5
majdoor	3/4 m. days	@ Rs. 45	= Rs. 33.75
Bhisti	1/4 m. days	@ Rs. 45	= Rs. 11.25
Bar-binder	1/8 m. days	@ Rs. 45	= Rs. 5.60
Helper	1/8 m. days	@ Rs. 43	= Rs. 5.40

(c) Miscellaneous :

L.S.			= Rs. 10.00

Cost per sq. m. of concrete = Rs. 50.24

(V) FINISHING : (1:4)

.(i) Material :

cement	1.2 kg	@ Rs. 2.7	= Rs. 3.25
sand	0.002 cu.m	@ Rs. 115/cu.m	= Rs. 0.30

.(ii) labour :

mason	1/2 m. days	@ RS. 90	= Rs. 45
Majdoor	1/2 m. days	@ RS. 45	= Rs. 22.50
Scaffolding	L.S.		= Rs. 10.00
		Total	Rs. 81.05

Taking 10 sq. m. area

R.C. PLANKS	22 Nos.	@ Rs. 83.3 each	= Rs. 1832.60
R.C. JOIST	1 No.	@ Rs. 489.5 each	= Rs. 489.50

FINISHING	= Rs. 81.05
CONCRETE	= Rs. 502.40
Total	Rs. 12905.55

10 % contractor profit = Rs. 295.50

COST OF R.C.C. PLANK & JOIST ROOF PER SQ. M. = Rs. 319.6

D. PRECAST BRICK PANEL & R.C.C. JOIST ROOF

(i) Moulds:

(A) PRE FAB BRICK PANEL (118 X 56 X 7.5 CM)

Wooden mould :

(a) Materials

Timber(Deodar)	= 0.0137 cu.m.	@ Rs. 24000.00/cu.m	= Rs. 328.40
Nails	= 0.025 kg	@ Rs. 17.5/kg	= Rs. 0.90

(b) Labour

Carpenter	0.50 m. days	@ Rs. 100	= Rs. 50.00
Majdoor	0.50 m. days	@ Rs. 45	= Rs. 22.5

			Rs. 60.00

Let us assuming that one mould can be used for 500 castings

HENCE, COST PER CASTING OF THE MOULD = Rs. 392.20/500 = Rs. 0.80

(B) PARTIALLY PRECAST R.C. JOIST (LENGTH = 3.0 M)

Wooden mould :

(a) Materials :

Timber Deodar	0.32 cu.m.	@ RS. 24000.00/cu.m	= Rs. 768.00
M.S. Tie bolts 10 mm dia, 30 cm long with washer and nut			
	2 Nos.	@ Rs. 5	= Rs. 10.00

			Rs. 778.00
M.S. Angles Iron clamp made of 25 x 25 x 3 mm			
	2 Nos	@ Rs. 15.00 each	= Rs. 30.00

(b) Labour

Carpenter	0.50 m. days	@ RS. 90	= Rs. 45.00
Majdoor	0.50 m. days	@ Rs. 40	= Rs. 20.00
			Rs. 873.00

One mould can be used for 100 castings.

HENCE, COST OF EACH CASTING = Rs. 873/100 = Rs. 8.73

(2) CASTINGS OF COMPONENTS

(i) Pre fab Brick Panel (118 x 56 x 7.5 cm)

(a) Material :

Volume of panel	= 1.18 x 0.56 x 0.075	= 0.0496 cu.m
Volume of 18 bricks	= 18 x 0.225 x 0.115 x 0.075	= 0.0349 cu.m.
Volume of concrete , M15 grade	= 0.0496 - 0.0349	= 0.0147 cu.m.

Cement	0.094 bag	@ Rs. 135/bag	= Rs. 12.70
Coarse sand	0.0065 cu.m.	@ Rs. 425/cu.m.	= Rs. 2.76
Stone aggregate	10mm gauge = 0.013 cu.m	@ Rs. 680/cu.m.	= Rs. 8.84
M.S. Reinforcement	6 mm dia bars(2 Nos.) 0.57kg.	@ Rs. 16.5/k	= Rs. 9.40
Bricks	18 Nos. @ Rs. 1.40/ brick		= Rs. 25.20

(b) Labour:

for casting and stacking:

Mason	1/24 m. days	@ Rs 90	= Rs. 3.75
majdoor	1/12 m. days	@ Rs. 45	= Rs. 3.75
Bhisti	1/200 m. days	@ Rs. 45	= Rs. 0.23
Barbender	1/100 m. days	@ Rs. 45	= Rs. 0.45
Helper	1/200 m. days	@ Rs. 43	= Rs. 0.23
			Rs. 67.31
		+ 0.8 cost of used mould	= Rs. 68.10

(II) PARTIALLY PRECAST R.C. JOIST

- Size (3.00 x 0.13 x 0.10 m)

(a) Material :

Volume of cement aggregate 0.3 x 0.13 x 0.10 = 0.039 cu.m.

