

CONSTRUCTION BUILDING DIGEST

NBRRI

NIGERIAN BUILDING AND ROAD RESEARCH INSTITUTE

BUILDING CONSTRUCTION DIGEST



BUILDING CONSTRUCTION DIGEST

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BUILDING CONSTRUCTION DIGEST

Foreword

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Cost Analysis of a Residential Building	No. 1 :
Building Construction Digest No. 2:	
STONECARETE BLOCK MASONRY FOR WALLS AND ROOFS	No. 2 :
THIN REINFORCED CONCRETE RIBBED SLAB FOR FLOORS AND ROOFS	No. 4 :
CHANNEL UNIT FLOORING/ROOFING SCHEME	No. 5 :
GADGETS FOR INCREASING PRODUCTIVITY OF SOME BUILDING OPERATIONS	No. 6 :
Building Construction Digest No. 6:	
Gadgets for increasing productivity of some building operations	

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1985

BUILDING CONSTRUCTION DIGEST

- No. 1 : COST ANALYSIS OF A RESIDENTIAL BUILDING
- No. 2 : STONECRETE-BLOCK MASONRY FOR WALLS
- No. 3 : REINFORCED CONCRETE PLANK FLOORING/ROOFING SCHEME
- No. 4 : THIN REINFORCED CONCRETE RIBBED SLAB FOR FLOORS AND ROOFS
- No. 5 : CHANNEL UNIT FLOORING/ROOFING SCHEME
- No. 6 : GADGETS FOR INCREASING PRODUCTIVITY OF SOME BUILDING OPERATIONS

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A. D. Mador
Director
February, 1993

J. S. Sharma, M. P. Jaisiah and J. D. Barua

FOREWORD

One of the strategies widely accepted in the country today to reduce the ever increasing cost of housing is the use of alternative building materials developed from locally abundant raw materials. This strategy has in general been most effective in significantly bringing down the cost of low cost housing.

The use of burnt clay bricks and cement stabilised blocks has reduced by 40-45% the cost of bungalows in various parts of the country. The success of this strategy should not lead us to ignore other methods and strategies which can lead to a meaningful reduction of building costs. The Nigerian Building and Road Research Institute has always been conscious of this fact and accordingly undertook research projects in these areas side by side with work on locally abundant raw materials.

In this publication, technologies, techniques and devices which will help in increasing the productivity of the builder in appropriate circumstances are brought together for easy reference. The Reinforced Concrete (RC) Plank Flooring/Roof Scheme, Thin RC Ribbed Slab for Floors and Roofs, Channel Unit Flooring/Roofing Scheme describe schemes and techniques which reduce construction time and labour costs in relevant building projects. Of special interest are simple gadgets for increasing the productivity of artisans and craftsmen in the building industry.

The original plan was to publish the digests separately. However, a few production difficulties delayed the release of some of the digests as they became ready. With the increase in cost of publication, the plan was revised to combine the digests into the booklet. This has reduced the cost of production and it is my fervent hope that it will lead to a wider patronage in the building industry. The response and suggestions of users will be very much appreciated and incorporated in new editions.

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BUILDING CONSTRUCTION

DIGEST

NO. 1

COST ANALYSIS OF A RESIDENTIAL BUILDING

By
J. S. Sharma, M. P. Jaisingh and J. O. Bereola

1.00	1. Flush and paneled doors with timber frame	2.00
2.04	ii. Metal work louvre windows and fittings	4.04
9.0		11.00

A knowledge of the cost and plinth area of an existing building can be used as a guidance for assessing the cost of a similar building, provided the specifications are similar and cognisance is given to inflationary trends. Where there is shortage of funds, the tendency is to attempt to reduce the plinth area, which may not be acceptable for functional and social requirements. In such a situation, a knowledge of the cost distribution of the various elements of a building would assist the architect, engineer or builder to choose elements to consider for cost reduction depending upon the functional requirement of the building. Thus construction costs can be significantly reduced by selecting economical alternative specifications for such

elements. Also a breakdown of the cost of the different building elements will provide guidance for making interim payments for work executed.

Consequent on the above, studies were conducted into the bill of quantities of buildings. For a residential single storey low cost building, Table 1 shows the analysis of the breakdown of the cost distribution of the various elements of the building in percentages. The building under consideration has conventional specifications such as strip foundation, hollow sandcrete block masonry walls, rendered and emulsion painted, flush and panelled doors with timber frames, metallic louvered windows and asbestos sheet roofing over timber frame.

Table 1. A DETAILED BREAKDOWN OF COST OF A RESIDENTIAL BUILDING

Main Element	Sub-Element	Sub-Element percentage of total Cost	Main Element percentage of total Cost
1. Foundation and plinth	i. Excavation and earth-work	1.05	8.9
	ii. Anti-termite treatment	0.37	
	iii. Plain in-situ concrete (1:3:6)	3.96	
	iv. Block work	3.14	
	v. Damp proof course	0.42	
2. Floor	i. Hardcore under floor	2.48	10.0
	ii. RCC (1:2:4)	7.52	
3. Wall	i. Hollow sandcrete block-work	12.34	16.8
	ii. RCC in beams, lintels	4.46	
4. Roof	i. Wall plates, rafters, purlins etc.	7.05	15.3
	ii. Corrugated asbestos cement roofing	8.29	
5. Doors and windows	i. Flush and panelled doors with timber frame	3.00	9.0
	ii. Metal work louver windows and fittings	6.04	

Main Element	Sub-Element	Sub-Element percentage of total Cost	Main Element percentage of total Cost	
6. Finishes	i. Plaster work	3.76	21.6	
	ii. Rendering	1.25		
	iii. Painting on walls	6.53		
	iv. Painting on wood	0.86		
	v. Painting on metal work	0.38		
	vi. Ceiling lining	2.60		
	vii. Glazing	2.36		
	viii. Paving	3.82		
7. Services	a. Internal	i. Sanitary appliances and installations	2.60	11.4
		ii. Cold water installations	1.47	
		iii. Electrical installations	7.30	
	b. External	i. Sanitary work, drain, pipe works & manholes	2.73	7.0
		ii. Septic tank	1.56	
		iii. Water & electric connection from mains	1.47	

There may be minor variations in the percentage costs of the elements depending upon the location, changes in planning, the cost of materials and labour and use of different specifications. However, such variations may be around ± 10 per cent of the values given in Table 1. This table would be useful in designing and planning low cost housing projects. Also labour and material cost planning for different elements of the building would be possible by working out the cost of the element from the Table and appor-

tioning it as follows; 45% for labour and 55% for materials.

For the ready use of non-professional who may want to construct houses of their own without engaging an architect or engineer, a simplified break-down of the cost of a residential building is given in Table 2. From the total estimated cost of the house, and with the help of this Table, the approximate cost of construction of different elements of a house can be worked out and interim payments made accordingly.

Table 2. A SIMPLIFIED BREAKDOWN OF COST OF A RESIDENTIAL BUILDING

Element	Percentage of total cost
1. Foundation and plinth	9
2. Floor	10
3. Wall	17
4. Roof	15
5. Doors and windows	9
6. Finishes	22
7. Services	
a. Internal	11
b. External	7
Total	100

There may be minor variations in the percentage costs of the elements depending upon the location, changes in planning, the cost of materials and labour and use of different specifications. However, such variations may be around ± 10 per cent of the values given in Table 1. This table would be useful in designing and planning low cost housing projects. Also labour and material cost planning for different elements of the building would be possible by working out the cost of the element from the table and applying it as follows; 45% for labour and 55% for materials. For the ready use of non-professionals who may want to construct houses of their own without engaging an architect or engineer, a simplified break-down of the cost of a residential building is given in Table 2. From the total estimated cost of the house, and with the help of this table, the approximate cost of construction of different elements of a house can be worked out and interim payments made accordingly.

BUILDING CONSTRUCTION

DIGEST

NO. 2

STONECRETE BLOCK MASONRY FOR WALLS

By

J. S. Sharma, M. P. Jaisingh and J. O. Bereola

Type	Nominal Dimensions			Actual Dimensions		
	L	B	H	L	B	H
A	300	200	150	290	190	140
B	300	150	150	290	140	140
C	300	150	90	290	140	140

In addition to the above mentioned sizes, 1/3, 1/2, 2/3 and 1 length blocks for breaking the joints in courses, can be made. A block 290 x 190 x 140mm (weight 18kg, special blocks of 290 x 90 x 140mm (11g.S) and 190 x 190 x 140mm with semi-circular recess can also be made to accommodate conduits, pipes etc. in the wall.

MATERIALS
The stonecrete blocks are made of large stone pieces bound together with lean cement concrete mix 1:2:8 (1 cement: 2 sand: 8 graded coarse aggregate of size 10mm and below). The sizes of the stone pieces used are as large as can be accommodated in the mould. Stone pieces 250mm to 50mm size are used.

The concrete should possess good workability and consistency at the green stage. However, being a lean concrete, plasticity and workability to impart plasticity and workability. Therefore the rate of sand in the concrete is very significant. The size, shape, texture and grading of the sand has to be carefully chosen. The sand should be well graded and have 15 to 20 per cent fine particles passing 200 micron sieve and 5 to 15 per cent passing 150 micron sieve. Where such sand is not available, the proportioning of sand for the aggregate should be suitably adjusted by making a trial mix.

MOULD
The moulds have a clear width of 290mm and the length is the sum of the nominal length (300mm) plus the thickness of partition plates. The thickness of partition plates, 140mm or 190mm depending upon the type of block to be casted from 3mm thick mild steel (M.S.) sheet and angle iron stiffeners are used for producing the blocks. Each mould can be used for casting 6 blocks at a time. The moulds have a clear width of 290mm and the length is the sum of the nominal length (300mm) plus the thickness of partition plates. The thickness of partition plates, 140mm or 190mm depending upon the type of block to be casted from 3mm thick mild steel (M.S.) sheet and angle iron stiffeners are used for producing the blocks. Each mould can be used for casting 6 blocks at a time.

Stones are available in many parts of the country and form a good local building material. In the past, stones have been used to construct random rubble masonry walls of thickness 400mm or more. Apart from consuming large quantities of stone, the rate of construction is slow. Hence, random rubble masonry was later replaced by sandcrete block masonry.

Sandcrete blocks can be used for load bearing walls in single storey buildings; but for buildings two or more storeys high, reinforced cement concrete (R.C.C.) columns and beams are normally provided and the blocks are used as filler walls. This results in greater consumption of cement and steel. In towns, the cost of land is going up. In a single storey construction cost is more. The trend is to go in for two or three storey buildings. There is therefore a need to develop some walling units which could utilise local stones, be simple to produce and have the required strength.

DETAILS OF BLOCKS
It is possible to have different surfaces. The bottom face with exposed stone texture forms the external face, when the wall is built. Other textures can be obtained by embedding aggregates of different sizes/colours on the face of the blocks during the casting stage.

For ease of handling and other requirements, the nominal length and height of the blocks are kept at 300mm and 150mm respectively, while the width is kept at 200mm, 150mm or 100mm. For load bearing walls, the 200mm wide blocks are used with 150mm wide blocks as partition walls. In some single storey buildings, they could be used as load bearing walls. The actual blocks dimensions are kept 10mm less than the nominal sizes to accommodate mortar joints. The nominal and actual sizes of blocks are given in Table I.

1. INTRODUCTION

Stones are available in many parts of the country and form a good local building material. In the past, stones have been used to construct random rubble masonry walls of thickness 400mm or more. Apart from consuming large quantities of stone pieces and mortar, this type of construction calls for specialised skills of masons and the rate of construction is slow. Hence, random rubble masonry was later replaced by sandcrete block masonry.

Sandcrete blocks can be used for load bearing walls in single storey buildings; but for buildings two or more storeys high, reinforced cement concrete (R.C.C) columns and beams are normally provided and the blocks are used as filler walls. This results in greater consumption of cement and steel. In most towns, the cost of land is going up and as single storey construction costs more, the trend is to go in for two or three storey buildings. There is therefore a need to develop some walling units which could utilise local stones, be simple to produce and have the required strength.

2. DETAILS OF BLOCKS

It is possible to have different surface textures (Fig.1) for the stonecrete blocks. The blocks are cast such that the bottom face with exposed stone texture forms the external face, when the wall is built. Other textures can be obtained by embedding aggregates of different sizes/colours on the face of the blocks during the casting stage.

For ease of handling and other requirements, the nominal length and height of the blocks are kept at 300mm and 150mm respectively, while the width is kept at 200mm, 150mm or 100mm. For load bearing walls, the 200mm wide blocks are used while for partition walls, the 100mm wide blocks are used. The 150mm wide blocks are also used as partition filler walls, but in some single storey buildings, they could be used as load bearing walls. The actual blocks dimensions are kept 10mm less than the nominal sizes to accommodate mortar joint thickness in construction. The nominal and actual sizes of blocks are given in Table 1.

Table 1. DIMENSION OF BLOCKS (mm)

Type	Nominal Dimensions			Actual Dimensions		
	L	B	H	L	B	H
A	300	200	150	290	190	140
B	300	150	150	290	140	140
C	300	100	150	290	90	140

In addition to the above mentioned sizes, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{2}{3}$ and $\frac{3}{4}$ length blocks required for breaking the joints in alternate courses, can be made. A block 290 x 190 x 140mm weighs 18kg. Special blocks of 290 x 90 x 140mm (Fig.2) and 190 x 190 x 140mm with semi-circular recess can also be made to accommodate conduits, pipes etc. in the wall.

3. MATERIALS

The stonecrete blocks are made of large stone pieces bound together with lean cement concrete mix 1:5:8 (1 cement: 5 sand: 8 graded coarse aggregate of size 10mm and below). The sizes of the stone pieces used are as large as can be accommodated in the mould. Stone pieces 260mm to 50mm size are used.

The concrete should possess good workability and cohesiveness at the green stage. However, being a lean mix, the concrete lacks fine particles to impart plasticity and workability. Therefore the role of sand in the concrete is very significant. The size, shape, texture and grading of the sand has to be carefully chosen. The sand should be well graded and have 15 to 20 per cent fine particles passing 300 micron sieve and 5 to 15 per cent passing 150 micron sieve. Where such sand is not available, the proportioning of sand to the aggregate should be suitably adjusted by making a few trial mixes.

4. MOULD

Battery moulds Figs. 3 and 4 fabricated from 3mm thick mild steel (M.S.) sheet and angle iron stiffeners are used for producing the blocks. Each mould can be used for casting 6 blocks at a time. The moulds have a clear width of 290mm and the length is the sum of the heights of six blocks (6 x 140mm) plus the thicknesses of partition plates. The height of mould is 190mm, 140mm or 90mm depending upon the type of block to

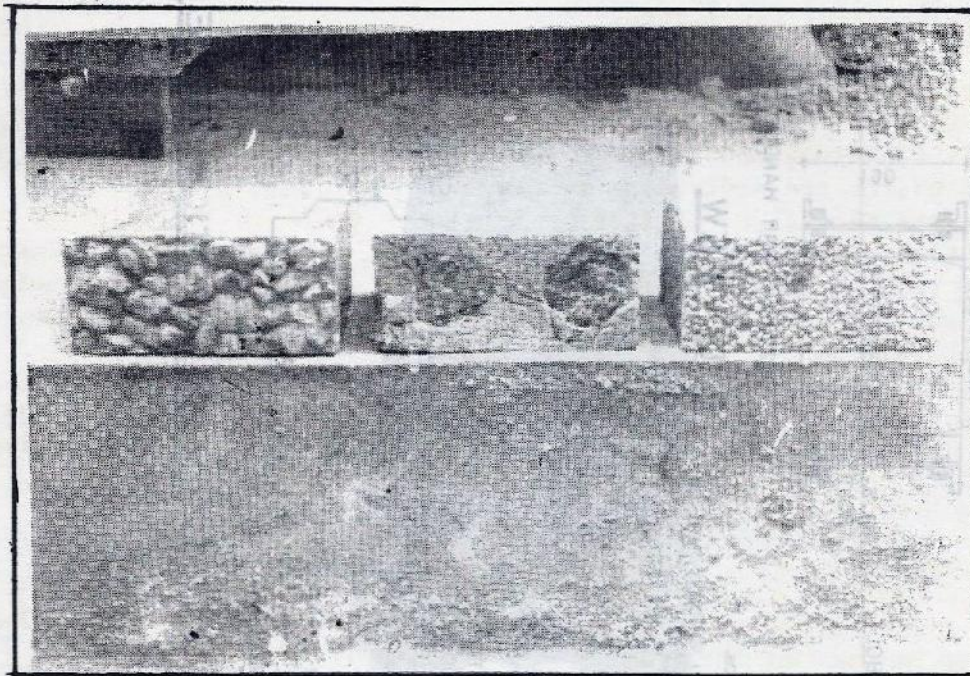


FIG. 1. STONECRETE BLOCKS WITH DIFFERENT SURFACE TEXTURES

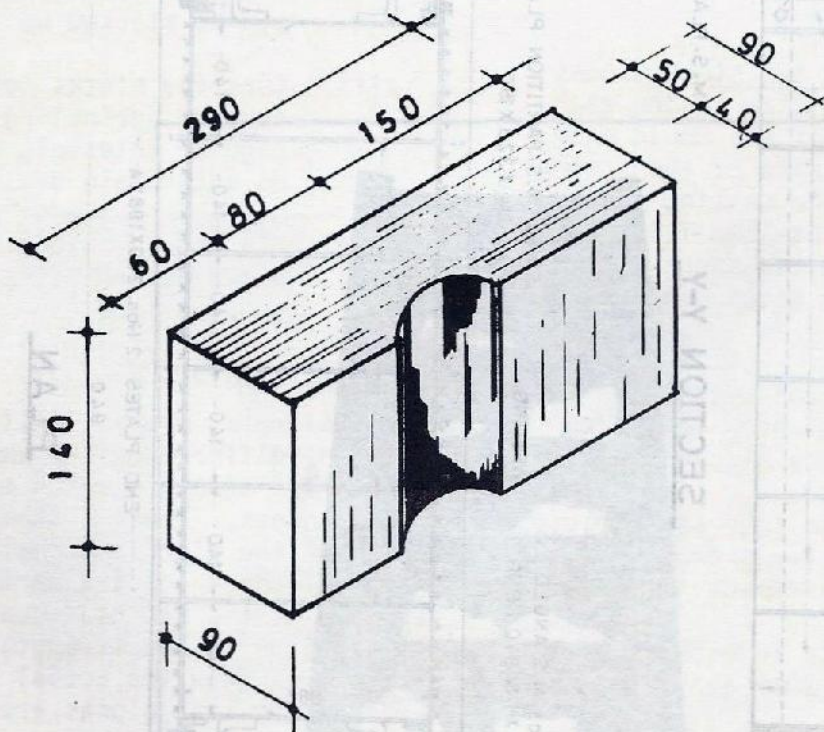
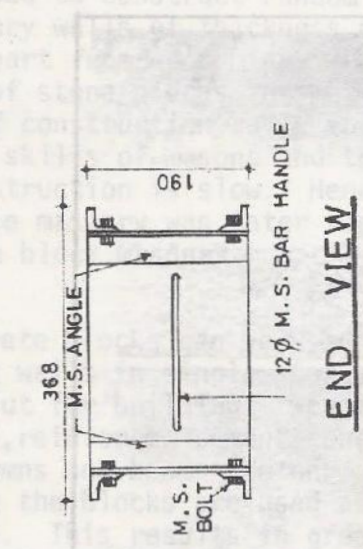
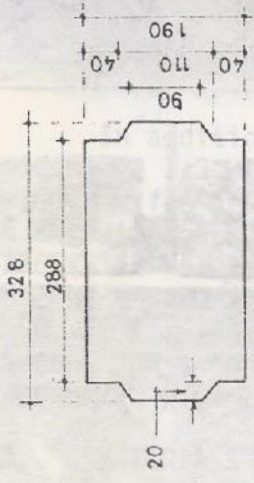


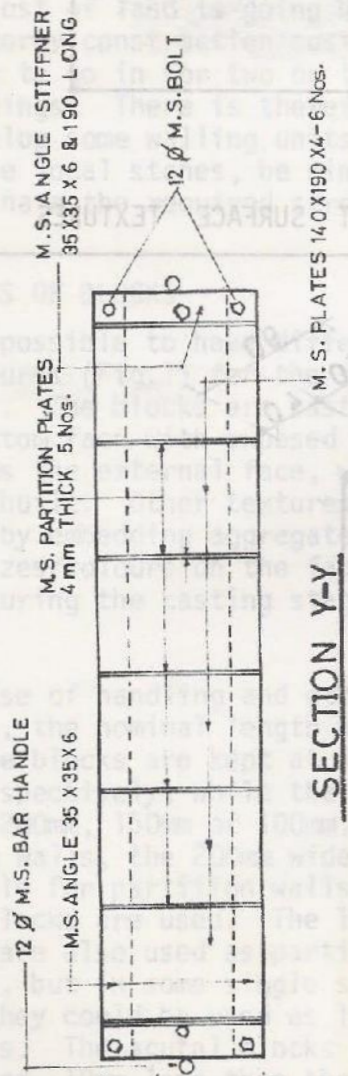
Fig 2 BLOCK WITH RECESS FOR EMBEDDING CONDUITS & PIPES.