Cement	0.25 bag	@ Rs. 135/bag	= Rs 33.75
Sand	0.017 cu.m	@ Rs. 115/cu.m	= Rs. 2.00
Stone aggregate	0.035 cu.m	@ Rs. 680/cu.m	= Rs. 23.8
Tor Steel = 13.22 kg		@ RS. 16 per kg	= Rs. 211.68
G.I. Binding wire (24 gauge)	0.10 kg	@ Rs. 25/kg	= Rs. 2.5 kg

(b) Labour:

Mason	1/16 m. days	@ Rs 90	= Rs. 5.60
majdoor	1/8 m. days	@ Rs. 45	= Rs. 5.60
Bhisti	1/100 m. days	@ Rs. 45	= Rs. 0.45
Barbender with Helper	3/18 m. days	@ Rs. 45	= Rs. 16.87

Rs. 302.25

TOTAL COST = RS. 302.25 + 8.73(MOULD COST) = RS. 311.00

(III) ERECTION AND ASSEMBLY (ERECTION UPTO 6 M LIFT)

(A) PARTIALLY PRECAST JOIST :

(a) Material :

for proping (ballies etc)	L.S.		= Rs. 2.00

(b) Labour:

mason	1/20 m. days	@ Rs. 90	= Rs. 4.50
majdoor	1/5 m. days	@ Rs. 45	= Rs. 9.00

Rs. 13.50

(B) PREFAB BRICK PANEL:

(a) Material (1:4):

Cement	1.0 kg.	@ Rs. 2.7/kg	= Rs. 2.70
sand	0.004/cu.m	@ Rs. 115/cu.m	= Rs. 0.50

(b) Labour :

mason	1/30 m,. days	@ Rs. 90	= Rs. 3.00
Majdoor	1/10 m. days	@ Rs. 45	= Rs. 4.50

Rs. 10.70

ROOFING WITH BRICK PANEL SYSTEM :

Taking roof 5.1. m x 3.0 m = 15.3 sq.m.)

(I) BRICK PANELS

20 Nos.	@ Rs. 68.1/panel	= Rs. 1362.00
Erection and assembly	20 Nos @ Rs. 10.70/panel	= Rs. 214.00

Rs. 1576.00

(II) P.P. JOISTS :

3 Nos.	@ Rs. 311/joist	= Rs. 933.00
Erection and assembly	3 Nos @ Rs. 13.5/joist	= Rs. 40.50

Rs. 973.50

(III) DECK CONCRETE :

4 cm thick deck concrete over prefab brick panel

(a) Materials :

Cement concrete M15 15.3 x 0.04 = 0.61 cu.m

Cement	3.90 bags	@ Rs. 135/bag	= Rs. 526.50
Ballast	0.54 cu.m	@ Rs. 680/cu.m	= Rs. 367.20
M.S Reinforcement	16.11 kg.	@ Rs. 16/kg	= Rs. 257.76
G.I. Binding wire 24 gauge	= 0.15 kg	@ Rs. 25/kg	= Rs. 3.75

(b) Labour

Mason	1.53 x 1/2 m. days	@ Rs 90	= Rs. 68.85
majdoor	1.53 x 1 m. days	@ Rs. 45	= Rs. 68.85
Bhisti	1.53 x 1/4 m. days	@ Rs. 45	= Rs. 17.21
Barbender with Helper	1.53 x 1/5 m. days	@ Rs. 45	= Rs. 13.77

Rs. 1356.30

TOTAL COST = (I) + (II) + (III)

= 1576.00 + 973.5 + 1356.30= Rs 3905.80

HENCE, COST OF ROOF /SQ.M. = RS. 3905.80/115.3 = RS. 255.30

TABLE : COST COMPARISION

S.No.	Type of Roofing	Cost/m^2 (Rs)
1.	R.C.C. (10cm thick)	393.00
2.	R.B.C. (11.5cm thick)	308.50
3.	R.C.C. plank and joist system	319.00
4.	Brick panel & R.C.C. joist system	255.30

5.6 RATE OF ANALYSIS FOR DIFFERENT TYPES OF DOORS

(I) CONVENTIONAL FLUSH DOOR (35 MM)	= Rs. 530 /sq.m.
(II) COUNTRY WOOD DOOR OF MANGO	= Rs. 350/sq.m.
(III) FERROCEMENT DOOR	=
(IV) PLASTIC COMPOSITE FLUSH DOOR(35 MM)	= Rs. 340/sq.m.
PANELS (25 MM)	= Rs. 190/sq.m.

5.7 DRAINAGE

Rain water Pipe 100 mm dia pipe

Cost Rs. 20/mt.

Total length of pipe = ceiling height + Plinth height

= 3.0 + 0.3 = 3.3 m

Cost = 3.3 mt @ Rs. 20.00/mt. = Rs. 66.00

PROJECTED U-CHANNEL :

(a) Materials :

Bricks	8 Nos.	@ Rs. 1.40/brick	= Rs. 11.20
Mortar	0.015 cu.m.	@ Rs 800/cu.m	= Rs. 12.00

(b) Labour :

Mason	1/10 m. days	@ Rs. 90	= Rs. 9.00

TOTAL COST OF EACH CHANNEL = RS. 32.20

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

Major findings and conclusions, emerging from various case studies, surveys and analysis, in form of guidelines are covered under following topics :

MATERIALS :

1. The recycling of agro-industrial wastes, in plains of U.P., like flyash from thermal power stations, lime sludge and stoneblock from sugarmills, rice husk from rice mill and red mud from aluminium factory (HINDALCO IN U.P.) is being encourage through various state housing supports and incentives.
2. To increase the production of alternative building materials, U.P. state government should establish more numbers of large and small scale factories in every district/town of the state.

CONSTRUCTION TECHNIQUES :

1. Generally, design of foundation is governed by the soil bearing capacity and load of structure. Foundation should be designed taking the consideration of vertical expansion or incremental growth. In plains of U.P. where good bearing capacity of soil is available following types of foundation should be provided.

For single storey	60cm wide x 45cm depth
For double storey	75 x 75 cm
For 3-4 storeyed	90 x 90 cm

With 1:6:12 base concrete of 15 cm thick.

PLINTH :

The height of plinth for low income urban housing in plains of U.P. should not be more than 30 cm. Any height above 30 cm simply increase the cost of house.

D.P.C. :

25 mm thick with M15 grade mix concrete should be provided for D.P.C.

SUPER STRUCTURE

More than 32% of the cost of the buildings goes to the walls so to reduce this cost special attention should be given to the following parametere

(i) Thickness of wall

(ii) Total length of wall and common wall

The unit should be compact as possible and minimum off setting. In super structure where over burnt bricks (O.B.B.) are available in low rate compared to conventional first class brick, O.B.B. blocks should be used for walling.

Types of Housing	*Options*
Single storey E.W.S. Housing	* Brick panels * 10 cm thick stone panel or O.B.B. panels.
Double storeyed L.I.G. housing	* 19 cm brick wall * Rat trap bond masonry walls * O.B.B. block masonry.
3-4 storeyed	* 23 cm designed brick masonry wall stoneblock or O.B.B. block.

in 1:6 cement : sand mortar.

MINIMUM HEIGHT :

The minimum height of rooms spaces shall be as follows :

a. Habitable room 2.6 mt.

b. Kitchen 2.6 mt.

c. Bath/W.C. 2.1 mt.

d. Corridor 2.1 mt.

which will satisfy the functional requirements.

Optimum Height of Ceiling : For low income urban housing, optimum height of the ceiling, i.e. 2.75 mt is recommended. Unnecessary increasing of the height will affect the ceiling cost.

DOORS/WINDOWS :

Doors and windows serve as media to distribute the light and ventilation into the building, which consume more than 15 % of the building cost. So special attention should be given to

* Size of opening
* Location
* Selection of materials

If windows are designed as per desired illumination, 20 to 40% saving in window area can be achieved, which will decrease the cost of windows. For low income urban housing in plains of U.P. following types of options are available :

* Doors without frame in single panel
* Ferrocement door panel (Cast in situ) in single leaf.
* Brick jali or R.C.C. jali
* Composite plastic door in single panel.