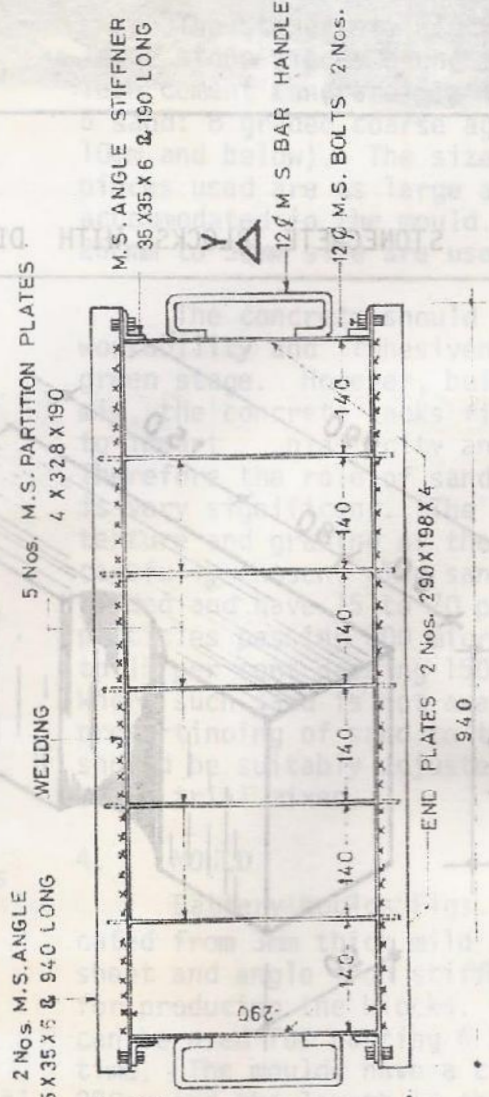
END VIEW



M.S. PARTITION N PLATE



SECTION Y-Y



PLAN

Fig 3 MOULD FOR STONECRETE BLOCKS

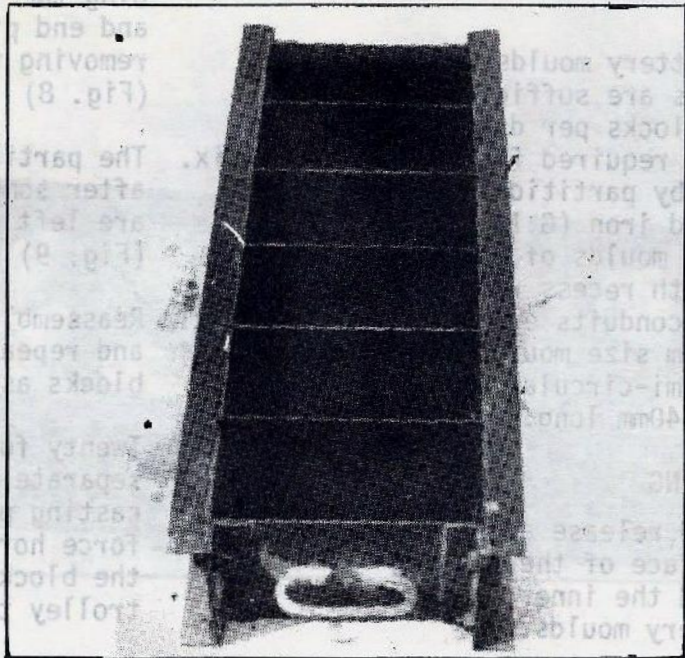


FIG. 4. MOULD FOR STONECRETE BLOCKS

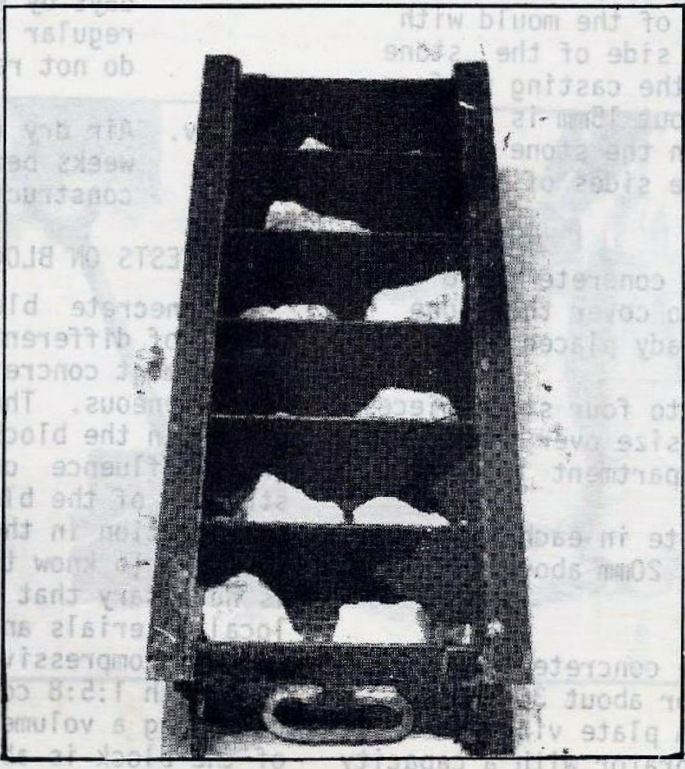


FIG. 5. MOULD WITH STONE PIECES IN POSITION

be produced. The mould consists of two longitudinal members, two end pieces with handles fixed to them and 5 partition plates. Slots are provided in the longitudinal members to locate the partition plates. After assembling the members, nuts and bolts are used to fix them together.

Four to five battery moulds with extra partition plates are sufficient to cast 300 stonecrete blocks per day. Smaller length blocks required for breaking bond can be cast by partitioning the moulds with galvanised iron (G.I.) sheets or by having separate moulds of each type. For casting blocks with recess required for embedding pipes, conduits etc. in the wall, 290 x 90 x 140mm size moulds could be used along with semi-circular timber pieces 80mm dia and 140mm long.

5. METHOD OF CASTING

- i. Apply a bond release agent to the top surface of the casting platform and the inner faces of the battery moulds.
- ii. Arrange four to five battery moulds on the casting platform in a row with a gap of 150mm between each.
- iii. Place one or two stone pieces 260 to 120mm size inside each compartment of the mould with the flatter side of the stone resting on the casting platform. A gap of about 15mm is to be left between the stone pieces and also the sides of the mould (Fig. 5)
- iv. Pour cement concrete 1:5:8 inside the mould to cover the stone pieces already placed.
- v. Insert two to four stone pieces 50 to 60mm size over the concrete in each compartment (Fig. 6)
- vi. Fill concrete in each compartment up to about 20mm above the top of the mould.
- vii. Compact the concrete with a plate vibrator for about 30 seconds (Fig. 7) A plate vibrator is a shutter vibrator with a capacity of about 375 watts, fixed to a 5mm thick steel plate 450 x 750mm size with handles welded to the

plate.

- viii. Repeat the above mentioned steps in the adjoining moulds and when concrete has been compacted in all the moulds, which may take about 10 minutes, start demoulding the longitudinal members and end pieces of the mould by removing the nuts and bolts (Fig. 8)
- ix. The partition plates are removed after some time and the blocks are left on the casting platform (Fig. 9)
- x. Reassemble the battery moulds and repeat the casting of the blocks as above.
- xi. Twenty four hours after casting, separate the blocks from the casting platform by applying force horizontally and carry the blocks in a platform trolley to the curing yard.
- xii. Arrange the blocks in the curing yard such that only two tiers are formed of the freshly cast blocks. Subsequently, blocks can be stacked up to 5 tiers.
- xiii. Cure the blocks for seven days by sprinkling water at regular intervals so that they do not remain dry.
- xiv. Air dry the blocks for three weeks before using them in any construction.

6. TESTS ON BLOCKS

Stonecrete blocks consist of stone pieces of different sizes and shapes and lean cement concrete which make them heterogeneous. The position of stone pieces in the block and their volume have great influence on the performance and strength of the blocks. Hence, there may be variation in the strength of individual blocks. To know the actual strength, it is necessary that blocks are cast with local materials and tested. The average 28 days compressive strength of blocks cast with 1:5:8 concrete with stone pieces occupying a volume of about 25 per cent of the block is about $7N/mm^2$. The blocks can be used for the construction of load bearing walls for buildings up to 3 storeys high.

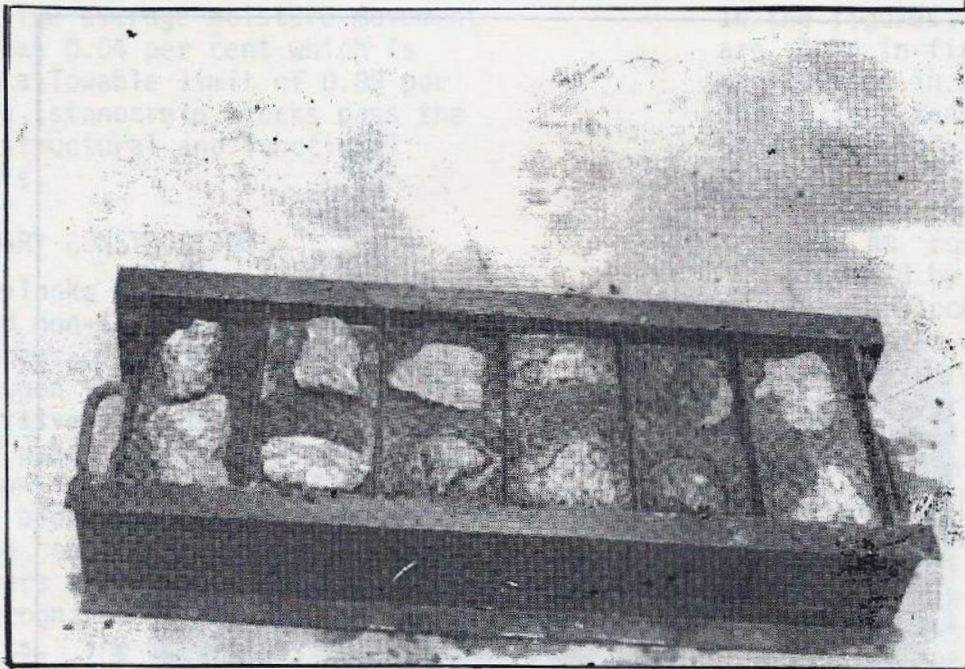


FIG. 6. MOULD PARTIALLY FILLED WITH CONCRETE AND STONE PIECES

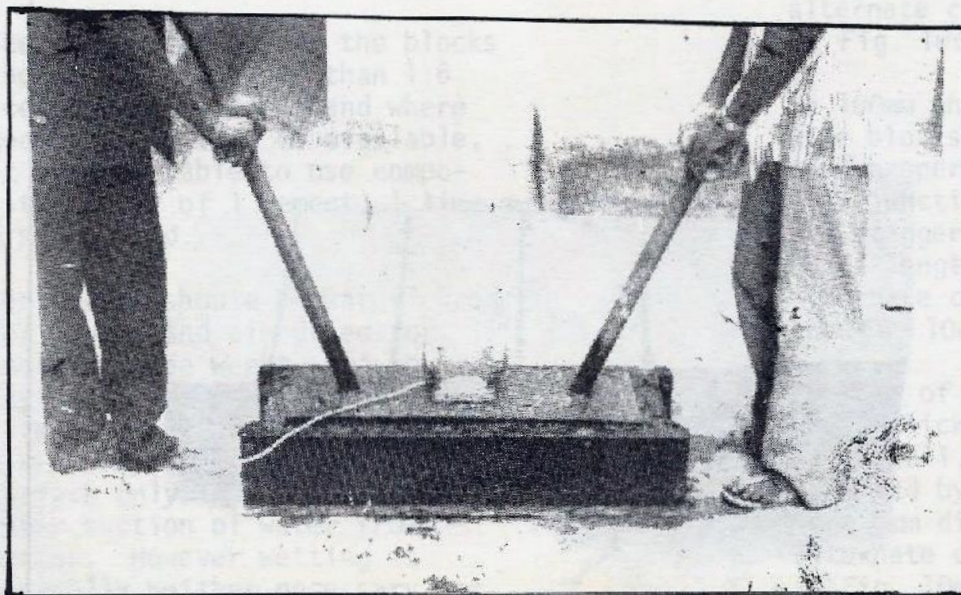


FIG. 7. STONECRETE BLOCKS BEING COMPACTED IN A MOULD WITH A PLATE VIBRATOR

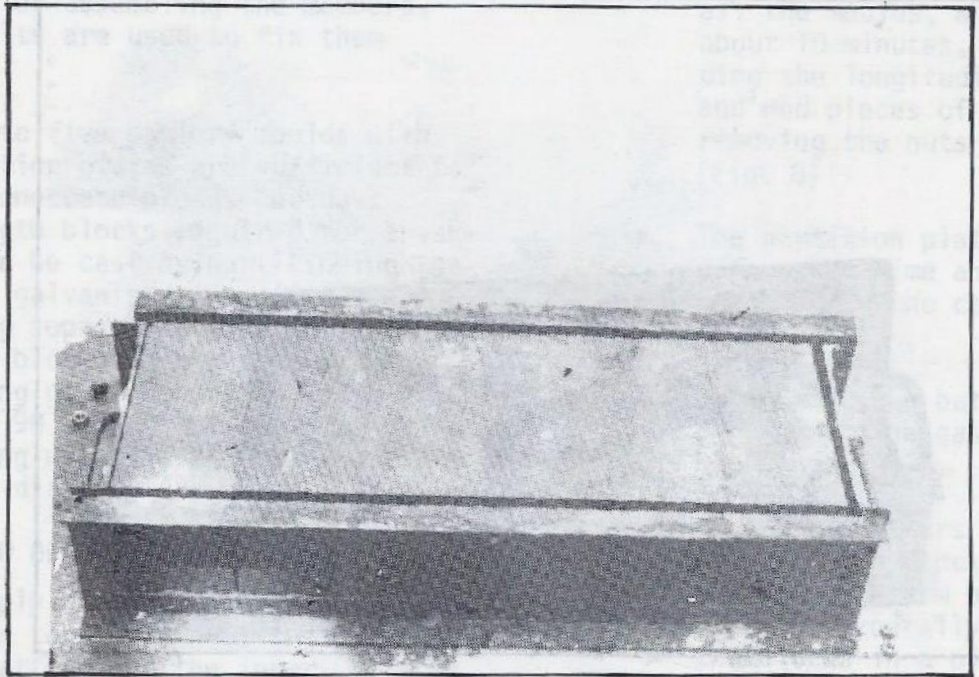


FIG. 8. DEMOULDING

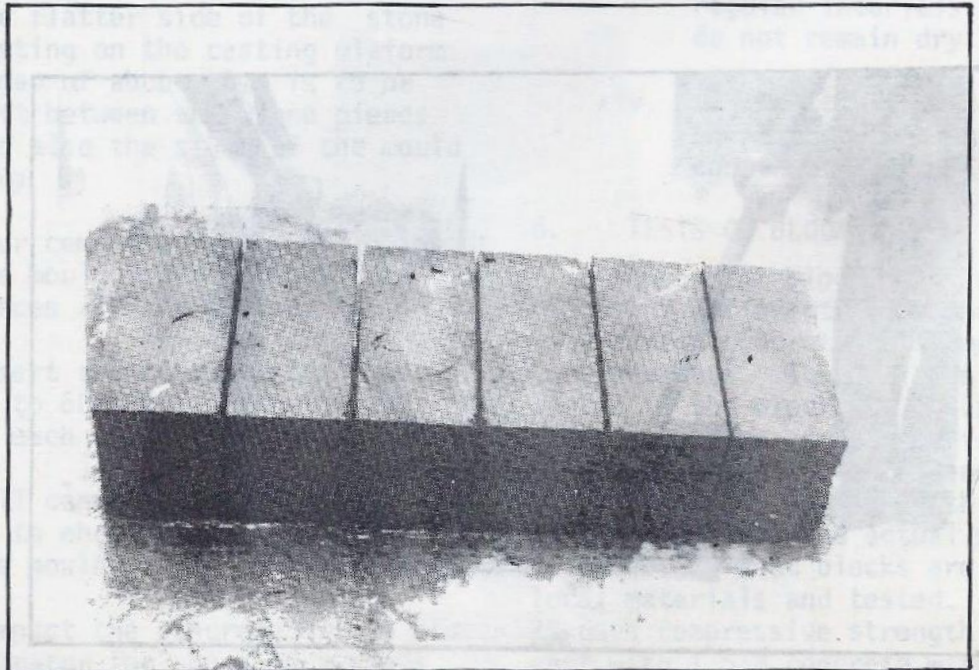


FIG. 9. STONECRETE BLOCKS AFTER DEMOULDING (THE STONE TEXTURE IS AT THE BOTTOM FACE)

The blocks were also subjected to water absorption and moisture movement tests. The average water absorption of the blocks was 4.9 per cent which is well within the permissible limit of 10 per cent. The average moisture movement of blocks was 0.04 per cent which is within the allowable limit of 0.09 per cent. Thus, stonecrete blocks pass the tests for structural and functional requirements.

7. MASONRY CONSTRUCTION

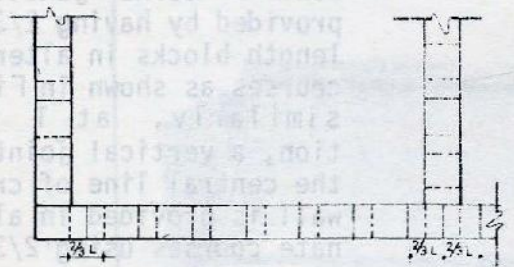
The blocks are used both for load bearing and non-load bearing walls. The thickness of the wall is designed depending upon the load coming over it, the compressive strength of blocks and the mortar used. While many of the construction features for building with stonecrete blocks are similar to those used in the construction with sandcrete blocks, there are some differences which must be recognised in order to obtain best results. The important aspects of construction with sandcrete blocks are discussed below:-

- i. As cutting of stonecrete blocks is not recommended, the building should be planned to suit the block dimensions i.e., all lengths of walls, openings, spaces between openings etc. should be in multiples of 100mm and all heights should be in multiples of course height i.e. 150mm.
- ii. The mortar for laying the blocks should not be leaner than 1:6 (cement: sharp sand) and where good quality lime is available, it is preferable to use composite mortar of 1 cement: 1 lime: 6 sharp sand.
- iii. The blocks should be water cured for a week and air dried for another three weeks, before laying in the masonry. If the climate is hot and dry, the blocks may be wetted on the surface only in order to reduce their suction of water from mortar. However wetting is generally neither necessary nor desirable. The consistency of the mortar should be adjusted to suit the suction of the blocks.
- iv. For breaking of vertical joints

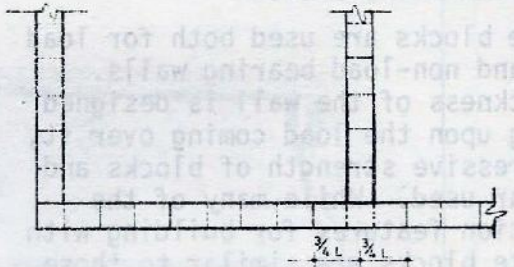
in alternate courses, smaller length blocks are used. The masonry bonds for various wall thicknesses at corners and junctions are shown in Fig. 10. In the figures, even courses are shown in firm lines and odd courses in dotted lines. The salient features of the bonds are explained below:-

- a. In 200mm thick walls, proper bond at corner junction is provided by having 2/3 length blocks in alternate courses as shown in Fig 10a similarly, at T junction, a vertical joint at the central line of cross wall is provided in alternate courses using 2/3 size blocks.
- b. In 150mm thick walls, full size blocks can be used to have proper bond at corners. At T junctions, a vertical joint at the central line of cross wall is provided in alternate courses using 3/4 size blocks as shown in Fig. 10b
- c. In case of T junction of 200mm thick wall with 100mm thick wall, the joints are staggered by using 1/3rd and 2/3rd length blocks in alternate courses as shown in Fig. 10c
- d. In 100mm thick walls, full size blocks can be used to have proper bond at corners. At T junctions, the joints are staggered by using 1/3rd length blocks in alternate courses as shown in Fig. 10d
- e. In case of T junction of 150mm thick wall with 100mm thick wall, the bonding is achieved by providing 200mm long 6mm dia. bars in alternate courses as shown in Fig. 10e For embedding the metallic ties, only cement and mortar should be used. Junction of 200mm thick wall with 150mm thick wall is also

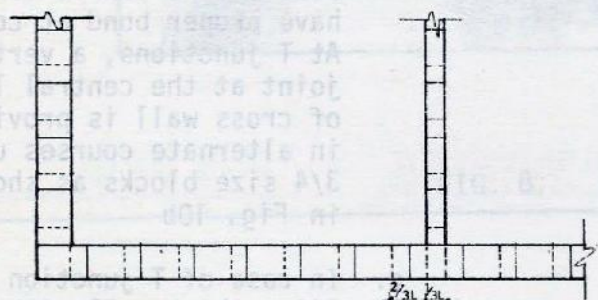
length blocks are used. The masonry bonds for various wall thicknesses at corners and junctions are shown in Fig. 10. In the figures, even courses are shown in fine lines and odd courses in dotted lines. The salient features of the bonds are explained below:-



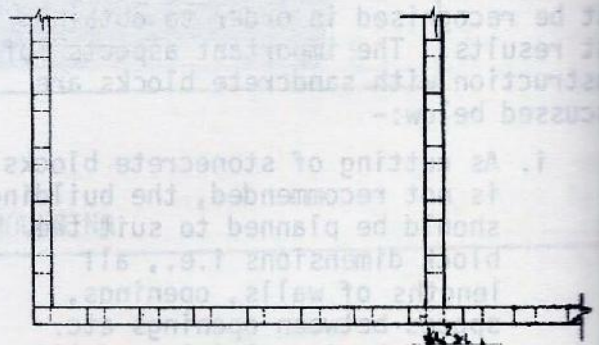
(a) CORNER & T-JUNCTION OF 200X200mm WALL



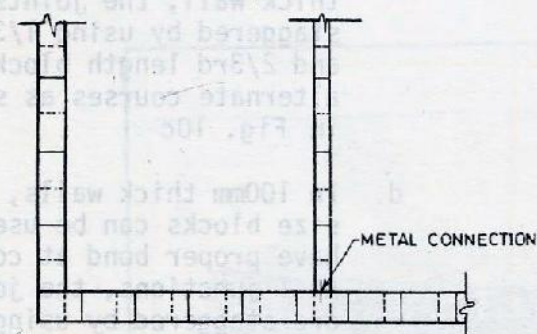
(b) CORNER & T-JUNCTION OF 150X150mm WALL



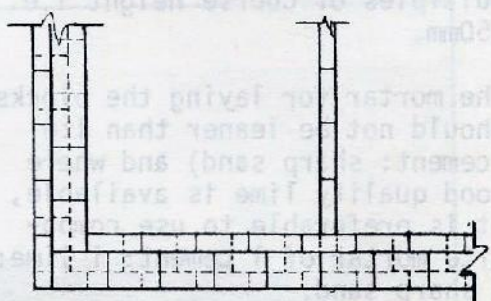
(c) T-JUNCTION OF 200X200mm WALL



(d) CORNER & T JUNCTION OF 100X100 mm WALL



(e) T-JUNCTION OF 150X100mm WALL



(i) CORNER OF 300 X 300 mm WALL & T-JUNCTION OF 300 X 100 mm WALL

Fig 10 DETAILS OF BOND IN STONECRETE BLOCK WALL

MASONRY CONSTRUCTION

The blocks are used both for bearing and non-bearing walls. The thickness of the wall is depending upon the load coming over it. The compressive strength of blocks is 10 N/mm². Thus, stonecrete blocks are suitable for structural and functional requirements.