ARCHES/LINTELS :

* Segmental arch in brick work upto 1.2 mt. span.
* Pre cast RCC thin lintels in M15 grade concrete upto 1.8 mt. span ensuring composite action between lintel and brickwork above.
* Stone patties of suitable sizes (in Jhansi, Varanasi & Lalitpur districts)

LIGHTING AND VENTILATION :

The opening through windows, ventilators and other openings for lighting and ventilation shall be as follows :

(i) One-tenth of the room floor area in plains of U.P.

The opening should be in open space where sufficient light and ventilation present.

ROOF :

The type of roof for low income urban housing should be as follows in place of conventional R.C.C. or R.B.C.

(i) E.W.S. Housing — Brick panels and precast R.C.C. joist system

(ii) L.I.G. Housing — Partially precast R.C.C. plank and joist system

which is about 18 % and 25 % respectively cheaper to conventional roofing system.

SERVICES

All services should be centralised.

Plumbing

Single stack system are modified one pipe system of plumbing subject to municipal bye laws.

W.C. :

W.C. without cistern for EWS housing should be provided.

R.W.P. :

Projected U channel should be provided for R.W.P.

Water Supply :

While doing the internal layout of water supply, minimum bend should be provided as number of bends decreases, the efficiency of water flow increases.

Electrical :

Plastic conduit should be used for electrical wiring.

Points should be design in such a way that less number of fixtures and type is used.

FORM AND PLANNING :

In whole plains of U.P. moderately dense low rise cluster based form is suitable for this climate. The advantage of low rise development being greater contact to ground which will help in balancing the internal temperature and cluster should be such that which can perform the community facilities; amenities and workplace for income producing activities.

LANDSCAPE :

Deciduous plants are useful as they provide shade in hot season and admit the sun in the winter.

GENERAL

The use of technologies which are cost effective, incrementally upgradable and environmentally appropriate is being systematiclly encouraged as a part of State housing policy. A technology package for low income urban housing should be formulated in order to increase the accessibility of low income families in plains of U.P.

BUILDING CENTRES :

A building centre should be established in every district by Government, voluntary and cooperative societies to accelerate the training of masons and transfer of technologies.

MASS MEDIA :

An awareness programme based on technical know how, cost effective techniques and materials should be advertised by mass media and to relay the demostrating projects undertaken by propagating agencies and conversation with house holders so that people believe in cost effective techniques.

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APPENDICES

APPENDIX -A

MANUFACTURE OF CLAY FLYASH BRICKS

CAPACITY : Taking 30,000 bricks per day i.e. 72,00000 bricks per year of working days (240)

1. CAPITAL INVESTMENT	CLAY FLYASH BRICKS	
A. Fixed Capital on land & Building	Mechanical Mixer 1(Rs)	Manual Mixer 2(Rs)
a) Land for bull's kiln shed and storage etc. - 1 acre @ Rs. 60/sq.mt.	2,43,000	2,43,000
b) Building 15 sq. mt. @ Rs. 2,000 per sq. mt. (office room)	30,000	30,000
c) shed @ 1200/sq.mt.	60,000 ($50mt^2$)	30,000 ($25\ m^2$)
TOTAL (Rs)	3,33,000	3,03,000
B. Fixed Capital on Plant		
1. Purchased Equipments delivered (P.E.) (Delivery charges 2 - 4 % of equipment cost)		
(I) Bull's trench kiln	2,25,000	2,25,000
(II) Mechanical mixer/blunger	75,000	
(III) Tube well	30,000	30,000
TOTAL (Rs.)	3,30,000	2,55,000

2. Equipment erection (L.S.)	10,000	6,000
3. Electrical Installation 10% of (P.E.)	33,000	25,500
4. Instruments & control and maintenance of tools 5% of (P.E.)	16,500	12,750
5. Water services and drainage (L.S.)	7,500	7,500
6. Laboratory testing etc. (L.S.)	7,500	7,500
7. Engineering & Supervision 5% of (P.E.)	16,500	12,750
8. Contingency 10% of items 1 to 7	42,100	32,700
TOTAL (Rs.)	4,63,100	3,59,700

FIXED CAPITAL (A + B)	7,96,100	6,62,700
C. WORKING CAPITAL	18,40,500	16,20,000
25% of annual sales		
TOTAL CAPITAL INVESTMENT (A + B + C)	26,36,600	22,82,700

2. COST OF PRODUCTION

(BASIS 240 WORKING DAYS PER ANNUM)

(1). Raw materials	1	2
(a) Cost of clay if land is acquired on lease @ Rs. 45/1000	3,24,000	3,24,000