As the laying of stonecrete blocks is recommended, the building should be planned to suit the block dimensions, i.e., all the joints of wall courses should be in the same vertical line.

The mortar for laying the blocks should not be leaner than (cement: sand) and good quality lime is available. The mortar should be used within 30 minutes after preparation.

For breaking of vertical joints, the mortar should be adjusted to suit the suction of the blocks. The consistency of mortar, however, wetting is generally neither necessary nor desirable. The consistency of mortar should be adjusted to suit the suction of the blocks. The mortar should be adjusted to suit the suction of the blocks. The mortar should be adjusted to suit the suction of the blocks.

done in a similar way.

f. The bonding at the corner of a 300mm thick wall and at T junction of a 300mm thick wall with 100mm thick wall are shown in Fig.10f.

v. The hold fasts for doors, windows etc. are fixed by embedding in 1:3:6 cement concrete.

vi. Double scaffolding should be used for constructing the walls. No holes should be left in the masonry to support the scaffolding.

vii. The external face of the wall with stone texture exposed may be finished with any desirable pointing. The internal face may be plastered.

viii. It is advisable to pre-plan the services and make provision during the construction of walls. Where large openings are required for provision of appliances, full blocks should be taken out and gaps filled with concrete, after placing the appliances. Plugs for fixing service pipes electrical fittings etc. may be inserted in the joints of the masonry. Space for niches or for fixing electrical switch board etc. is created by using thin blocks.

8. COST ECONOMICS

The cost of construction of walls with stonecrete blocks will vary from place to place and from time to time, depending upon the basic cost of materials and labour. However, from the data given here, the cost can be calculated, knowing the prevailing rate of materials and labour at a given place. For the production of 100 stonecrete blocks of nominal size 300 x 200 x 150mm, 1.8 bags of cement, 0.28m³ of sand, 0.45m³ of coarse aggregate 10mm and down and 0.37m³ of stone pieces 50 to 260mm size are required. One mason with five helpers can produce about 300 blocks per day (8 hours shift) which includes casting, stacking and curing for 7 days. Five battery moulds will be required for the production of 300 blocks and each mould can be reused at least 200 times. For the construction of 10m² of wall of 200mm thickness, about 222 stonecrete

blocks and 0.19m³ of mortar will be required. One mason with two helpers for the supply of mortar will be able to lay about 7.5m² of wall per day (8 hour shift).

From the above mentioned data, the cost of stonecrete block wall can be worked out and compared with the cost of walls built with sandcrete blocks, bricks etc. The cost of R.C.C. columns and beams used along with sandcrete blocks should also be taken into account, while comparing the cost of two or more storeyed buildings.

9. COMPARISON OF CEMENT CONSUMPTION

A comparison of cement required in case of 225mm thick sandcrete block masonry wall with 200mm thick stonecrete block masonry wall is given below. In both the cases, the inner face of the wall is plastered with 1:6 cement; sand mortar. In the case of sandcrete block wall, the outer face is plastered while in the case of stonecrete block wall the outer face is painted with 1:3 cement; sand mortar.

Table 2. Comparison of Consumption of cement for 10m² of Wall Area

S/No	Item	Cement Consumption (Bags)	
		Sandcrete Block Wall	Stonecrete Block Wall
1.	Blocks	7.02	3.42
2.	Mortar	0.72	0.95
3.	Plaster inside	0.72	0.72
4.	Plaster outside	0.72	-
5.	Painting outside	-	0.20
	Total	9.18	5.29

It can be seen that the use of stonecrete blocks in place of sandcrete blocks will result in a saving of 42 per cent in the consumption of cement. This will also result in considerable saving in foreign exchange for the nation, as bulk of the cement is imported.

10. ADVANTAGES

Stonecrete block masonry has the following advantages:

- i. Production of stonecrete blocks is a labour intensive technique of prefabrication. It will create job opportunities for many people.
- ii. Heavy capital investment or sophisticated equipments are not required for the production of the blocks.
- iii. The blocks can be produced at construction sites or at small scale factories, in areas where stones are abundantly available.
- iv. Compared to sandcrete block wall, the construction is simpler and faster, as stonecrete blocks are lighter and as there are no cavities, spreading of mortar is easy.
- v. Being solid walls, they do not provide access to rats, vermins etc.
- vi. The external face of the wall with exposed stone texture gives an aesthetically pleasing appearance Fig.11.
- vii. As stonecrete blocks have high compressive strength, they can be used in buildings upto 4 or 5 storeys high for load bearing walls, thus eliminating columns and beams normally required in case of buildings with sandcrete blocks.
- viii. Use of stonecrete blocks result in a saving of about 40 per cent in cement compared to sandcrete block walls.
- ix. In areas where stones are abundantly available, there will be considerable saving in overall cost also, by adopting this technique of construction.

Table 2. Comparison of Consumption of Cement for 10m² of Wall Area

S.No	Text	Cement Consumption (Bags)
1.	Blocks	7.02
2.	Mortar	0.75
		7.77

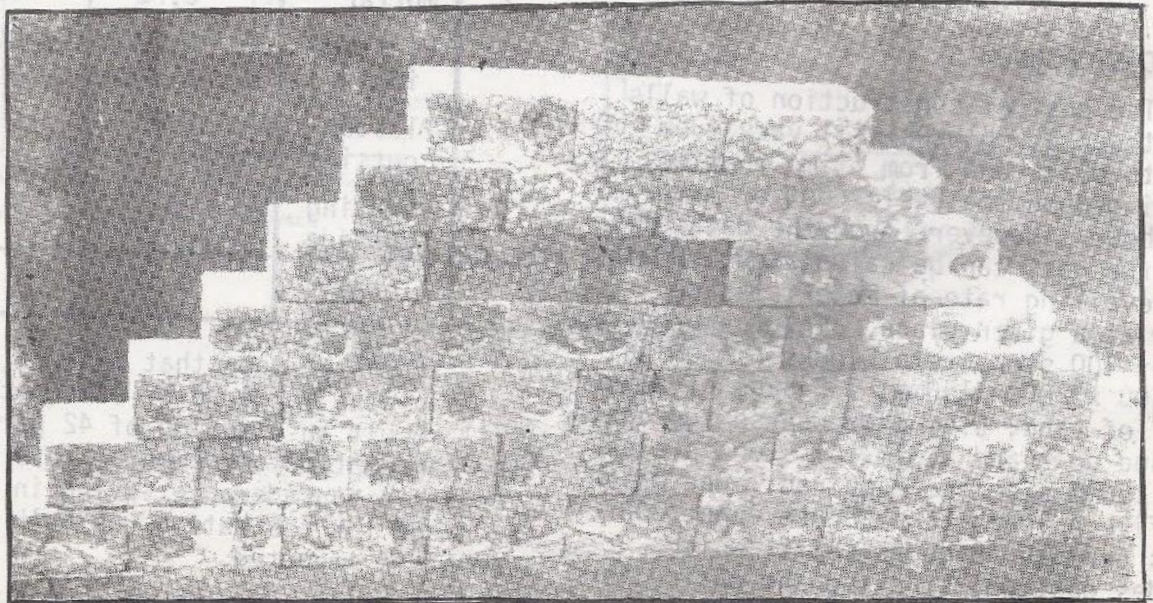


FIG. 11. A WALL BUILT WITH STONECRETE BLOCKS.

BUILDING CONSTRUCTION DIGEST

NO. 3

REINFORCED CONCRETE PLANK FLOORING/ROOFING SCHEME

By

J. S. Sharma, M. P. Jaisingh and J. O. Bereola

1. INTRODUCTION

In a building, the floor/roof costs about 25 percent of the building cost, consume substantial share of scarce materials like cement and steel and accounts for considerable part of the construction time. Any saving in this element alone will go a long way in reducing the overall cost of the building. Hence, Nigerian Building and Road Research Institute is putting considerable effort in developing economical flooring/roofing schemes. One such scheme, on which research studies have been carried out at the Institute, is discussed in this paper.

2. DETAILS OF THE SCHEME

The floor/roof consists of partially precast Reinforced Concrete joists with partially precast Reinforced Concrete planks laid over them and insitu deck concrete is provided over the planks. In case of floor, the flooring is laid directly over the planks, after the deck concrete is cured. In case of roof, waterproof treatment with or without thermal insulation layer is laid over the planks. In areas where there is considerable rainfall, the roof should be laid to a slope of at least 1 to 6.

The details of the structural components of the scheme are shown in Fig.2. The components are described below:

PRECAST R.C. PLANK

The partially precast R.C. plank (Figs. 3 and 4) has a width of 300mm and a length upto 1450mm. For the joist and the plank to act monolithically after the insitu deck concrete is laid over them, the plank is made 30mm thick with 100mm wide tapering ribs at both the ends for a length of 300mm and 50mm thick at the central portion. Reinforcement should be provided in the planks as per design. Three 6mm diameter mild steel (M.S) bars as main reinforcement and 6mm diameter M.S. bars spaced at 200mm centres as transverse reinforcement should be sufficient for the plank to be used in normal residential buildings.

The maximum weight of the plank is 45kg. It can be transported manually with ease. The plank is cast with cement concrete mix 1:2:4 (1cement: 2 sharp sand: 4 graded coarse aggregate 12mm and down).

PRECAST R.C. JOIST

The partially precast R.C. joists are 150mm wide and 150mm thick. Cement concrete 1:2:4 (1 cement: 2 sharp sand: 4 graded coarse aggregate 20mm and down) is used for casting the joist. Reinforcement is provided as per design. The stirrups are kept partly projecting out. The joists are placed at a spacing of upto 1.5m centre to centre and can be used for spans upto 4.2m in single and multi-storey buildings having load bearing walls or frames.

STRUCTURAL DESIGN

The R.C. Plank is designed for two stages of loading. In the first stage, it is designed as a simply supported member for self-weight including insitu concrete in the haunches, weight of deck concrete and live load during the construction. In the second stage, it is designed as continuous slab for live loads and the dead load of the floor finish or roof finish, as the case may be.

The precast R.C. joists are designed as simply supported or continuous T-beams depending upon the end conditions. Due to the shape of the R.C. planks and the insitu deck concrete with reinforcement provided over them, the joists and the planks act monolithically as T-beams. The reinforcement is provided as per design requirements, depending upon the spacing and span of joist and the loads. When the joists are designed as continuous beams, reinforcement as per design requirements should be provided over the supports. The beams should also be checked for crack width at working load stage and for long term deflection

PRECASTING OF R.C. PLANK

The R.C. planks are cast in steel moulds (Figs. 5 and 6), fabricated from M.S. plates and angle irons over a smooth and level surfaced concrete casting platform as described below:-

- i. Apply a bond-release agent to the surface of the casting platform and to the inner sides of the steel mould members.
- ii. Assemble the members of the mould over the casting platform.