(b) Cost of flyash - 3,600 tonnes @ Rs. 60/tonne at site load to 15 to 20 k.m.	2,16,000	2,16,000
(c) Sand @ Rs. 25/1000 brick	1,80,000	1,80,000
TOTAL Rs.	7,20,000	7,20,000
(2) Utilities	50,000 K.W.H.	20,000 K.W.H.
(a) Electric power @ Rs. 2.00/ K.W.H.(unit)	1,00000	40,000
(b) Fire wood 20 tonnes @ Rs. 1400/tonne	28,000	28,000
(c) Coal for day flyash brick 14 tonnes/lakh bricks. Taking - 8 tonnes coal per lakh bricks @ Rs. 3,000/T	17,28,000	17,28,000
and Rice husk 10 tonnes/lakh bricks @ Rs. 60/tonne flyash.	43,200	43,200
(d) Consumable including chimney & water supply	16,000	16,000
TOTAL RS.	19,15,200	18,55,200

3. LABOUR & SUPERVISION
(L & S)

(a) Manual mixing of clay & flyash @ Rs. 20/1000 bricks	-	1,44,000
(b) Digging clay and molding of bricks @ Rs. 100/1000 bricks	7,20,000	7,20,000
(c) In case of blunger/mixer is used,	1,80,000	

transporting clay first to mixer, then to moulder @ Rs. 25/1000 bricks		
(d) Transportation of dry bricks to the kiln @ Rs. 25/1000 bricks	1,80,000	1,80,000
(e) Setting of bricks in kiln @ Rs. 12/1000 bricks	86,400	86,400
(f) Ash laying over bricks @ Rs. 7.5/1000 bricks	54,000	54,000
(g) Unloading of fired bricks @ Rs. 25/1000 bricks	1,80,000	1,80,000
(h) Firemen (4 Nos), Mistry(1), Coal supplier (1), Helper (1) Pump attendent (1) , Total (7 Nos.) @ Rs. 1,600/person for 8 months	89,600	89,600
(i) Supervisor - 1 @ Rs. 1800/month for full year	21,600	21,600
(j) Watchman - 1 @ Rs. 1600/month for full year	19,200	19,200
(k) One operator for mechanical mixer @ Rs. 1600/month for 8 months	12,800	
TOTAL RS.	15,43,600	14,94,800

4. MAINTENANCE & REPAIRS (M & R)

(a) Plant @ 6 % of items 1, 4, 5 and 6 in - B	21,690	16,965
1. Building @ 2 % of item b in A	1800	1,200
TOTAL Rs.	23,490	18,165

5. OPERATING SUPPLIES 15 % of (M & R)	3,524	2,725
6. TAXES AND INSURANCE 2 % on fixed capital (A + B)	15,992	13,254
7. PLANT OVERHEAD 20 % of (L & S) including cost of general plant overhead, packing, medical services, safety and protection laboratories, storage facilities etc.	3,08,720	2,98,960
8. INCIDENTAL LOSSES OF BRICKS DUE TO BAD WEATHER 10 % of (L & S)	1,54,360	1,49,480
9. DEPRECIATION		
(I) Plant @ 10 % of items (1,4,5,6, in - B)	36,006	28,162
(ii) Building @ 2.5 % of item (b) in A	2,250	1,500
TOTAL	38,256	29,662
(Rs.)		
10 ADMINISTRATIVE EXPENSES @ 2 % of annual sales	1,47,240	1,29,600
11. Interest on total capital investment @ 18 % per annum	4,74,588	4,10,886
TOTAL COST OF PRODUCTION	53,44,900	51,22,729
Average cost of production on assuming 5 % rejects per 1000 bricks	742	711.50
PROFITABILITY		
(1) Gross annual income	73,62,000	64,80,000

(2) Annual cost of production	53,44,900	51,22,729
(3) Annual return	20,17,100	13,57,271
Return of investment =	(Annual Return x 100)/(Total Capital Investment) =(20,7,100x100)/(26, 36,600) = 76.5 %	(Annual Return x 100)/T.C.I.) =(13,57,271x100)/22, 82,700) = 59.4 %

GROSS ANNUAL INCOME-BREAK UP

	MECHANICAL MIXER		MANUAL MIXER	
75 % I Class	1150/-	62,10,000	1000/-	54,00,000
15 % II Class	850/-	9,18,000	800	8, 64,000
5 % III Class	650/-	2,34,000	600/-	2, 16,000
TOTAL (RS)		73,62,000		64,80,000

MANUFACTURE OF MODULAR BRICKS FROM RED & BLACK SOILS

CAPACITY : Taking 30,000 per day i.e. 72,00000 bricks per year of working days (240)

1. CAPITAL INVESTMENT	Modular Bricks from Red & Black Soils (Rs.)
A. Fixed Capital on land & Building	
a) Land for bull's kiln shed and storage etc. - 1 acre @ Rs. 60/sq.mt.	2,43,000
b) Building 15 sq. mt. @ Rs. 2,000 per sq. mt. (office room)	30,000
shed - 25 sq. mt. @ 1200/sq.mt.	30,000
TOTAL (Rs)	3,03,000
B. FIXED CAPITAL ON PLANT	
1. Purchased Equipments delivered (P.E.)	
(I) Bull's trench kiln	2,25,000
(II) Tube well	30,000
(III) Blunger/manual qhol, settling and dry tanks for removal of coarser line Nodules	75,000
TOTAL (Rs.)	3,30,000
2. Equipment erection (L.S.)	10,000
3. Electrical Installation 10% of (P.E.)	33,000

4. Instruments & control and maintenance of tools 5% of (P.E.)		16,500
5. Water supply services and drainage (L.S.)		7,500
6. Laboratory testing (L.S.)		7,500
7. Engineering & Supervision 5% of (P.E.)		16, 500
8. Contingency 10% of items 1 to 7		42,100
	TOTAL (Rs.)	4,63,100

HENCE TOTAL FIXED CAPITAL (A+B)	7, 66,100
C. WORKING CAPITAL	16,20,000
25% of annual sales	
TOTALCAPITAL INVESTMENT	23,86,700
(A + B + C)	

2. COST OF PRODUCTION

(BASIS 240 WORKING DAYS PER ANNUM)

(1). Raw materials:

(a) If land is acquired on lease @ Rs. 45/1000 bricks (3 tonnes clay)		3,24,000
(b) Cost of openly material such as flyash/grog/stone dust etc. - 3,600 tonnes @ Rs. 60/tonne at site load to 15 to 20 k.ms.		2,16,000
(c) Sand @ Rs. 25/1000 bricks		1,80,000
	TOTAL Rs.	7, 20, 000

(2) UTILITIES

(a) Electric power, 20,000 K.W.H.@ Rs. 2.00/K.W.H.(unit)	40, 000
(b) Fire wood 20 tonnes @ Rs. 1400/tonne	28, 000
(c) *Coal 18 tonnes/lakh bricks taking 12 tonnes/lakhs bricks coal 864 tonnes @ Rs 3000/tonne.	25, 92, 000
Rice husk 14 Tonne per lakh bricks, 1008 tonne @ Rs. 60/Tonne.	65, 520
* (Saving of coal consumption upto 20% it flyash or rice husk ash is used as a opening material with black & red soil, which has not been taken into account).	
(d) Consumable including chimney & dampers, tube well etc.	16,000
TOTAL Rs.	27, 41, 250

3. LABOUR & SUPERVISION (L & S)

a) Manual mixing of material and removal of lime modules , @ Rs. 20/1000 bricks	1,44,000
b) Digging clay and molding of bricks @ Rs. 100/1000 bricks	7,20,000
c) Transportation of dry bricks to the kiln @ Rs. 25/1000 bricks	1,80,000
	86,400
d) Setting of bricks in kiln @ Rs. 12/1000 bricks	57,600
e) Ash laying over bricks @ Rs. 8.0/1000 bricks	1,80,000
f) Unloading of fired bricks @ Rs. 25/1000 bricks	
(g) Firemen (4 Nos), Mistry(1), Coal supplier (1), Helper	69,600

(1) , Total (7 Nos.) @ Rs. 16,00/person for 8 months]		19,200
(h) Watchman - 1 @ Rs. 1600/month for full year		21,600
(i) Supervisor(1) @ Rs. 1800/month for full year		
	TOTAL Rs.	14,98,400

4. MAINTENANCE & REPAIRS (M & R)

(a) Plant @ 6 % of items 1, 4, 5 and 6 in - B		23,670
(b) Building @ 2 % of item in A		1,100
	TOTAL (Rs)	24,770
5. OPERATING SUPPLIES		3,716
15 % of (M & R)		
6. TAXES AND INSURANCE		15,332
2 % on fixed capital (A + B)		
7. PLANT OVERHEAD		2,99,680
20 % of (L & S) including cost of general plant overhead, payroll services, safety and protection etc.		
8. INCIDENTAL LOSSES OF BRICKS DUE TO BAD WEATHER		1,49,840
10 % of (L & S)		
9. DEPRECIATION		
(I) Plant @ 10 % of items (1 and 3 to 6), in - B		39,292
(ii) Building @ 2.5 % of item (b) in A		1,375
	TOTAL (Rs.)	40,667
10 ADMINISTRATION EXPENSES		1,29,600
@ 2 % of annual sales		