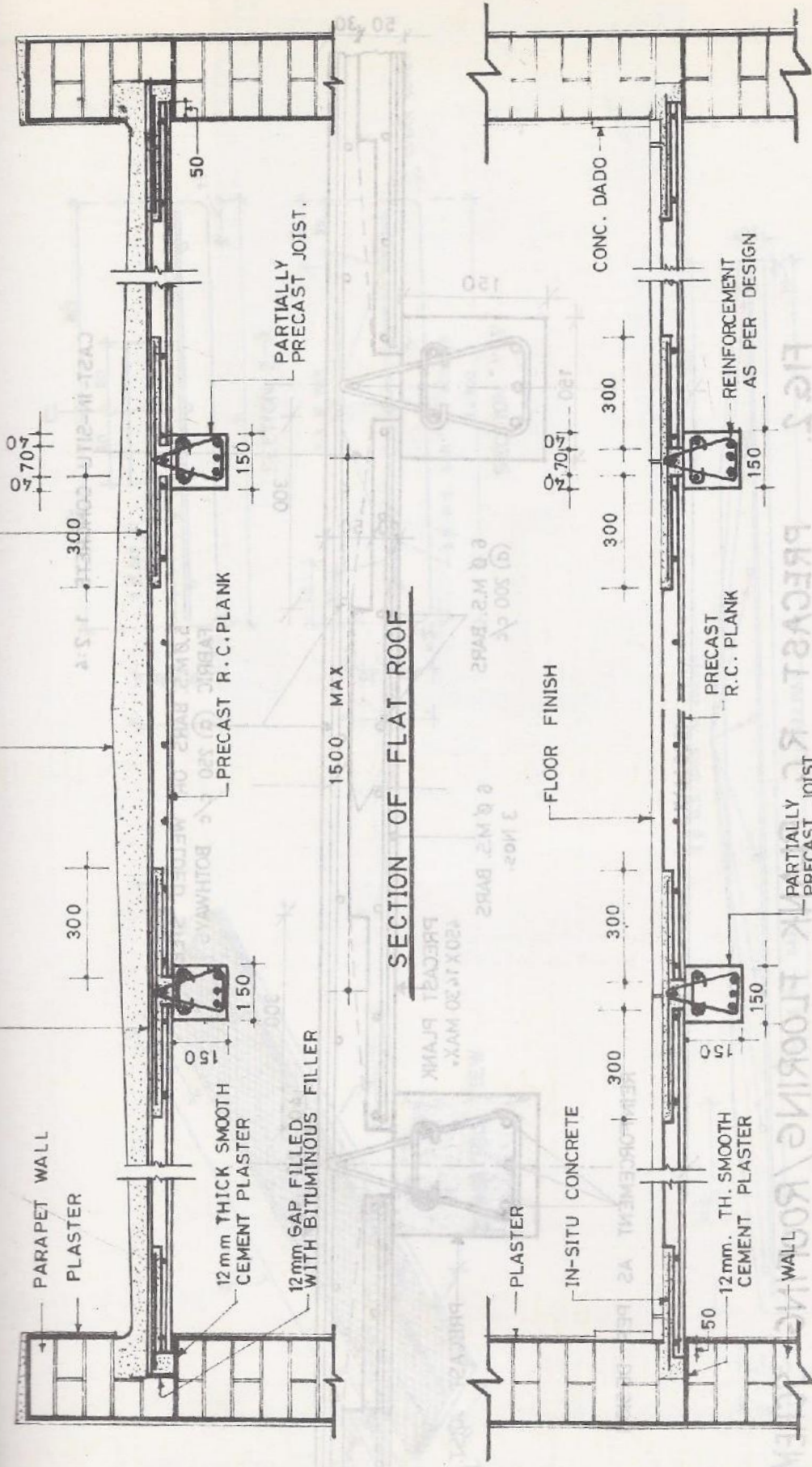


Fig 1 PRECAST R.C. PLANK FLOOR/ROOF

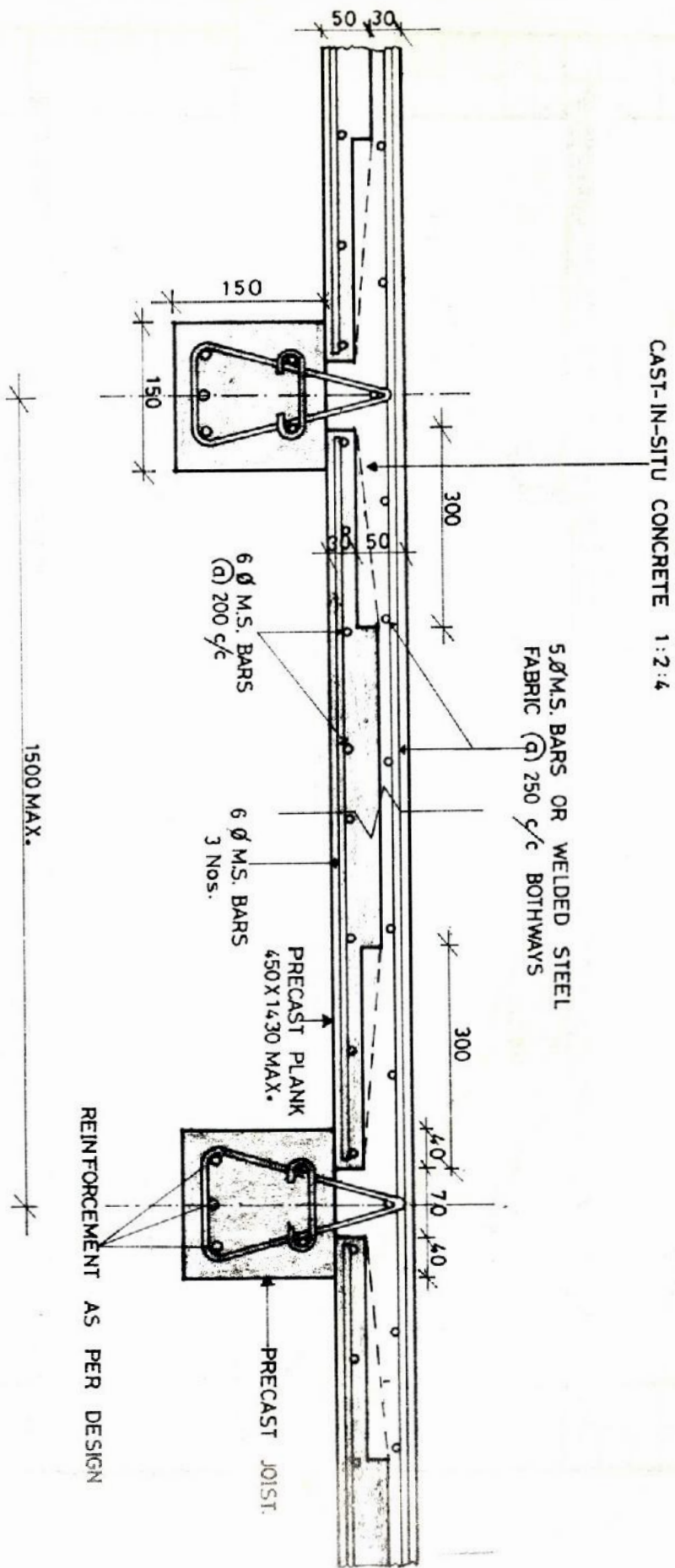


FIG. 2. PRECAST R.C. PLANK FLOORING/ROOFING SCHEME

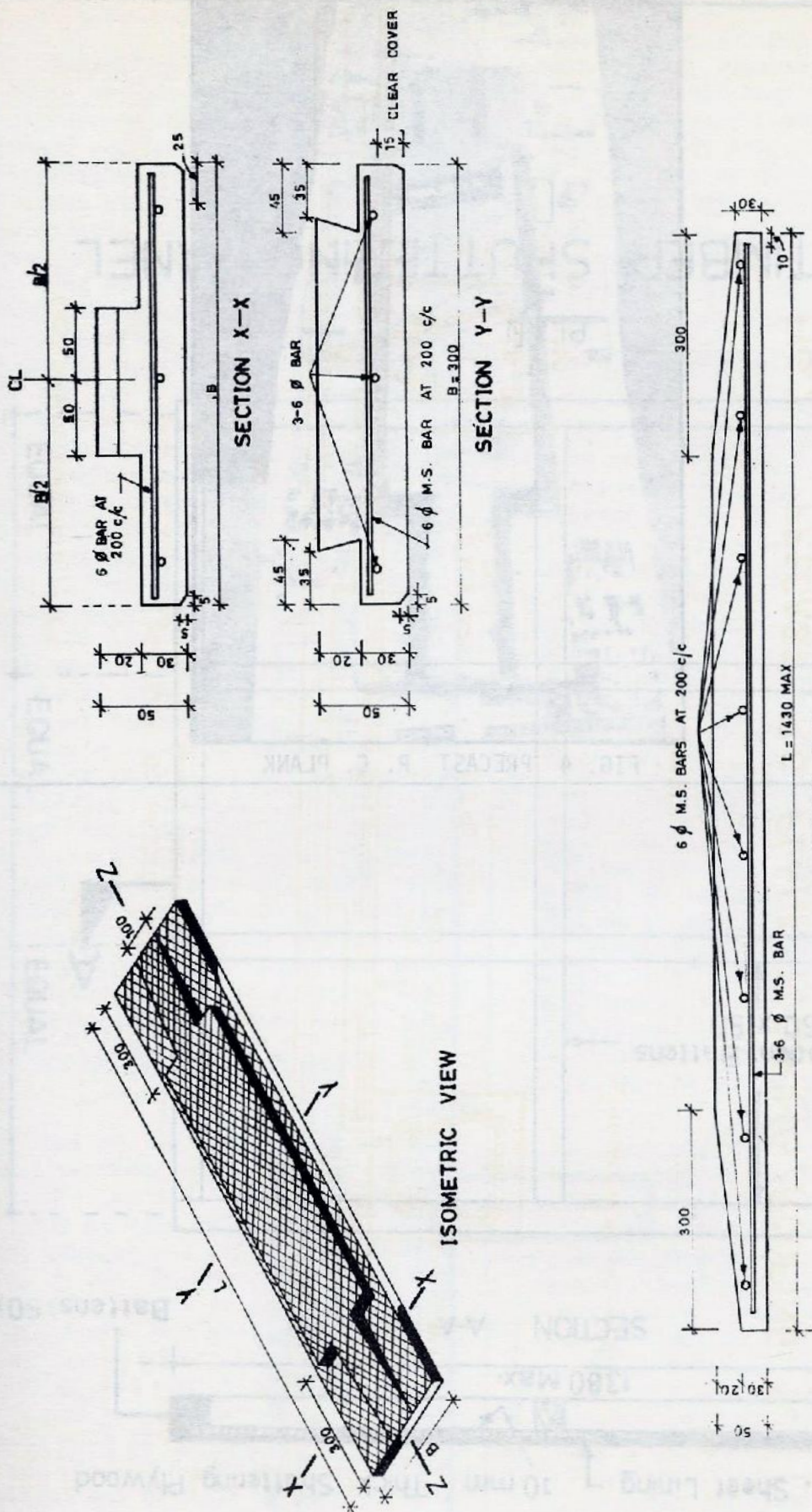


FIG 3 PRECAST R.C. PLANK

КНИГА 3. Р. ТАСЭРЭ 3 ДТ

FIG 2 PRECAST R.C. PLANK STRONG/ROOFING SCHEME

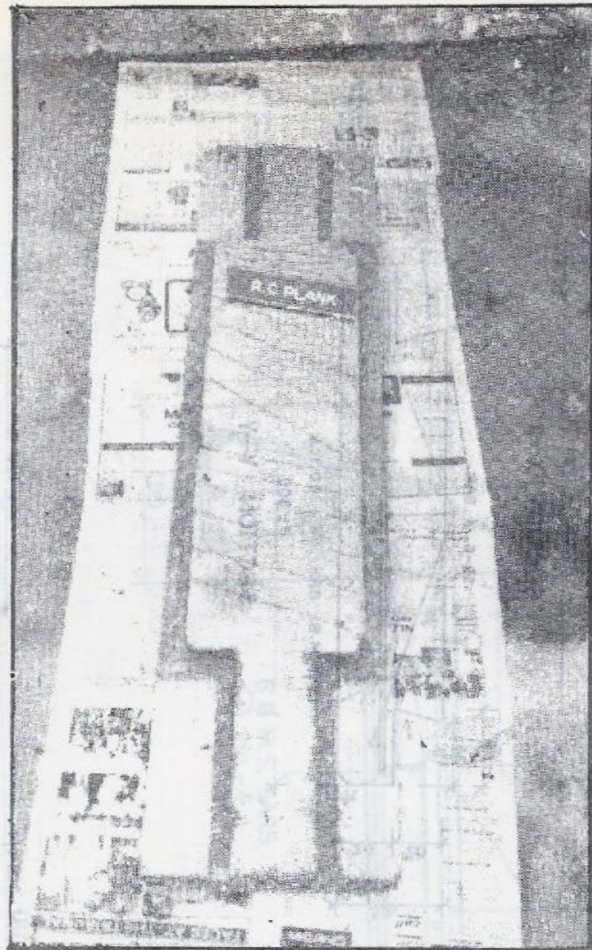
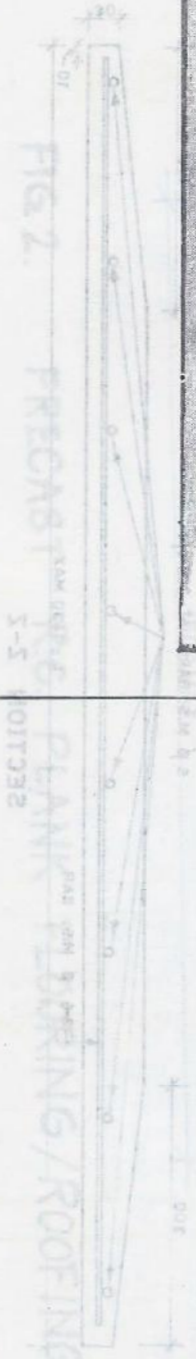
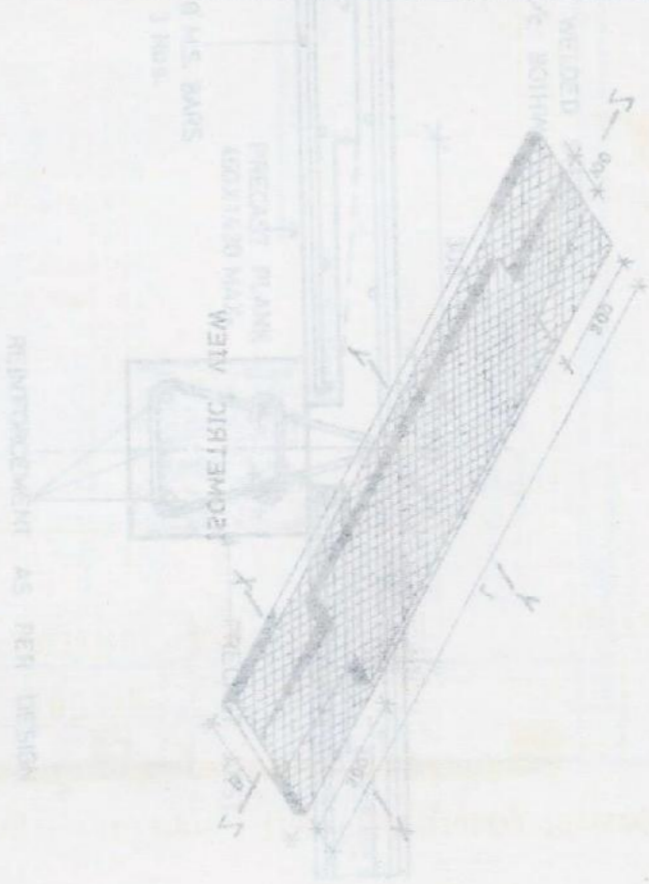
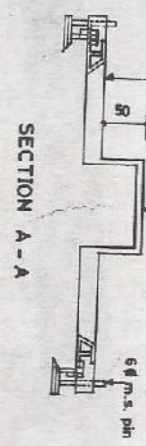
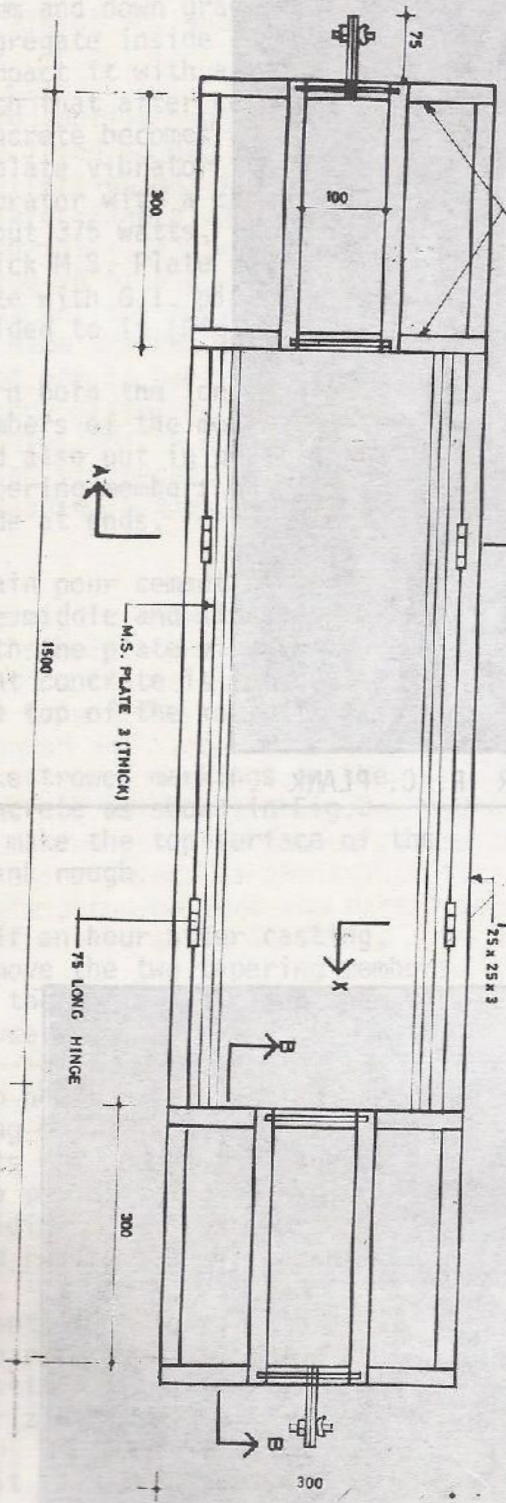


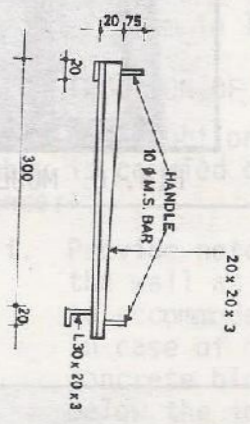
FIG. 4 PRECAST R. C. PLANK



PLAN



SECTION B-B



SECTION X-X

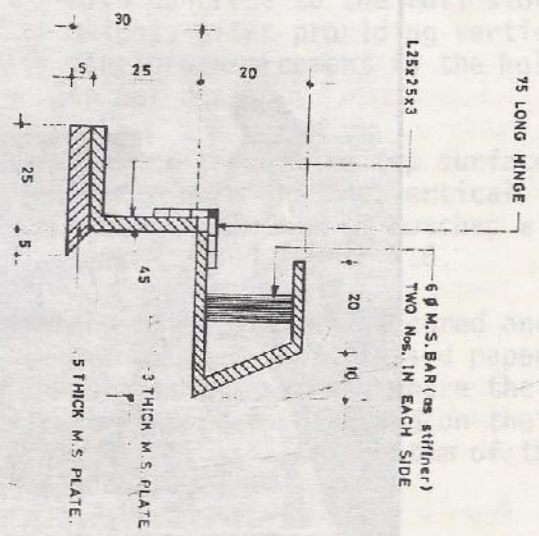


FIG. 5 MOULD FOR R.C. PLANK

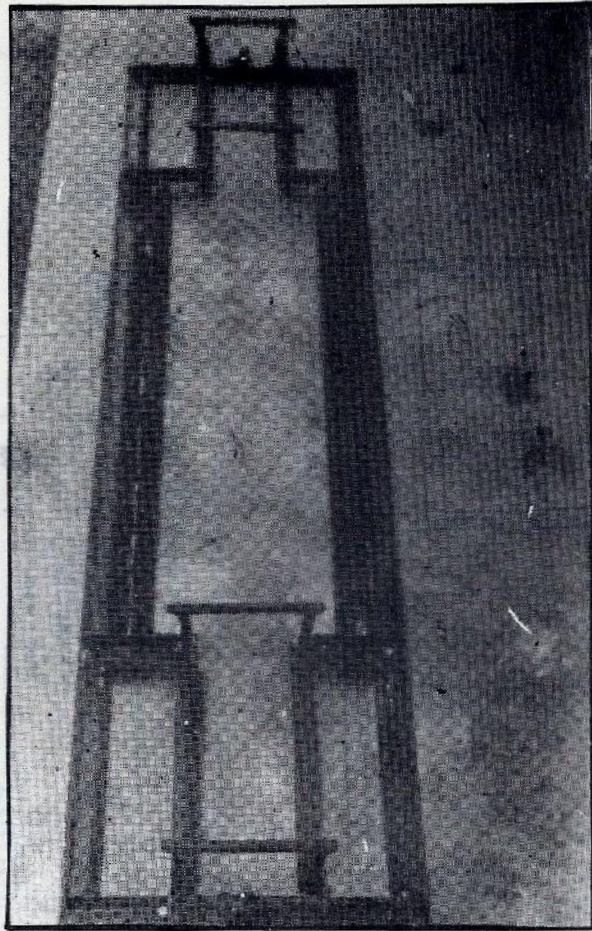


FIG. 6 MOULD FOR R. C. PLANK

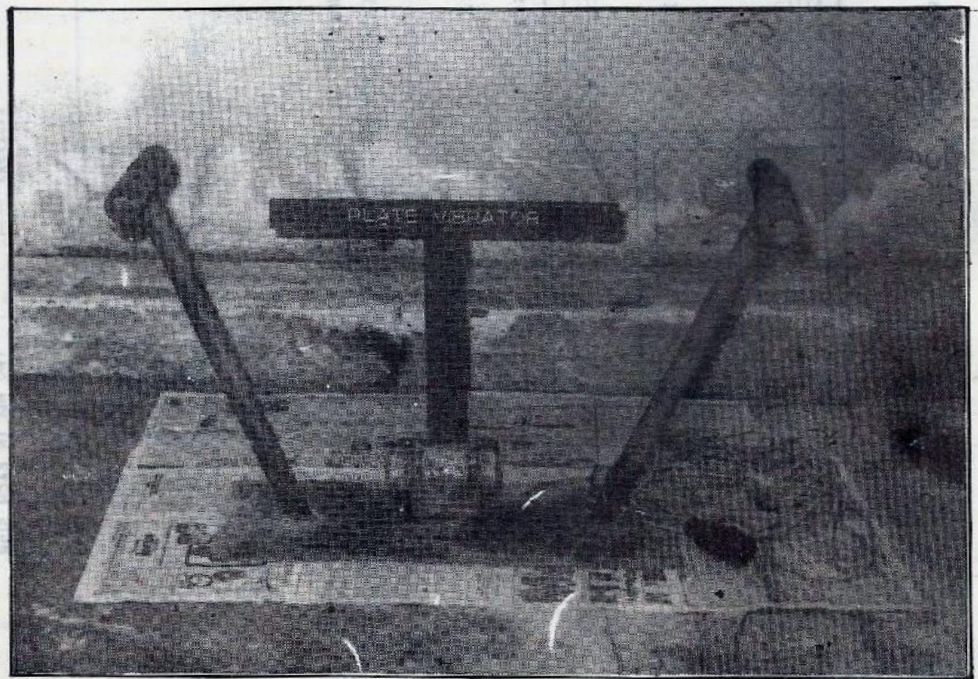


FIG. 7. PLATE VIBRATOR

iii. Place the reinforcement cage inside the mould with 15mm thick cover blocks tied to them to ensure sufficient cover to the reinforcement.

iv. Pour 1:2:4 cement concrete with 12mm and down graded coarse aggregate inside the mould and compact it with a plate vibrator such that after compaction, the concrete becomes 30mm thick. A plate vibrator is a shutter vibrator with a capacity of about 375 watts, fixed to a 5mm thick M.S. Plate 450 x 750mm size with G.I. pipe handles welded to it (Fig.7)

v. Turn both the longitudinal side members of the mould upwards and also put in position the tapering members on either side at ends.

vi. Again pour cement concrete in the middle and sides and vibrate with the plate vibrator such that concrete is in level with the top of the mould.

vii. Make trowel markings on the concrete as shown in Fig.3 to make the top surface of the plank rough.

viii. Half an hour after casting, remove the two tapering members of the mould and clean them for reuse.

ix. Two hours after casting, depending on the weather, open the nuts and remove the sides of the mould by light tamping and sliding away. Clean the mould and reassemble for reuse.

x. Twenty four hours after casting, separate the plank from the casting platform by pushing it horizontally.

xi. Tilt the plank through 90° on long edge and transport it in vertical position and stack it vertically against support in a curing yard.

ii. Cure the plank by sprinkling water for two weeks and allow them to dry for another two

weeks before using them in the construction of floor/roof.

The permissible tolerances in the planks are ± 3 mm in width and thickness and ± 5 mm in length.

PRECASTING OF R.C. JOIST

R.C. Joists are precast in steel mould like casting any other beam. The only difference in this case is that the stirrups are kept partly projecting above the mould. The cover to the reinforcement is kept as 25mm and cement concrete 1:2:4 with 20mm size graded coarse aggregate is used. A needle vibrator is used to compact the concrete. Fan-hooks may be provided in the required number of joists while casting them. For accommodating fanhooks during the casting operation, notches have to be provided in the casting platform. The joists are water cured for two weeks and air dried for another two weeks, before using them in the construction. The permissible tolerance in the joists are ± 3 mm in breadth and depth and ± 10 mm in length.

CONSTRUCTION OF FLOOR/ROOF

The construction of the floor/roof assembly is carried out in the following sequence:-

i. Provide notches at the top of the wall at the required spacing to accommodate the R.C. joists. In case of hollow sandcrete/concrete block walls, the hollows below the joists should be filled with concrete to the full storey height, after providing vertical steel reinforcement in the hollows, as per design.

ii. Plaster the entire top surface of the wall and the vertical sides and bottom of notches with cement: sand mortar 1:6.

iii. After the plaster is cured and dried, place bitumenised paper on the wall surface where the planks are to rest and on the vertical side and bottom of the notches.

iv. Place the joists in the notches with a minimum bearing of 75mm, align and level them. In case of framed structures, the joists are provided over the beams.

- v. Immediately after erecting the joist, support it at midspan at the correct level with a prop having a timber piece 350mm long, 150mm wide and 10mm thick, fixed to its top (Fig. 8).
- vi. Place the precast planks over the joists and the walls side by side with a minimum bearing of 40mm over the joist and 50mm over the walls (Fig. 9).
- vii. Provide proper cat-walks resting on the walls/beams for the workers to move about, without causing load on the planks and joists.
- viii. Lay 6mm dia. M.S. bars at 200mm spacing in both directions or an equivalent wiremesh over the entire area of planks and beams. Also provide reinforcement over the support sections of the joists, as per design, wherever the joists have been designed as continuous beams.
- ix. Apply cement water wash with 4kg of cement/10m² area over the joists and planks just before laying in-situ deck concrete.
- x. With a trowel, apply a thick paste of cement and mortar 1:4 at the joints of adjacent planks along their length to fill upto the bottom and cover the joints.
- xi. Place cement concrete 1:2:4 (1 cement: 2 sand: 4 graded coarse aggregate 10mm and down) over the joists and planks in the haunches and 30mm thick over the entire area.
- xii. Compact the concrete with a plate vibrator.
- xiii. Cure the insitu concrete by ponding water for a minimum period of 10 days.
- xiv. Remove the props under the joists, when the concrete laid insitu has attained strength. A minimum period of 17 days is recommended for the removal of the props.
- xv. After the concrete is dried, clean the surface and provide flooring or roofing treatment directly over it.
- xvi. Provide 'V' groove pointing in cement: sand mortar 1:4 in the ceiling along the joints of the planks.
- xvii. Cantilever projections of the floor/roof can be built by projecting out the partially precast R.C. planks/joists (Figs 10 and 11). In such cases, the members are to be designed as cantilevers for the superimposed loads and the main reinforcement provided at the top of the member in the insitu concrete. The free end of the joint is to be propped adequately until the insitu concrete attains strength.

STRUCTURAL TESTS

The R.C. planks were subjected to deflection recovery and ultimate load tests as per standard practice. A plank was placed over short walls with 40mm bearing on either side. The haunches were filled with 1:2:4 concrete, water cured for two weeks and air dried for another two weeks, before carrying out the tests. A load equivalent to the weight of floor finish was applied uniformly with concrete blocks 72 hours before the start of the test.

A dial guage was fixed below the plank at its midspan and the initial reading noted. One and a quarter times the design live load was then applied over the planks uniformly with concrete blocks. Twenty four hours after the application of the load, the deflection at midspan of the plank was measured with dial guage and the live load was removed. Twenty four hours after the removal of the load, dial guage reading was again taken and the recovery in deflection was computed. It was found that the deflection recovery twenty four hours after the removal of the load was 87 percent of the deflection under the load for twenty four hours. The deflection recovery is more than the specified minimum recovery of 75 percent and hence the plank passes the test.