11. Interest on total capital investment @ 18 % per annum		4,29,498
TOTAL COST OF PRODUCTION		60,53,013
Average cost of production on assuming 5 % rejects per 1000 bricks		840.70
PROFITABILITY		
(1) Gross annual income		64,80,000
(2) Annual cost of production		60,53,013
(3) Annual return		4,26,987
(4) Return of Investment	=4,26,987 x 100/23,86,100 = 17.89 = 18 %	

GROSS ANNUAL INCOME-BREAK UP

75 % I Class (54,00,000)	1000/-	54,00,000
15 % II Class (10,80,000)	800/-	8,64,000
5 % III Class (3,60,000)	600/-	2,16,000
5 % losses as rejects		
TOTAL		64,80,000

MANUFACTURE OF MASONRY CEMENT

CAPACITY : Taking 20 tonnes masonry cement per day in 240 working days, i.e. 48,000 tonnes.

A. CAPITAL INVESTMENT

(a) Land, 2000 sq. mt, @ Rs. 60/sq.mt.	12,0000
(b) Building II class, 200 sq. mt. @ 1600/sq.m.	3,20000
(c) Electrical and water fitting (10% of building cost)	32,000
(d) Office equipment & furniture (L.S.)	7,500
(e) Ball mills - 2 nos.	2,25,000
(f) Seiving bins & misc. tools	12,000
(g) Storage bins & misc. tools	10,000
TOTAL (Rs)	7,26,500
Working Capital @ 45 days	12,80,861
Cost of raw materials, direct labour and utilities	20,07,361

B. COST OF PRODUCTION

1. Raw Materials

(I) Lime Sludge 2400 T @ Rs. 20/T	48,000
(ii) Cement and gypsum etc. including handling losses 2400 tonnes @ Rs. 2700/T	64,80,000
TOTAL (Rs)	65,28,000

2. Direct Labour

(a) Labour - 20 men @ Rs. 45 per day	2,16,000
(b) Supervisor (1) @ Rs. 1800/month for full year	21,600
TOTAL(Rs)	2,37,600

3. Utilities		
Electrical power and light		40,000
Water, fire wood, coal etc.		12,000
Repair & Maintenance		
(I) 3% on plant and machinery		7,110
(ii) 2% on building		6,550
	TOTAL(Rs)	65,660
4. Overheads		
(a) Manager @ Rs. 3,000/month for full year		36,000
(b) Clerk @ Rs. 1600 per month		19,200
(c) Watch & Ward @ Rs. 1500/month		18,000
Other Expenses, P.F., taxes, sales etc.		12,000
	TOTAL (Rs)	85,200
5. Interest on working capital @ 18%		2,30,555
6. Depreciation		
(I) 7% Plant & machinery		15,890
(ii) 5% on building		16,000
	TOTAL (Rs)	31,890
Total production cost of 4800 tonnes		71,78,905
Hence Manufacturing cost per tonne of masonry cement		1495.60
Manufacturing cost per tonne in jute bags		1545
Estimated selling per tonne in jute bags		1600

Prifitability

1. Gross annual income	76,80,000
2. Annual cost of production	71,78,905
3. Annual Return	5,01,095
Return of Investment	24.96% = 25%(say)

MANUFACTURE OF LIME FROM WASTE LIME SLUDGE BY BRIQUETTING PROCESS AND BURNING IN A VERTICAL KILN

CAPACITY : 12 Tonnes of brequettes to be calcines to make 7 tonnes of lime per day , per 300 days in a year, i.e. 7 x 300 = 2100 tonnes lime per annum.