The plank was then subjected to ultimate load test (Fig. 12) by placing

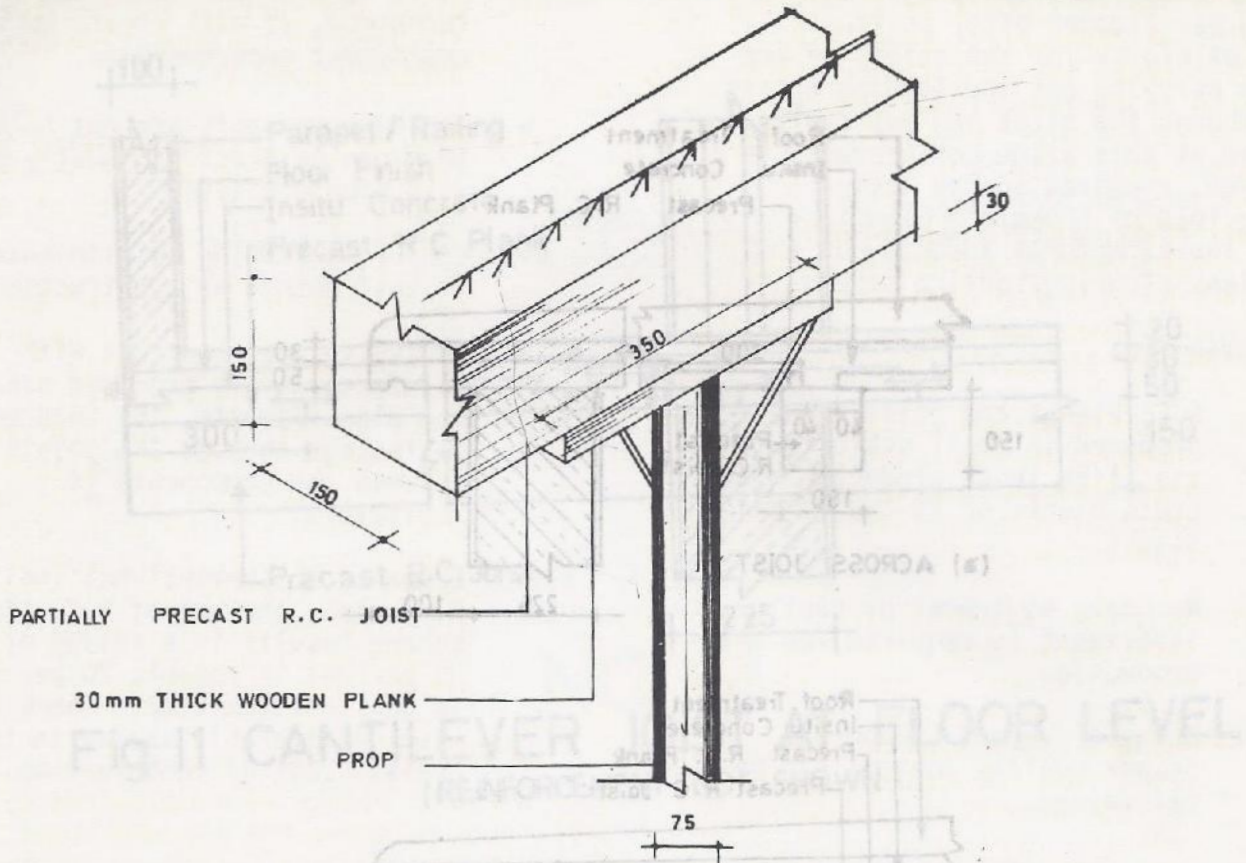


Fig 8 PROPPING OF PARTIALLY PRECAST JOIST

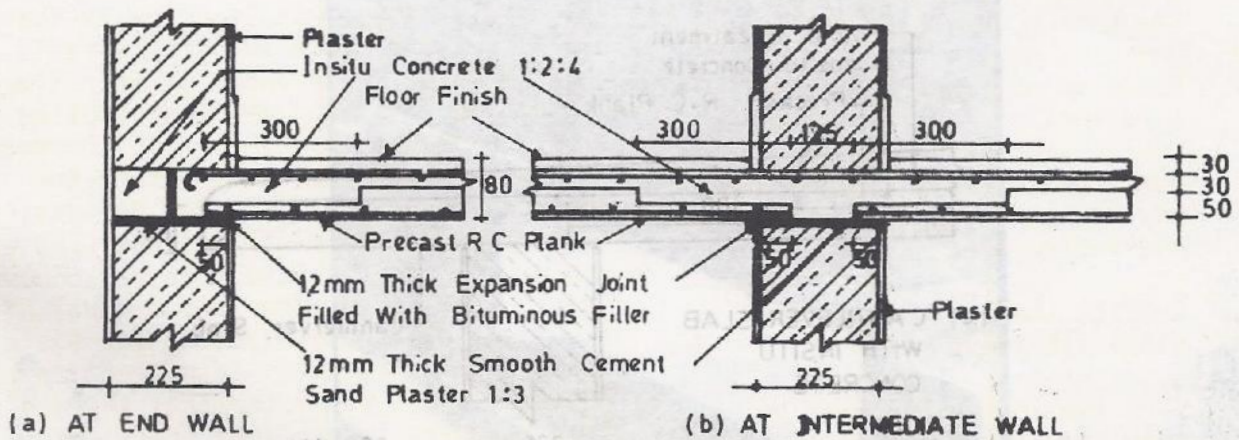


Fig 9 DETAILS SHOWING BEARING OF PLANKS OVER WALLS

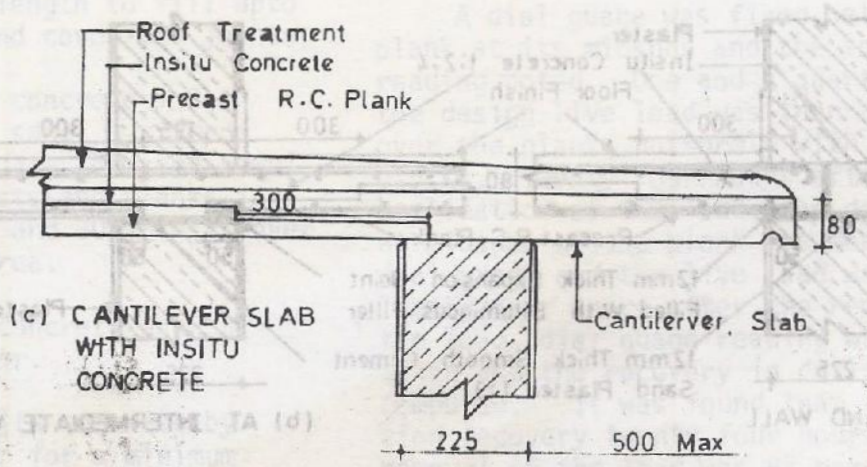
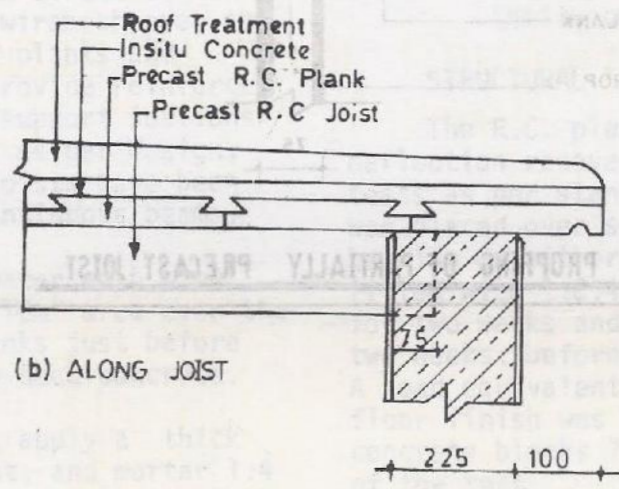
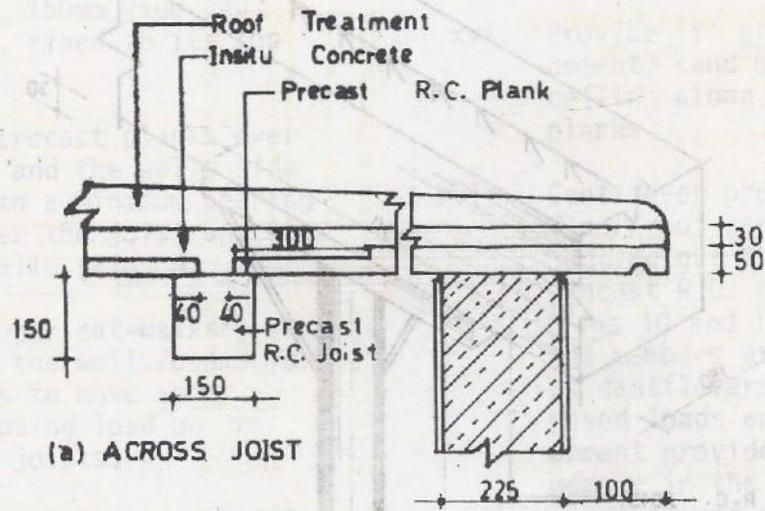


Fig 10 DETAILS OF ROOF PROJECTION.
(REINFORCEMENT NOT SHOWN)

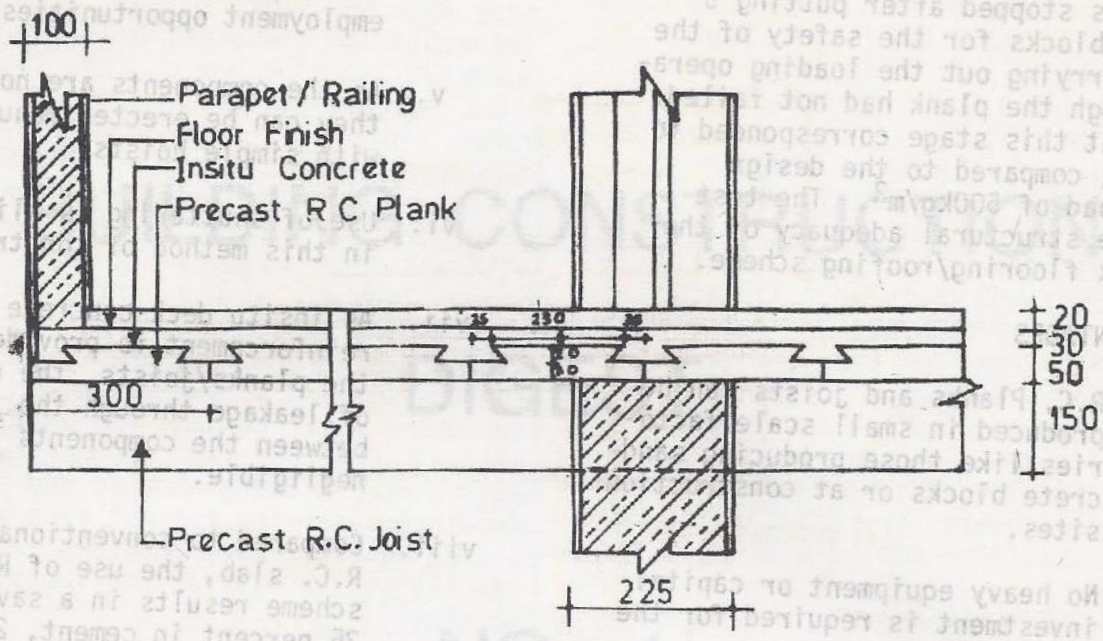


Fig. 11 CANTILEVER JOIST AT FLOOR LEVEL
 (REINFORCEMENT NOT SHOWN)

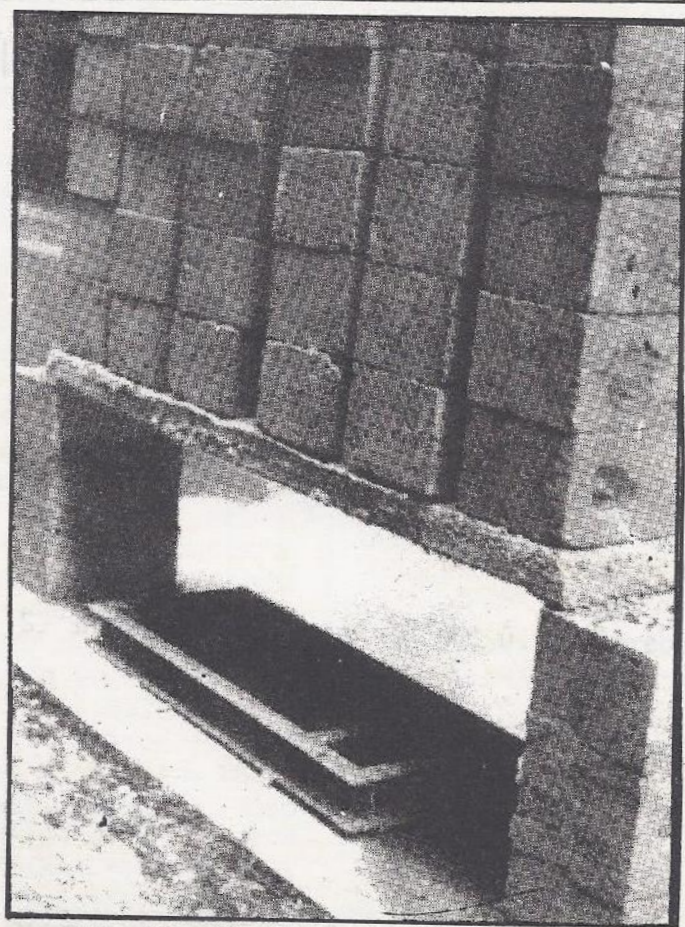


FIG. 12 PRECAST R.C. PLANK UNDER ULTIMATE LOAD TEST

concrete blocks uniformly over it. The loading was stopped after putting 5 layers of blocks for the safety of the workers carrying out the loading operation, though the plank had not failed. The load at this stage corresponded to 1424kg/m^2 , compared to the design working load of 500kg/m^2 . The test proves the structural adequacy of the R.C. plank flooring/roofing scheme.

ADVANTAGES

- i. R.C. Planks and joists can be produced in small scale factories like those producing sand-concrete blocks or at construction sites.
- ii. No heavy equipment or capital investment is required for the production.
- iii. Being a precast component, proper quality control can be maintained.

- iv. As it is a labour intensive technique, it will create more employment opportunities.
- v. As the components are not heavy, they can be erected manually or with simple hoists.
- vi. Use of shuttering is eliminated in this method of construction.
- vii. As insitu deck concrete with reinforcement is provided over the planks/joists, the chances of leakage through the joints between the components is negligible.
- viii. Compared to conventional insitu R.C. slab, the use of R.C. plank scheme results in a saving of 35 percent in cement, 20 percent in construction time. There is also considerable saving in the overall cost of construction.



FIG. 15 PRECAST R.C. PLANK UNDER ULTIMATE LOAD TEST

BUILDING CONSTRUCTION

DIGEST

NO. 4

THIN REINFORCED CONCRETE RIBBED SLAB FOR FLOORS AND ROOFS

By

J. S. Sharma, M. P. Jaisingh and J. O. Bereola

INTRODUCTION

Thin Reinforced Concrete ribbed slab consists of precast R.C. ribs 110mm x 200mm spaced at 1 to 1.5m centre to centre with 70mm thick cast-in-situ R.C. flange above (Fig.1). It can be used for floors and flat as well as sloping roofs in single and multi-storeyed residential and other types of lightly loaded buildings. In case of heavily loaded floors and roofs, the size and reinforcement of the ribs and flanges shown in Fig.1 may not be adequate and may have to be increased. Floor/roof treatment can be provided directly over the ribbed slab. Ceiling plaster could be avoided in low cost constructions. In situations where very good finish is called for, ceiling may be plastered.

STRUCTURAL DESIGN

The structural design may be carried out as per the limit state method or any other accepted theory. The precast ribs are designed to act as rectangular beams during the construction to support the weight of concrete in the flange, the shuttering and live load of workman and equipment. The ribs are designed to act as T-beams for the full design loads, after the concrete in the flanges has attained strength. The flange is designed as a continuous slab, spanning over the ribs. To keep the deflections within permissible limits, the span/depth ratios for the flange and the rib have been kept as per the relevant provisions of Nigerian Standard Code of practice for the structural use of concrete in buildings. To control flexural cracking, the spacing requirements for reinforcement as given in the code have been complied with. To ensure monolithic action of precast ribs with cast-in-situ flange, stirrups in the ribs have been kept projected into the cast-in-situ concrete of the flange.

PRECASTING AND ERECTION OF RIBS

The ribs are precast, preferably in steel moulds over a concrete casting platform. A bond release agent is applied to the top of the casting platform and the inner sides of the mould. The reinforcement cage is then kept in position leaving a clear cover of 25mm to the main reinforcement bars. To provide holes in the ribs, 25mm square M.S. hollow box sections are inserted through square holes in the longitudinal members of the

mould. 1:2:4 concrete (1 cement: 2 sharp sand: 4 graded coarse aggregate of size 20mm and down) is then poured into the mould and compacted thoroughly with a needle vibrator having 25mm diameter pin. The top surface is finished rough. About 3 to 4 hours after casting, the rib is demoulded by sliding the longitudinal pieces of the mould away from the precast rib. The rib is kept covered with wet gunny bags for 72 hours. Afterwards, they are slid horizontally on the casting platform to break the bond with the platforms and transported to the curing yard or curing tank. After two weeks water curing, the units are allowed to air dry for another two weeks, before using them in any construction. The precast ribs are placed in 115mm wide recesses left at the top of the wall at the specified spacing.

ASSEMBLY OF SHUTTERING PANELS

Plane simple shuttering panels (Fig.2.) made of timber framing and plywood panelling covered with G.I. Sheets are used for casting the flange portion. At least 20 reuses could be expected from G.I. Sheet lined shuttering panels. Alternatively, steel shuttering panels could be used in which case, the number of reuse will be more. The width of the shuttering panels is kept as the clear distance between the ribs with a clearance of 5mm both sides and the length of the panel is preferably kept in modules of 300mm i.e. 1200, 1500, 1800mm etc. A combination of them could be used to suit the span of the room. Even number of panel is used in each day, so that they could be placed symmetrical with respect to midspan of the rib. The shuttering panels are kept supported on 20mm square M.S. bars projecting out of holes left in the precast ribs as shown in Fig. 3. As the ribs are designed as rectangular beams to carry the load of insitu concrete, shuttering, workman and equipment during concreting, no props are required in this type of construction. The shuttering panels are kept in position and levelled with the help of wedges with the top surface of the precast rib in level with the top of the shuttering. Gaps, if any, between shuttering panels or between the panels and the precast ribs are to be filled with mud mortar or lean cement mortar and levelled flush with the top surface of the shuttering.

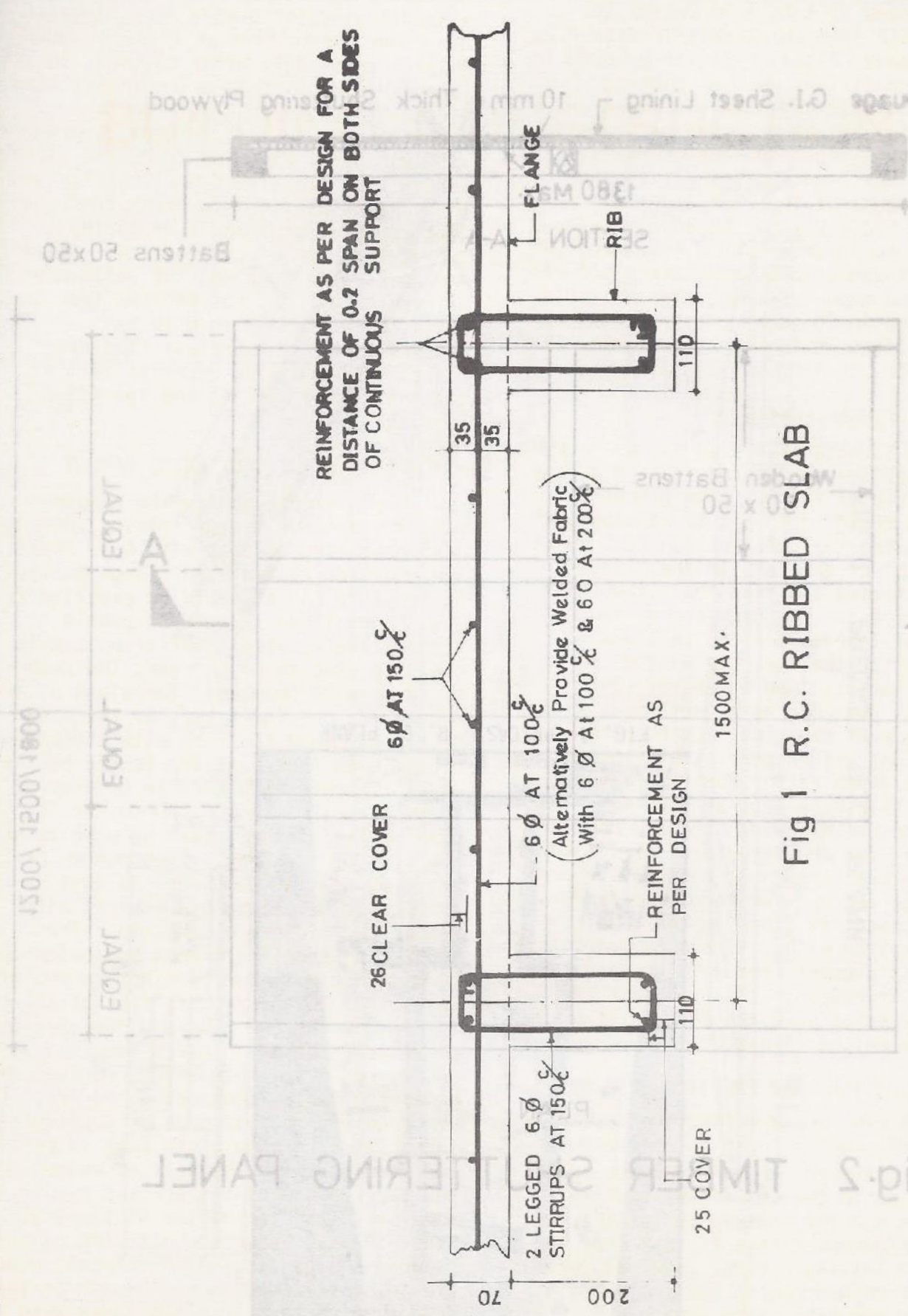
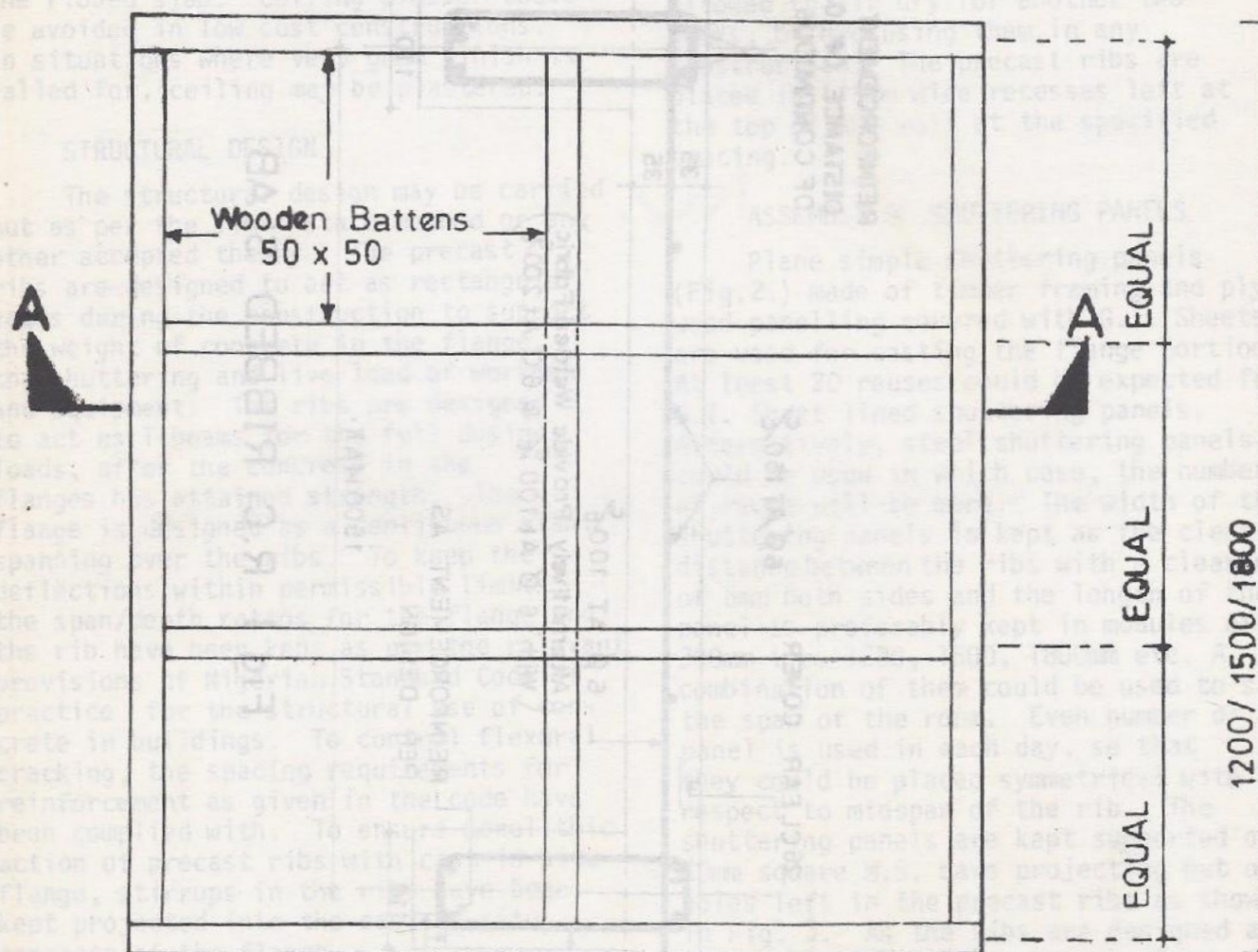
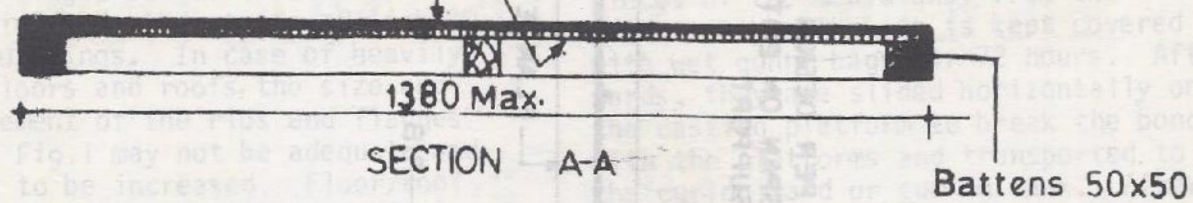


Fig 1 R.C. RIBBED SLAB

Thin Reinforced Concrete ribbed slab consists of precast R.C. ribs 110mm x 75mm spaced at 1 to 1.5m centre to centre with 20mm thick cast-in-situ R.C. concrete above (Fig. 1). It can be used for



PLAN

Fig.2 TIMBER SHUTTERING PANEL

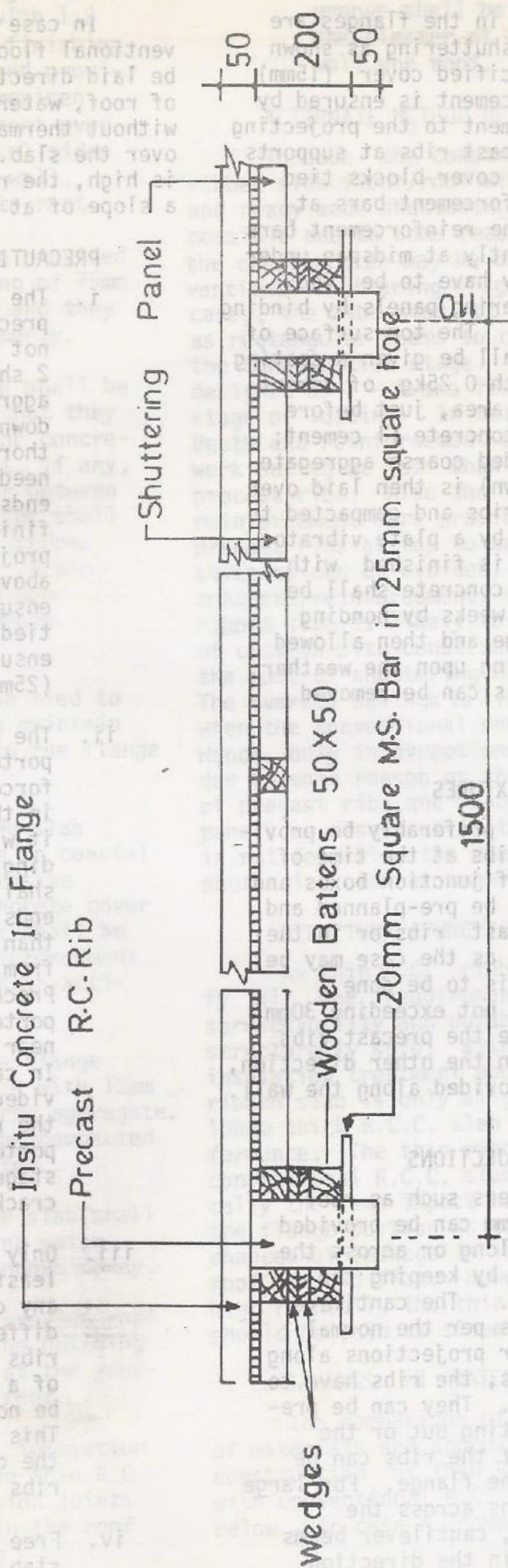


Fig 3 SHUTTERING PANELS IN POSITION

Reinforcement in the flanges are assembled over the shuttering as shown in Fig. 1. The specified cover (15mm) to the main reinforcement is ensured by tying the reinforcement to the projecting stirrups of the precast ribs at supports and by keeping 15mm cover blocks tied below the main reinforcement bars at midspan. In case the reinforcement bars do not sag sufficiently at midspan under selfweight, they may have to be tied down with the shuttering panels by binding wires at intervals. The top surface of the precast ribs shall be given a coating of cement slurry with 0.25kg of cement per square metre of area, just before concreting. 1:2:4 concrete (1 cement: 2 sharp sand: 4 graded coarse aggregate of size 12mm and down) is then laid over the shuttering and ribs and compacted to a thickness of 70mm by a plate vibrator and the top surface is finished with wooden floats. The concrete shall be water cured for two weeks by ponding water over the flange and then allowed to air dry. Depending upon the weather, the shuttering panels can be removed after three days.

FITTING AND FIXTURES

Fanhooks shall preferably be provided in the precast ribs at the time of casting. Position of junction boxes and other fittings shall be pre-planned and provided in the precast ribs or in the cast-in-situ flange, as the case may be. If concealed wiring is to be done, conduits of diameter not exceeding 30mm may be provided above the precast ribs along its length. In the other direction, conduits shall be provided along the wall.

CANTILEVER PROJECTIONS

Short cantilevers such as roof projections upto 500mm can be provided in the ribbed slab along or across the direction of the rib by keeping the flange projected out. The cantilever has to be designed as per the normal practice. For longer projections along the direction of ribs, the ribs have to be designed suitably. They can be pre-cast and kept projecting out or the cantilever portion of the ribs can be cast-in-situ along the flange. For large cantilever projections across the direction of the rib, cantilever beams have to be provided in the direction.

In case of ribbed slab floor, conventional floor finish such as tiles can be laid directly over the slab. In case of roof, waterproof treatment with or without thermal insulation can be laid over the slab. In areas, where rainfall is high, the roof shall be provided with a slope of at least, 1 to 6.

PRECAUTIONS IN CONSTRUCTION

- i. The concrete used for the precast ribs shall be of mix not leaner than 1:2:4 (1 cement: 2 sharp sand: 4 graded coarse aggregate of size 20mm and down). Concrete shall be thoroughly compacted with a needle vibrator and the top and ends of the ribs shall be finished rough. The specified projection of the stirrups above the rib concrete shall be ensured. Cover blocks shall be tied to the reinforcement to ensure the specified cover (25mm).
- ii. The precast ribs shall be transported only with the main reinforcement at the bottom, i.e. in the natural position in which it will be placed in the building. While transporting, they shall be supported from the two ends (at a distance not more than 0.15 times the length from the ends) and midspan. Precast ribs shall not be transported or kept supported at or near midspan only, at any stage. In case fanhooks have been provided in the ribs near midspan, the ribs shall not be kept supported on the fanhooks at any stage, as this could cause cracks in the rib.
- iii. Only precast ribs cured for at least 28 days shall be used in any construction. The age difference between two adjacent ribs in the same floor or roof of a building shall preferably, be not more than two weeks. This is necessary to ensure that the deflections of the adjacent ribs are practically the same.
- iv. Free movement of the ribbed slab roof over supporting walls/

plastering the bearing area of the flange and ribs with 1:3 cement: sand mortar, finishing it level and smooth and providing a layer of bitumenised paper or polythene sheet over the bottom and vertical sides of the recess in the wall, in which the rib is to rest.

- v. Precast ribs shall be provided with a minimum bearing of 75mm over the walls/beams and they shall be aligned properly.
- vi. The shuttering panels shall be kept supported such that they do not move during the concreting operation. Gaps, if any, between the panels or between the panels and the ribs shall be thoroughly packed before laying the concrete. Mould oil shall be applied over shuttering panels before concreting.
- vii. Cover blocks shall be tied to the reinforcement to maintain the required cover to the flange reinforcement.
- viii. When thin R.C. ribbed slab construction is done in coastal areas or in any corrosive environment, the concrete cover to the reinforcement shall be increased or the reinforcement shall be coated with an anti-corrosive paint.
- ix. The concrete for the flange shall be of mix 1:2:4 with 12mm and down graded coarse aggregate. The concrete shall be compacted using a plate vibrator.
- x. Proper curing of the slab shall be ensured by ponding water over it or by continuous spray.
- xi. It is advisable to provide roof projection around the building to prevent leakage at the junction of walls with roof.
- xii. In case no thermal insulation is provided over the thin R.C. ribbed slab, expansion joints shall be provided in the roof at a closer spacing.

slab is plastered, a 'Y' groove shall be provided in the plaster at the junction of wall and roof.

ALTERNATE METHOD OF CONSTRUCTION

In case the construction of R.C. ribbed slab floor/roof with precast ribs and ready made shuttering panels is not possible due to some reason or the other, the construction may be done with conventional shuttering (Fig.4). In such cases, the ribs need not be designed as rectangular beams to carry the load at the construction stage. They shall be designed as T - beams for the final stage of loading. In this case, the depth and reinforcement of the ribs may work out to be less than that of the precast ribs. Also the longitudinal reinforcement bars provided inside the precast ribs at top to take handling stresses can be avoided. The cost of concrete/reinforcement in the R.C. ribbed slab is likely to be less in case of cast-in-situ construction. However, the cost of shuttering will be more. The overall savings is likely to be less when the conventional shuttering is used. Hence, only in exceptional cases, where due to some reason or the other, the use of precast ribs and ready made shuttering panels as discussed in this NBRI Digest is not feasible, the use of conventional shuttering is recommended.

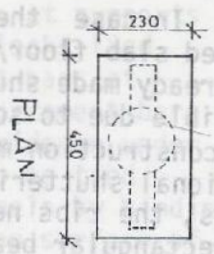
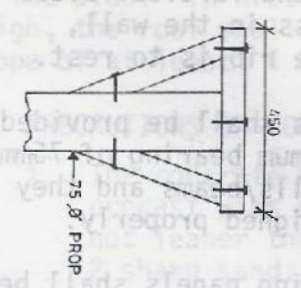
STRUCTURAL/FUNCTIONAL PERFORMANCE

As thin R.C. ribbed slabs satisfy all the requirements for strength, serviceability and durability, they are structurally safe. With the same thermal insulation treatment above, 50mm thick ribbed slab is only slightly inferior to 100mm thick R.C.C. slab in thermal performance. The thin ribbed slab and the conventional R.C.C. slab have got practically the same impact noise rating. As the flange portion is cast insitu, the chances of leakage is less, even if the roof is laid flat. However, in areas of high rainfall, the thin R.C. ribbed slab should be laid to slope.

SAVINGS IN MATERIALS AND COST

The comparison of the consumption of materials and approximate cost of construction of thin R.C.C. ribbed slab with conventional R.C. slabs are given below. In case A, comparison has been

ELEVATION



Details of top prop.

Note
The timber planks for shuttering of the flange and rib shall be 35mm thick.

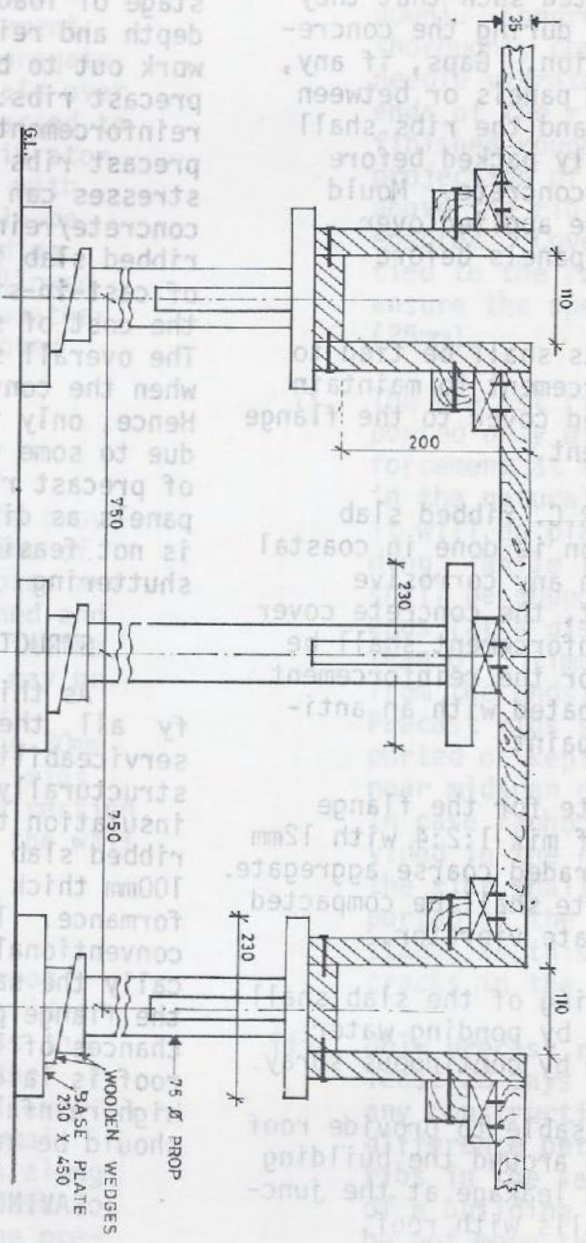


FIG. 4 CONVENTIONAL SHUTTERING FOR R.C. RIBBED SLAB

BUILDING CONSTRUCTION DIGEST

NO. 5

CHANNEL UNIT FLOORING/ROOFING SCHEME

By

J. S. Sharma, M. P. Jaisingh and J. O. Bereola

INTRODUCTION

Construction of buildings with pre-fabricated components has become popular in most of the developed countries. This type of construction has several advantages over conventional insitu construction. Shuttering and scaffolding can be eliminated completely or partially. As the moulds for precasting the components can be reused more number of times than the shuttering used for insitu casting of concrete floors and roofs, there is economy in cost. As production of precast components is repetitive in nature, there is increased productivity and better quality of work. As it is easy to precast components with structurally efficient shapes, there will be savings in the consumption of scarce building materials and cost of construction. Also, the precast construction is faster, compared to conventional insitu construction. Due to the several advantages offered by precast construction over conventional insitu construction, work was initiated at Nigerian Building and Road Research Institute to develop such construction techniques. One of the techniques developed at the Institute is the construction of floors and roofs with precast channel units. It is a precast reinforced concrete unit, trough shaped in section. It does not require any type of temporary support or propping during construction. It can be used for the construction of floors and roofs of buildings with load bearing walls or frames. This Building Research Paper gives the details of the technique, the structural design, precasting of units, construction of floor/roof with the precast units and its advantages.

DETAILS OF THE SCHEME

The floor/roof (Fig. 1) consists of precast reinforced concrete channel units and insitu deck concrete with nominal reinforcement laid over them. The precast channel units (Fig.2) are trough shaped reinforced concrete units of nominal size 600mm x 150mm in cross-section. The actual size of the unit is 595mm x 150mm. The length of the unit will depend upon the span to be covered. Units 150mm deep are suitable for normal residential buildings having spans 2.5 to 4.0m. For higher loads and/or longer spans, units with more depth or pre-stressed concrete units may be used. The unit has a minimum flange thickness of 35mm and weighs 78kg/m length. The sides

of the units are provided with corrugations. 30mm thick insitu deck concrete with 5mm dia. M.S. bars at 250mm centres in both directions or an equivalent welded wire mesh is provided over the units. When the insitu concrete laid in the joints between adjacent units attains strength, it acts along with the corrugations on the units and the deck concrete above to give monolithicity to the roof/floor in carrying the loads.

STRUCTURAL DESIGN

The section and the reinforcement of the channel unit may be designed either by using stress design method or limit state design method as given in Part 1 or II of N.C.P. 1:1973, Nigerian Standard Code of Practice for 'The Structural Design of Concrete in Buildings'. Depending upon the end conditions of the unit, it may be designed as simply supported or continuous. The units should be designed for the following two stages of loading:

(a) Stage I.

The unit should be checked for handling stresses, considering the permissible stress in concrete at the time of handling. At the time of laying the units, the load consists of self weight of the unit and the weight of concrete in joints between two units and incidental live load. The unit should be able to withstand this loading as simply supported beam.

(b) Stage II.

The unit should be designed for the full load acting on it, under the appropriate end conditions. When the floor/roof is of three or more continuous lays of approximately equal spans, in the absence of exact calculations, the following values may be taken for bending moments (B.M.) and shear forces (S.F.) for the two stages of loading.

(a) Stage I.

$$\begin{aligned} \text{B.M at midspan} &= (W_c + W_i) L^2/8 \\ \text{S.F.} &= (W_c + W_i) \times 0.5L, \end{aligned}$$

where

W_c = dead weight of the unit including the insitu concrete in the joint between units and over it for nominal width of one precast unit, uniformly distributed.

W_i = incidental live load for the width of one unit, uniformly distributed.

L = span

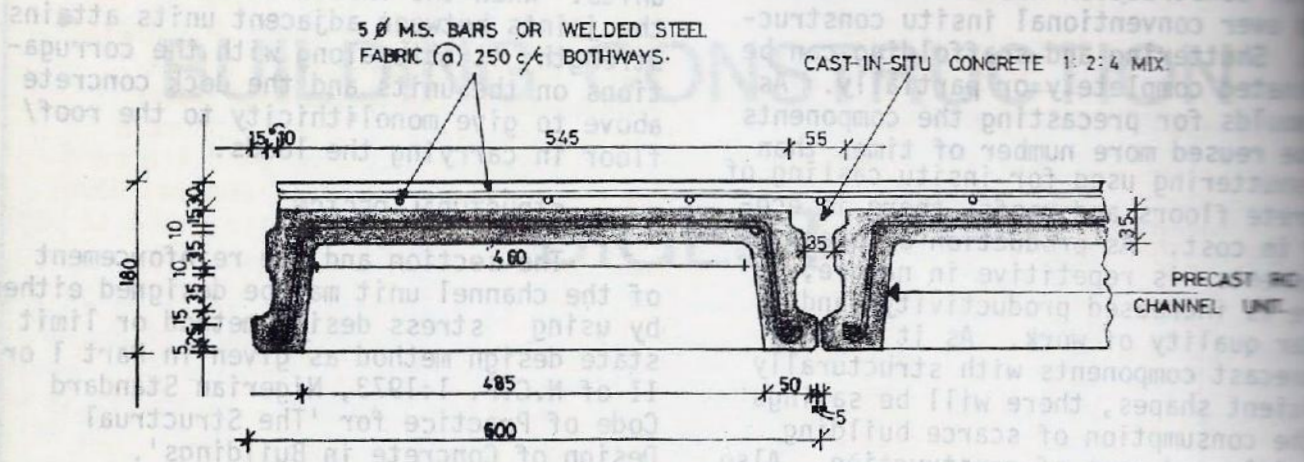


FIG. 1. PRECAST R.C. CHANNEL UNIT FLOOR/ROOF

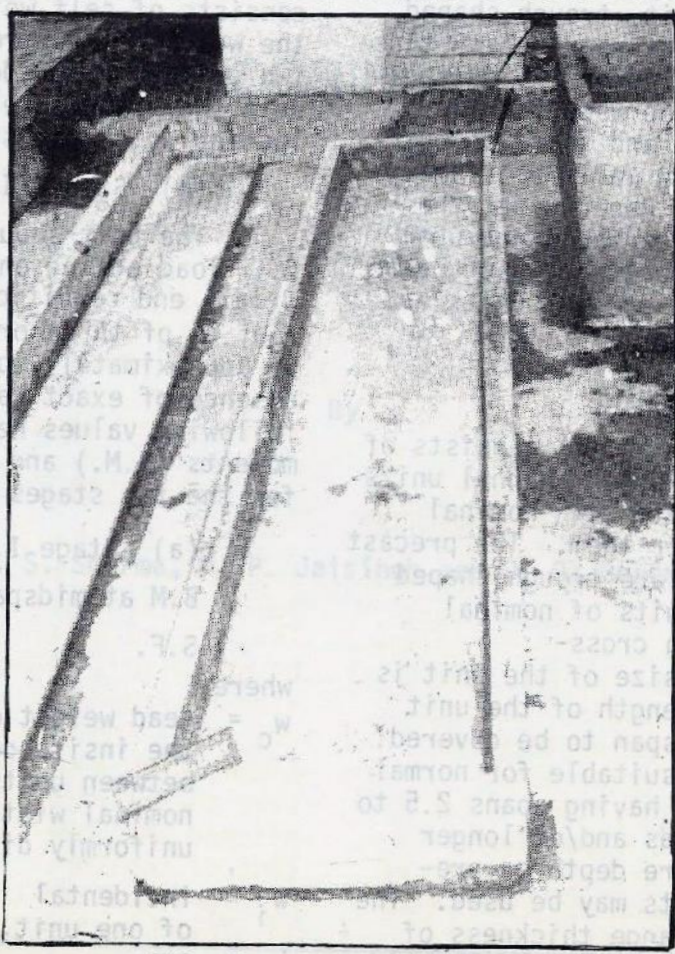


FIG. 2. CHANNEL UNIT

(b) Stage II.

1. B.M. at the middle of interior span

$$= \left[\frac{W_c}{8} + \frac{W_s}{12} + \frac{W_d}{24} \right] L^2$$

2. B.M. at the middle of end span

$$= \left[\frac{W_c}{8} + \frac{W_s}{10} + \frac{W_d}{10} \right] L^2$$

3. B.M. at support next to end support

$$= \left[\frac{W_d}{10} + \frac{W_s}{9} \right] L^2$$

4. B.M. at any other interior support

$$= \left[\frac{W_d}{12} + \frac{W_s}{9} \right] L^2$$

5. S.F. = $0.6(W_c + W_s + W_d) L$

where w_d = dead load due to flooring/roofing treatment etc. for nominal width of one channel unit, uniformly distributed.

w_s = Superimposed live load for nominal width of one channel unit, uniformly distributed.

When designing by limit state design method, the unit should be designed for the operating loads, considering partial safety factors for loads and material strength. The unit should be checked for shear, considering the thickness of two webs and the insitu concrete between them, as the width of the section resisting shear.

MOULD

The mould (Figs 3 and 5) is fabricated from mild steel plates, sheets and angle irons. It consists of an outer frame and an inner trough. The outer frame is made of two longitudinal members and two end pieces. The longitudinal members are fabricated from 6mm thick M.S. plates and 1.5mm thick M.S. sheets bent to the required shape and welded together. The end pieces are made from 6mm thick M.S. plates. The longitudinal members and end pieces are connected together by 6mm dia. M.S. bolts. The inner trough is fabricated from 1.5mm thick M.S. sheet with 50 x 50 x 5mm angle irons welded to it. The angle irons are provided with holes, matching with holes on the outer trough and are connected together by 6mm dia. M.S. bolts.