CAPITAL INVESTMENYT

Land 200 sq. m. @ Rs. 60/sq.mt.	12,000
Shed 100 sq.mt. @ Rs. 1600/sq. mt/	1,60,000
Mixed feed continuous kiln	95,000
Electricity & Water Installation	12,000
Contingency expenses	7500
TOTAL (Rs)	2,86,500

MANUFACTURING COST

(Basis 2100 tonnes lime)

Lime sludge briquettes 4200 tonnes @ Rs. 100/tonne	4,20,000
Coal 700 tonnes @ Rs. 3000/T	21,00000
Labour @ Rs 90/- per tonne Lime made	1,89,000
Electricity & Power	9000
Repair and Maintenance	3,000
Indirect Expenses	9,000
Depreciation	12,000
TOTAL (Rs)	27,42,000
	1305.7

COST PER TONNES *LIME	
Expected Selling cost per tonne	1375
Gross Annual Income	28,87,500
Cost of Production	27,42,000
Return of Investment	(1,45,500x 100)/(2,86,500) = 50 %

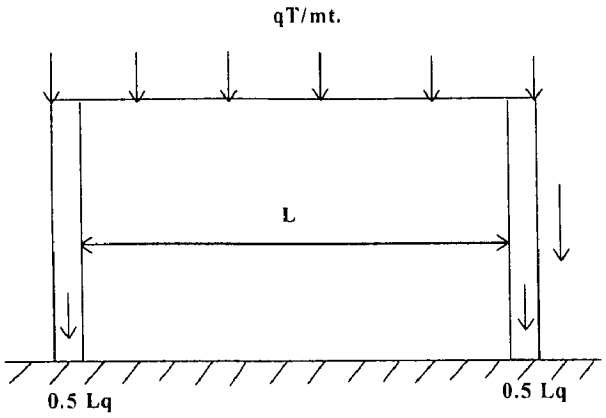
** B & E Grade Hydraulic Lime or Kankar Lime As Per 712*

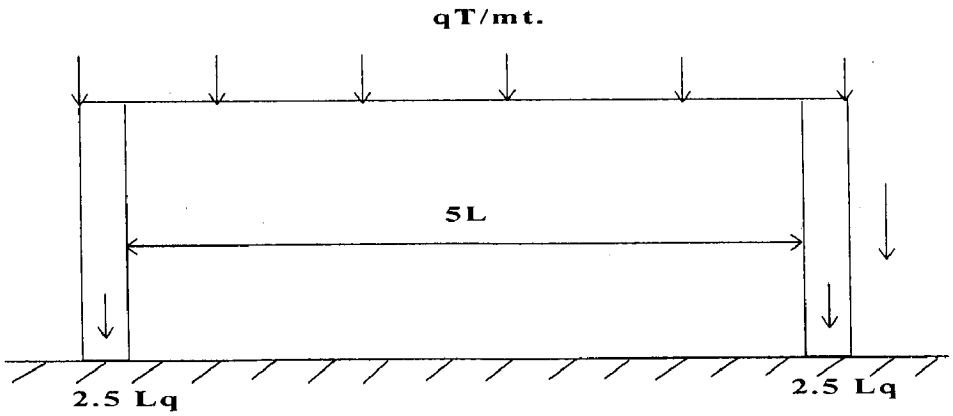
APPENDIX - B

DESIGN OF FOUNDATION

BEARING CAPACITY OF SOIL IN PLAINS OF U.P. = 10-15 T/sq.mt.

EFFECT OF SPAN ON FOUNDATION :





It show that, to economise the cost of foundation, one way roofing is more economical than two way.

For single storey building having 3.0 mt. span,

1. Load of wall per running metre = 3 mt. x 1.0 x 0.3

= 0.9 cu.mt. x density

= 0.9 x 1800 kg/sq.mt.

= 1620.00 kg

= 1.6 T/m

2. Load of slab per running metre = 1.5 mt. x 1.0 x 0.1 mt

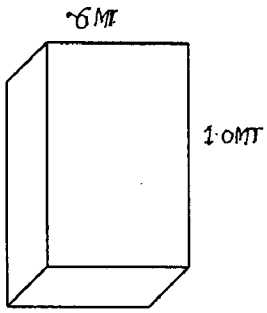
= 0.15 mt x 2500 kg/cu.mt.

= 375.00 = 0.4 T

3. Load of Lime concrete = 1.5 mt x 1.0 x 0.1 = 0.15 x 2200 = 0.3T

4. Load of foundation per running metre = 10% of wall load = 0.2 T

Total load = 1 + 2 + 3 + 4 = 2.5 T/m



Taking area of foundation base = 0.6 mt x 1 mt = 0.6 sq.mt.

Total Load on this area = bearing capacity of soil x 0.6 sq.mt.

= 6 T

which is 2.4 times more that the actual load coming on that particular area. Hence, 45 x 60 cm foundation trench is sufficient for single storey building in urban areas of U.P.