PRECASTING OF UNITS

The units are cast over a smooth and level surfaced concrete casting platform. After applying a bond-release agent on the casting platform and the inner sides of the outer frame of the mould, it is assembled over the platform. Reinforcement cage is then placed inside the mould with cover blocks tied to it. Cement concrete 1:2:4 (1 Cement: 2 Sharp sand 4 Graded coarse aggregate of size 12mm and down) is laid at the bottom of the mould to form the flange of the unit. The concrete is vibrated with a plate vibrator. (It is a shutter vibrator of capacity about 375 watts, fixed to a 5mm thick steel plate 450 x 750mm size with handles welded to the plate). After applying the bond release agent to its outer surface, the inner trough of the mould is kept inside the outer frame. The concrete already laid is levelled by moving the trough to and fro. The inner trough is then fixed to the outer frame with nuts and bolts. The gap between the two is filled with concrete, vibrated and finished level with the top of the mould.

About an hour after casting, the inner trough is removed and the concrete surface is trowelled to a smooth finish. Four hours after casting, the outer frame is dismantled. The units are cured at the casting platform itself for three days by sprinkling water. Then they are transported on trolleys to the stacking area, where they are stacked one over the other, with the troughs facing up. The troughs are filled with water to ensure proper curing. After two weeks water curing, the units are allowed to dry for another two weeks, before using them in any construction.

CONSTRUCTION

The top surface of the walls/beams over which the units are to rest are levelled with 1:4 cement: sand mortar. The precast units are then lifted one by one with a light hoist and placed side by side across the span to be covered. The channel units should be placed with a minimum bearing of 75mm over the walls/beams. The units are aligned and levelled properly. In the case of continuous floor/roof slabs, reinforcement to take negative moments is placed in the joints between the units, over the supports.

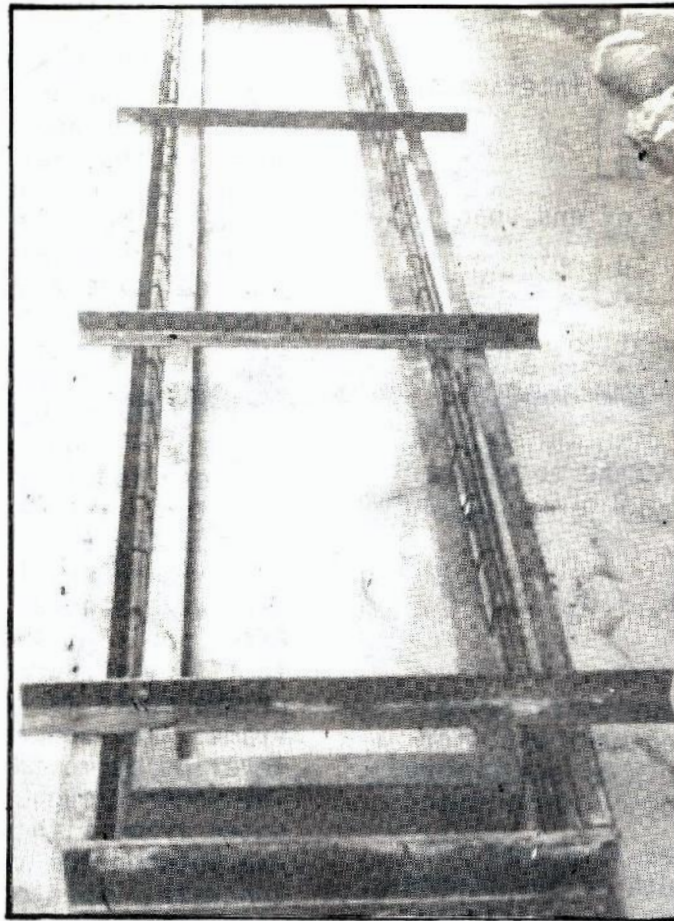


FIG. 3. MOULD FOR CHANNEL UNIT

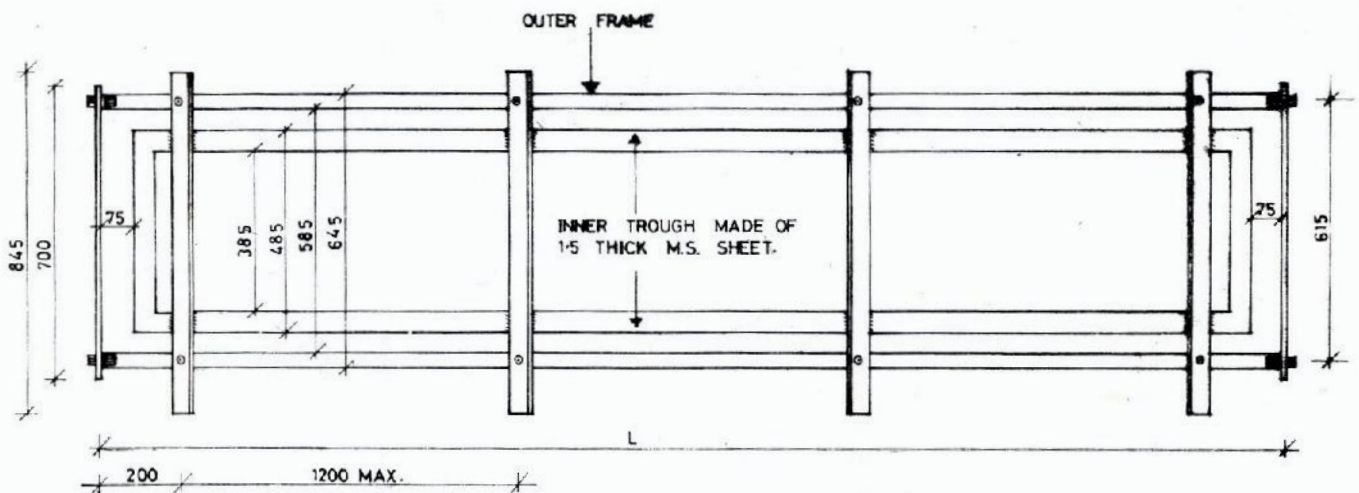


FIG. 4 PLAN OF MOULD FOR R.C. CHANNEL UNIT

The units are aligned and levelled properly. In the case of continuous floor/roof slabs, reinforcement to take negative moments is placed in the joints between the units, over the supports. 5mm dia. M.S. bars at 250mm centres bothways or an equivalent welded wire mesh is provided over the units. Thin₂ cement wash with 4kg of cement per 10m² area is applied to the sides of the units and the top, just before laying insitu concrete. Cement concrete 1:2:4 with 12mm and down graded coarse aggregate is placed in the joints between units and 30mm thick over them. The concrete is compacted with a plate vibrator. The concrete is cured for 14 days by sprinkling/ponding water over it and then allowed to dry. The floor finish in case of floor, and water-proofing and thermal insulation in case of roof are provided over the deck concrete. On the joints between the units in the ceiling, 1:4 cement: sand mortar is applied with the help of a piece of wet cloth. The joints are finished with deep ruled lines using a 450mm long tapered timber tool

CANTILEVER PROJECTIONS

For short cantilever projections in the same direction as the length of the unit, the unit can be kept projecting out by properly designing it and providing the necessary reinforcement. Alternatively, the cantilever can be cast-in-situ with reinforcement from units or from the deck concrete over the units kept projected out. For having cantilever projections across the span of the unit, reinforcement is kept in the deck concrete for sufficient distance to provide the restoring moment required to overcome the overturning moment caused by the loads over the cantilever portion. The reinforcement is kept projecting out for the length of the cantilever and insitu concrete is done. The cantilever across the span can also be provided by having cantilever beams and then placing channel units over the projecting beams in the usual way.

FIXTURES

Various fixtures like fanhooks, electrical conduits etc. could be provided in the following manner:-

1. Fanhooks. They may be kept in the cast-in-situ concrete of the joints between units, after

chipping off the edges of the units slightly, at the location of the fan

2. Electrical conduits. They may be embedded in the cast-in-situ concrete of the joints At right angles to the units, thin conduits could be placed in the deck concrete.
3. Electrical junction boxes. They may be fixed with real plugs in the cast-in-situ joints or embedded during filling the joint.
4. Light fixtures. Teakwood round block for fixing light fixtures may be provided.

PRECAUTIONS IN CONSTRUCTION

1. The main reinforcement of the unit should be to the full length of the unit. In exceptional cases, where shorter bars are to be used, they should be welded together.
2. During all stages of transport and erection, the units should be handled such that the main reinforcement is at the bottom of the unit.
3. While handling the unit, it should be supported near the ends, upto one fifth the span from either end and nowhere else.
4. No part of the unit should be broken or chipped off once it is cast, except as approved by the designer.
5. Only fully cured units free from damage and cracks and sound in all respects should be used in constructing floor or roof.
6. During construction, no heavy load should be permitted over the units, until the insitu concrete has attained strength.

ADVANTAGES

The channel units have been shaped such that the concrete near the neutral

axis and in the tension zone, which is not fully utilised structurally, is eliminated. Hence, there is savings in concrete and reduction in the self-weight of floor/roof with subsequent savings in steel. Compared to conventional insitu reinforced concrete slab, adoption of precast channel units of floor/roof will result in a savings of about 40 percent in concrete and 15 percent in steel, apart from considerable savings in overall cost of construction. The use of precast units completely eliminates the need for

shuttering. As the units can be precast and kept ready, as soon as the walls/beams for a floor are ready, the floor can be laid and the construction above can proceed. This will result in a savings of about 20 percent in the overall construction time. The precast units can be produced at the site of construction, in case of large construction projects. They can also be produced in small factories like sandcrete blocks and sold to persons building their own houses.

30 x 50 x 10cm joined together with... The longer flange has a 2cm... in the middle while the shorter flange has a 1cm deep groove on the inner side and two screws fixed projecting out by 5mm on outer face to keep the mason's thread wound round the screws.

Mortar guide board (Fig. 5) is made... thick plywood boxes of size equal to the hollows in sandcrete blocks and 12cm high. Six such boxes are joined by a 1400mm long M.S. Flat 20 x 6mm wire. The spacing between the boxes are kept such that they cover the hollows of the blocks and after every two boxes, the clear spacing is kept equal to twice the thickness of the outer skin of the blocks.

Two 2m and 100cm long are also fixed... with the help... at the end... distance from... end.

After levelling the area, one end frame is kept at each end of the wall to be built. The end frames are aligned, made to plumb and fixed in position by keeping two or three blocks over two wooden boards. A string holder is fixed to one of the end frames at first course height and another string holder is fixed to the other end frame at the same course height by tightening mason's string girders or 25mm diameter steel string holders (Fig. 6 and 7). Mortar is laid between the end frames and spread to the required thickness and width. Blocks are then placed one by one on the mortar layer to level and line, matching with the string holder. Vertical joints between the blocks are filled with mortar. Mortar guide board is then placed over the blocks (Fig. 8) and mortar is laid and spread horizontally to level the top of the guide. Afterwards the mortar guide board is lifted

GADGETS FOR BLOCK LAYING

In the conventional method of block laying, considerable time of the block layer (mason) is spent in laying the end blocks of a wall to level and line. By using tools of new design and layout... It has been observed that the time spent in... and U.S. operations... and laying mortar respectively. To improve the quality of work and increase the productivity of block layer, three gadgets, viz. end frame, string holder and mortar guide board have been designed and developed at the Institute. The gadgets and their use are discussed below:-

End frame (Figs. 1 and 2) is made of...

BUILDING CONSTRUCTION

DIGEST

NO. 6

GADGETS FOR INCREASING PRODUCTIVITY OF SOME BUILDING OPERATIONS

By

J. S. Sharma, M. P. Jaisingh and J. O. Bereola

FIXTURES

Various fixtures like fanhooks, electrical conduits etc. could be provided in the following manner:-

1. Fanhooks. They may be kept in the cast-in-situ concrete of the joints between units, after

ADVANTAGES

The channel units have been shaped such that the concrete near the neutral

INTRODUCTION

Labour accounts for a substantial percentage of the cost of construction of a building. By having well trained craftsmen, efficient tools and better methods of construction, the quality of work can be improved and the cost of construction reduced. However, in most of the developing countries, there is shortage of skilled craftsmen. With the increasing demand for houses and other buildings, this shortage is likely to increase further. It is seen that unskilled workers with limited practical experience are doing skilled jobs. This, apart from producing poor quality of work, gives low output and thus increases the time and cost of construction. Hence, there is need to evolve improved methods of working by providing efficient tools and gadgets, better work place layouts and proper sequence of working, to improve the quality of work and achieve higher productivity. The Nigerian Building and Road Research Institute has carried out studies in this direction and has developed a number of tools and gadgets. This Building Research Paper describes the salient features of the gadgets developed and their use for increasing the productivity of three building operations, viz; block laying, plastering and formwork for reinforced cement concrete (R.C.C.) slab, which consume about 16, 6 and 5 percent respectively of the building cost and take substantial part of the construction time.

GADGETS FOR BLOCK LAYING

In the conventional method of block laying, considerable time of the block layer (mason) is spent on laying the corner blocks of a wall to level and line. While laying further blocks, spirit level and string are used to adjust each block to level and line. Considerable time is spent on these operations, which are not directly productive. It has been observed that the mason spends about 23, 30 and 45 percent of time in levelling and stringing operations, laying blocks and laying mortar respectively. To improve the quality of work and increase the productivity of block layer, three gadgets, viz; end frame, string holder and mortar guide board have been designed and developed at the Institute. The gadgets and their use are discussed below:-

End frame (Figs. 1 and 2) is an L shaped gadget made of timber formwork with

shuttering plywood fixed on both the sides and stiffened with M.S. angle irons. The vertical member of the gadget is 2300mm high, while the base board is 300mm long. Its width is equal to the wall thickness, which may be 225, 150 or 100mm. The course height of the block-work is marked on the edges of the vertical members of the frame.

String holder (Figs. 3 and 4) is made of timber pieces 50 x 50 x 15mm and 35 x 50 x 10mm joined together with half lap. The longer flange has a 2mm wide slot in the middle while the shorter flange has a 1mm deep groove on the inner side and two screws fixed projecting out by 5mm on outer face to keep the mason's thread wound round the screws.

Mortar guide board (Fig. 5) is made of 3mm thick plywood boxes of size equal to the hollows in sandcrete blocks and 12mm high. Six such boxes are joined by a 1400mm long M.S. flat 20 x 6mm size. The spacing between the boxes are kept such that they cover the hollows of the blocks and after every two boxes, the clear spacing is kept equal to twice the thickness of the outer skin of the blocks. To prevent spilling of mortar outside the wall, two 10mm thick plywood strips 50mm deep and 1400mm long are also fixed to the central M.S. flat with the help of four cross runners, two at the end and two at one third distance from either end.

After levelling the area, one end frame is kept at each end of the wall to be built. The end frames are aligned, made to plumb and fixed in position by keeping two or three blocks over the base boards. A string holder is fixed to one of the end frames at first course height and another string holder is fixed to the other end frame at the same course height by tightening mason's string tied to the two string holders (Figs. 6 and 7). Mortar is laid between the end frames and spread to the required thickness and width. Blocks are then placed one by one on the mortar layer to level and line, matching with the string. Vertical joints between the blocks are filled with mortar. Mortar guide board is then placed over the blocks (Fig. 8) and mortar is laid and spread horizontally to the level of the guide. Afterwards, the mortar guide board is lifted and placed in subsequent position and

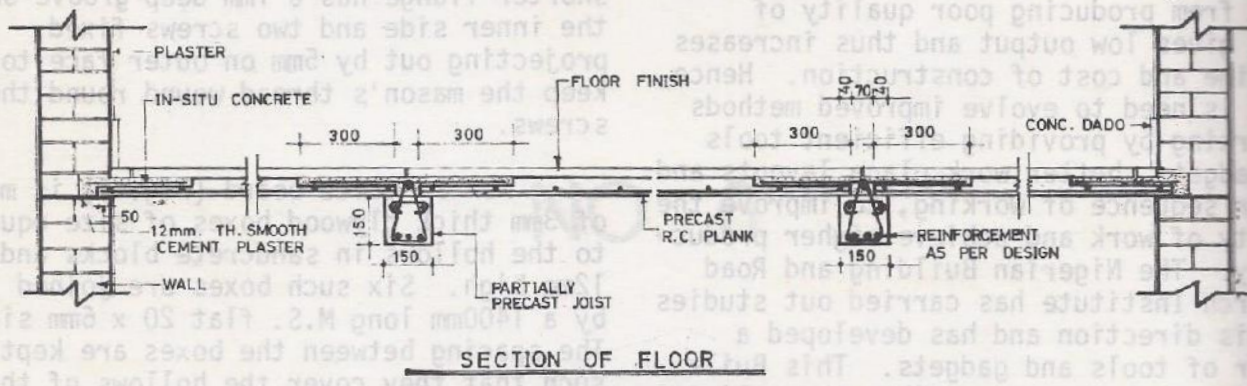
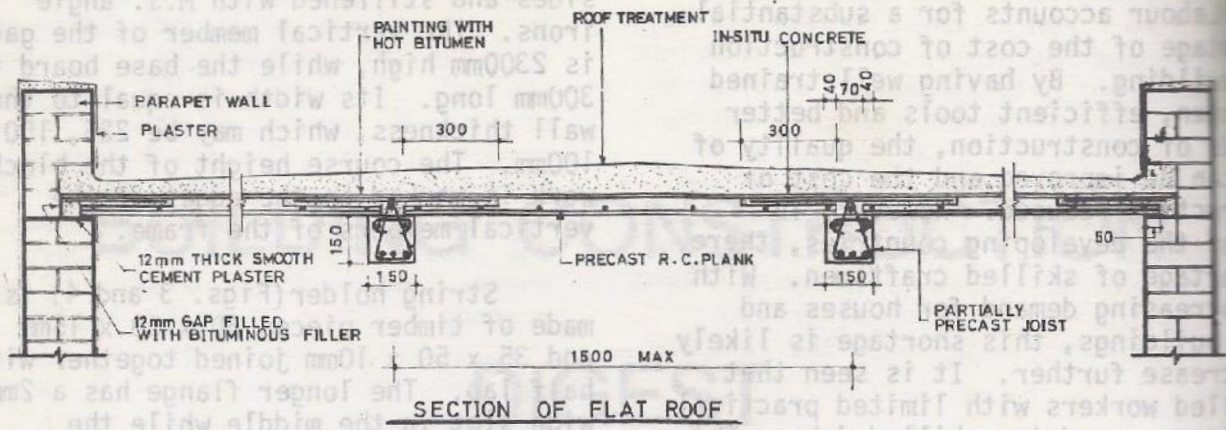
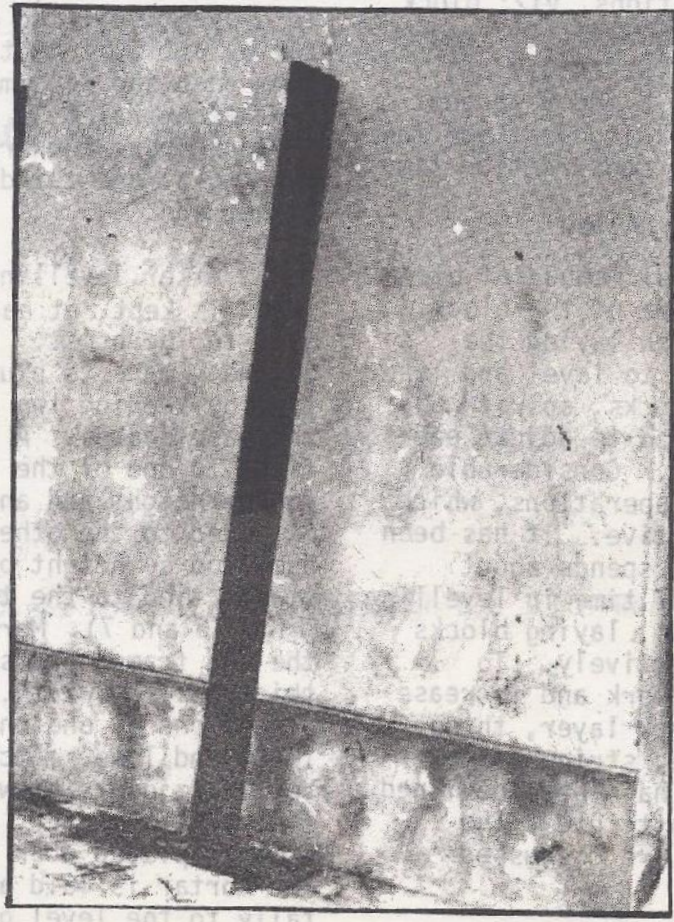
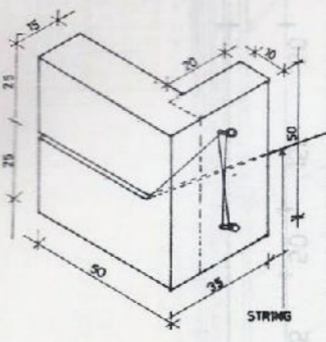
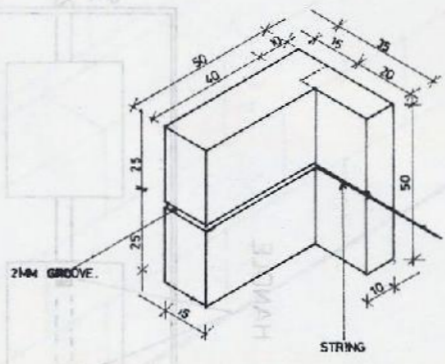


Fig 1 PRECAST R.C. PLANK FLOOR/ROOF





EXTERIOR VIEW



INTERIOR VIEW

FIG. 3 STRING HOLDER.

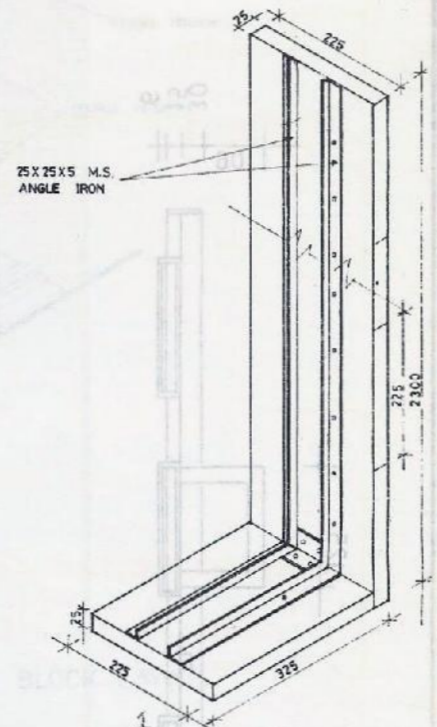


FIG. 1 END FRAME

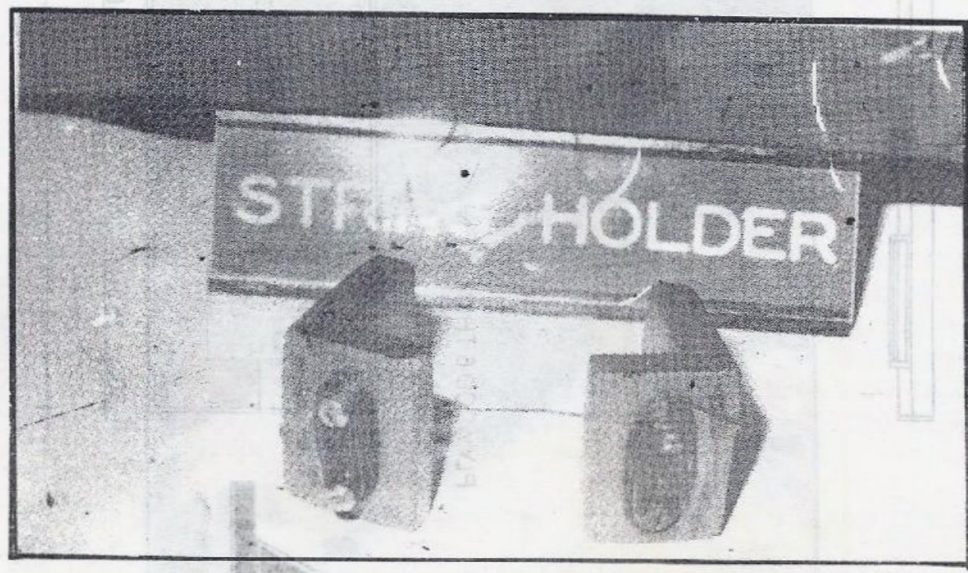
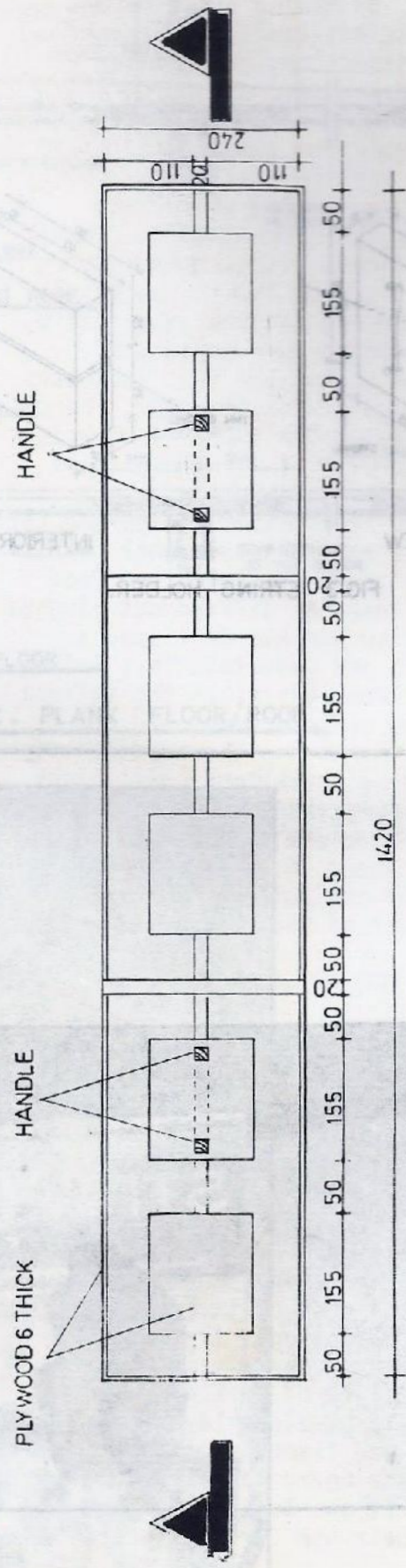


FIG. 4. STRING HOLDER IN USE



SECTION A-A



PLAN

Fig 5 MORTAR GUIDE BOARD.

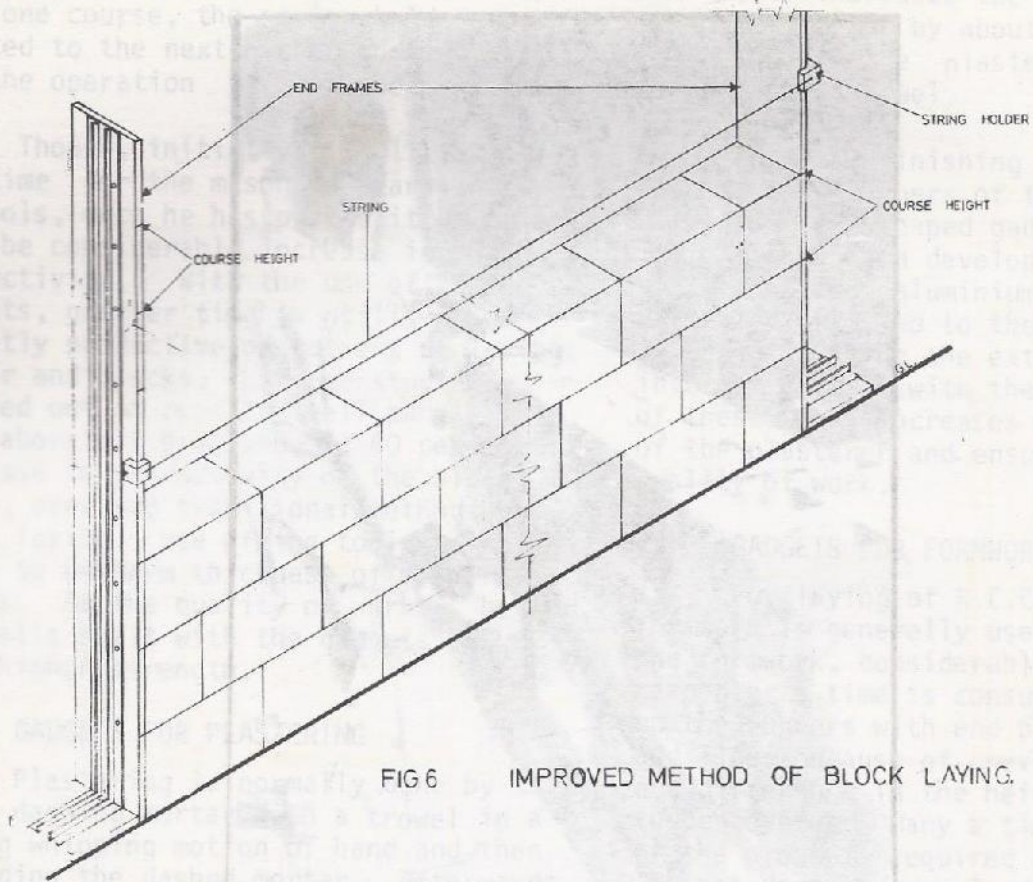


FIG 6 IMPROVED METHOD OF BLOCK LAYING.

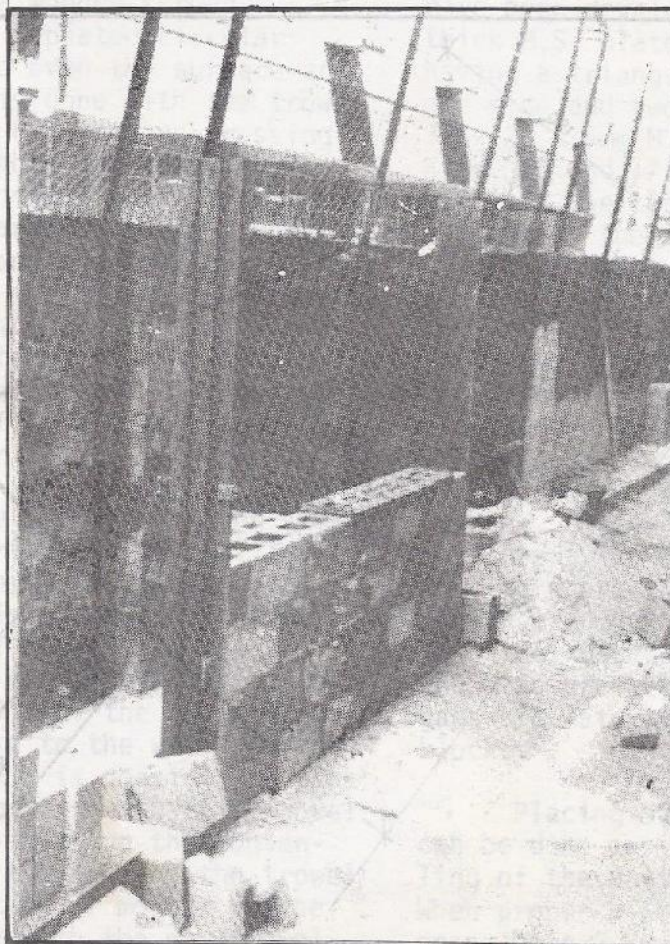


FIG. 7. ENDFRAMES AND STRING HOLDERS IN USE

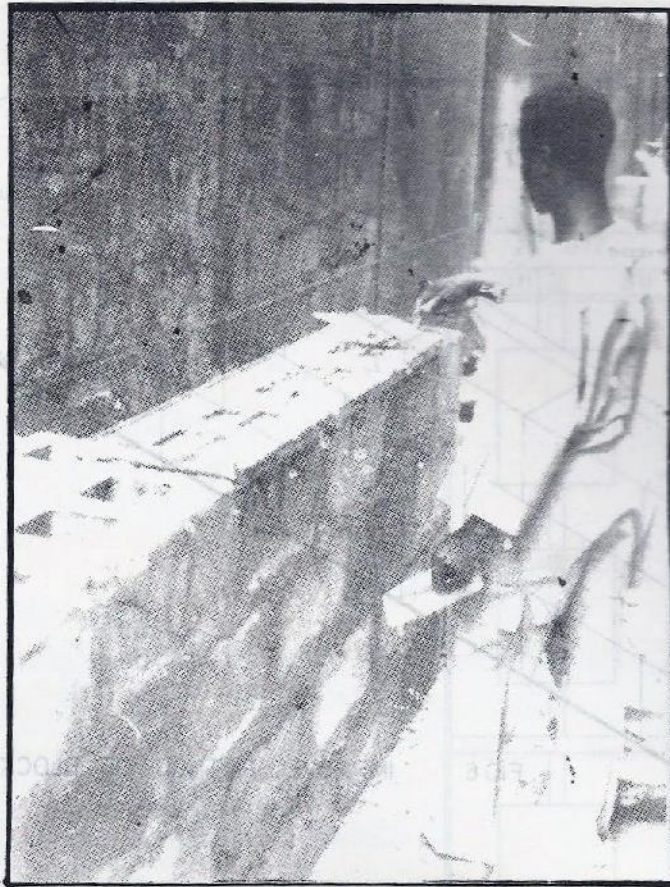


FIG. 8. MORTAR GUIDE BOARD IN USE

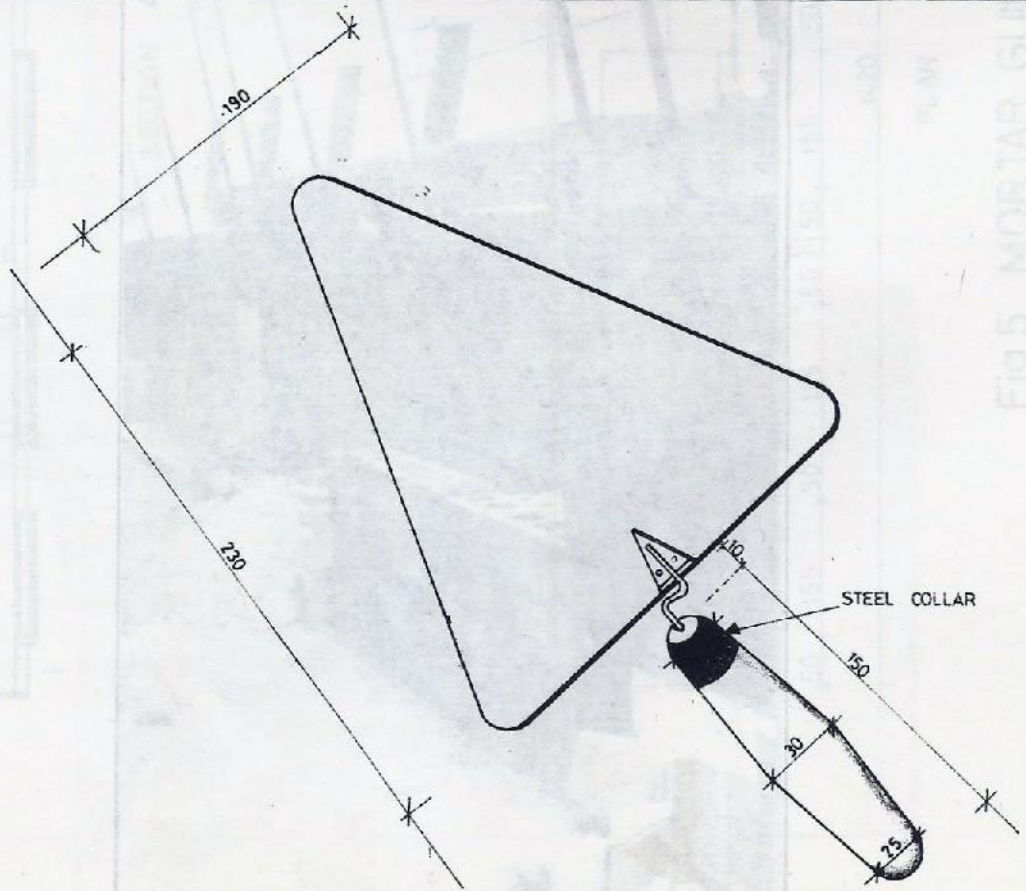


FIG 9 TRIANGULAR TROWEL FOR PLASTERING.

the operation is continued. After completing one course, the string holders are shifted to the next higher course level and the operation is continued.

Though, initially it will take sometime for the mason to learn the use of tools, once he has picked it up, there will be considerable increase in his productivity. With the use of the gadgets, greater time is utilised in directly productive operations of laying mortar and blocks. Limited studies carried out on practice wall panels in the laboratory have shown a 40 percent increase in productivity of the block layer, over the traditional method of block laying. Use of the tools, also leads to uniform thickness of mortar joints. As the quality of work is better, the walls built with the gadgets have higher strength.

GADGETS FOR PLASTERING

Plastering is normally done by first dashing mortar with a trowel in a strong whipping motion of hand and then spreading the dashed mortar. Afterwards, scrapping and levelling of the spread mortar is done by a wooden screed. Finally, vigorous repeated circular motion is given to even the surface and smooth finishing is done with the trowel or a steel float. Dashing and pressing of the mortar are the most laborious operations. The conventional trowel is of double triangular shape with larger triangle in the front and smaller triangle at the back, near the handle. Due to the double triangular shape, the centre of gravity of the mortar remains away from the wrist of the plasterer. Hence considerable amount of torque is required to throw the mortar.

To throw more mortar with the same effort, a simple triangular trowel (Figs. 9 and 10) has been developed. The area of the new trowel is more than that of conventional trowel and its handle has been provided very near the edge, so that the centre of gravity of the weight of mortar remains close to the wrist of the plasterer. Hence, it is possible to pick up and throw more mortar with this trowel with the same ease as using the conventional trowel. As the area of the trowel is more, more quantity of mortar can be spread and finished with the new trowel. Limited studies carried out in the laboratory have shown that the use of the

new trowel increases the productivity of the plasterer by about 30 percent. Fig. 11 shows the plastering of a wall with the new trowel.

For easy finishing of the internal and external corners of the walls during plastering, 'L' shaped gadgets (Figs. 12 and 13) have been developed. These are fabricated from aluminium angle irons with handles fixed to them. Figs. 14 and 15 show finishing the external and internal corners with these tools. Use of these tools increases the productivity of the plasterer and ensures better quality of work.

GADGETS FOR FORMWORK OF R.C.C. SLAB

For laying of R.C.C. Slab, timber formwork is generally used. In erecting the formwork, considerable part of the carpenter's time is consumed in putting up the runners with end props to level and line, because of uneven floor surface and difference in the height of spaces to be covered. Many a times, cutting of the props is required and their reuse is not very large. To do away with the need of end props, M.S. wall brackets have been developed. It is made of 5mm thick M.S. plate 400mm long, 90mm wide having a triangular base at bottom on one side and two arms 300mm high made of 35 x 20 x 5mm M.S. Channels projecting up. Figs. 16 and 17.

At the top-most course of block masonry at the floor/roof level, 100mm wide gaps 150mm deep are left at a spacing of 1 to 1.2m in the wall, where the runners for supporting the shuttering panels are to be located. M.S. brackets are placed in these gaps and runners are placed over them to correct level, with the help of timber wedges. Shuttering planks are placed one by one over the runners. After concrete has been laid and cured, the runners are lowered by pulling apart the wedges. The shuttering planks are then removed one by one and then the runners and wedges. Finally, the M.S. brackets are taken out. The gaps are later filled with concrete blocks.

Placing of the brackets and runners can be done easily. Similarly, dismantling of the shuttering can be done faster. When proper size runners are used, for spans upto 3.6m, no props are required to support the runners. Thus, uninterrupted space is available below the

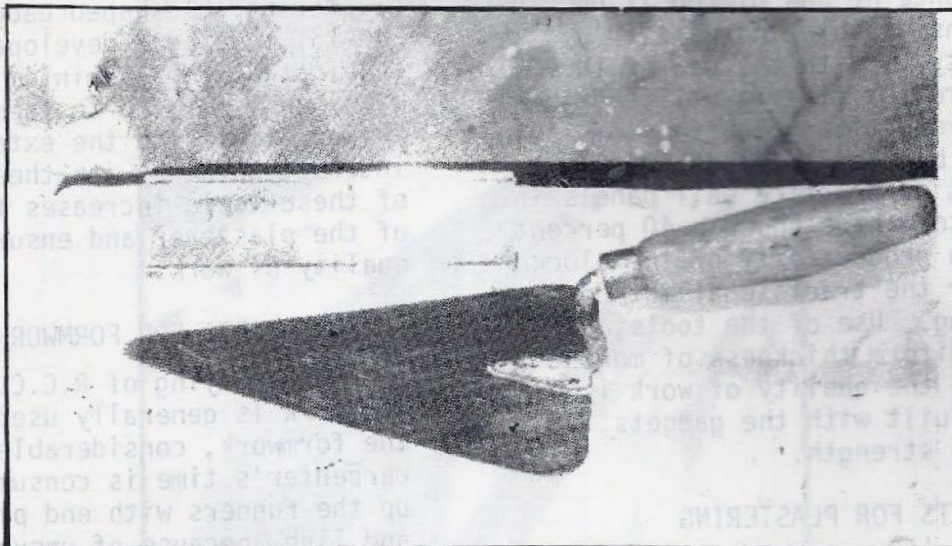


fig. 10. TRIANGULAR TROWEL FOR PLASTERING



FIG. 11. PLASTERING WITH TRIANGULAR TROWEL

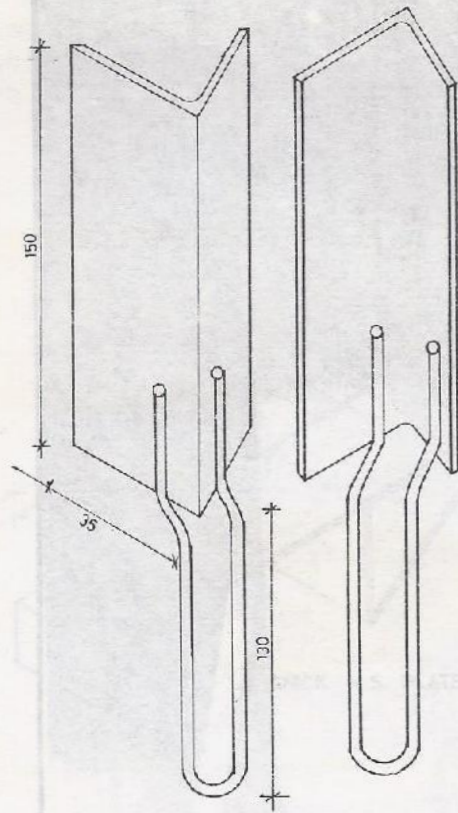


FIG.12 SHAPED GADGETS FOR MAKING CORNERS IN PLASTERING.

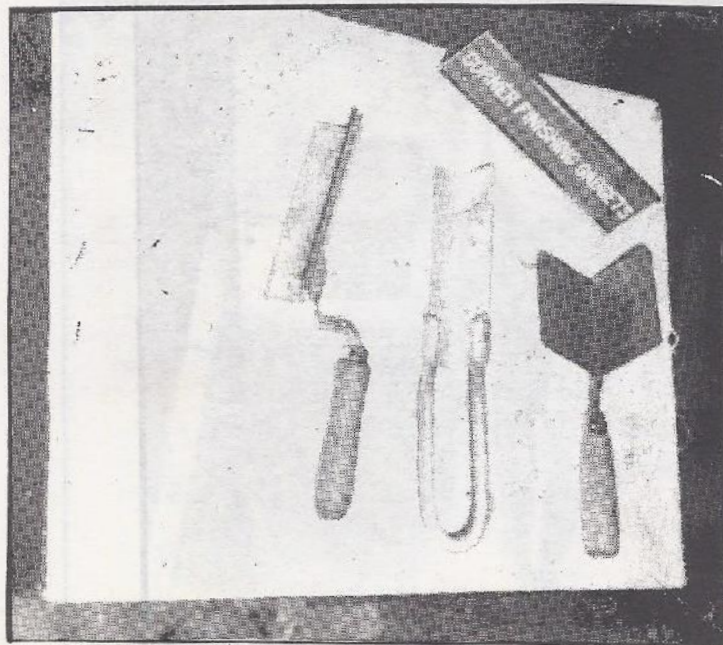


FIG. 13. L-SHAPED GADGETS FOR MAKING CORNERS IN PLASTERING



FIG. 14. FINISHING EXTERNAL CORNER WITH L-SHAPED GADGET



FIG. 15. FINISHING INTERNAL CORNER WITH L-SHAPED GADGET

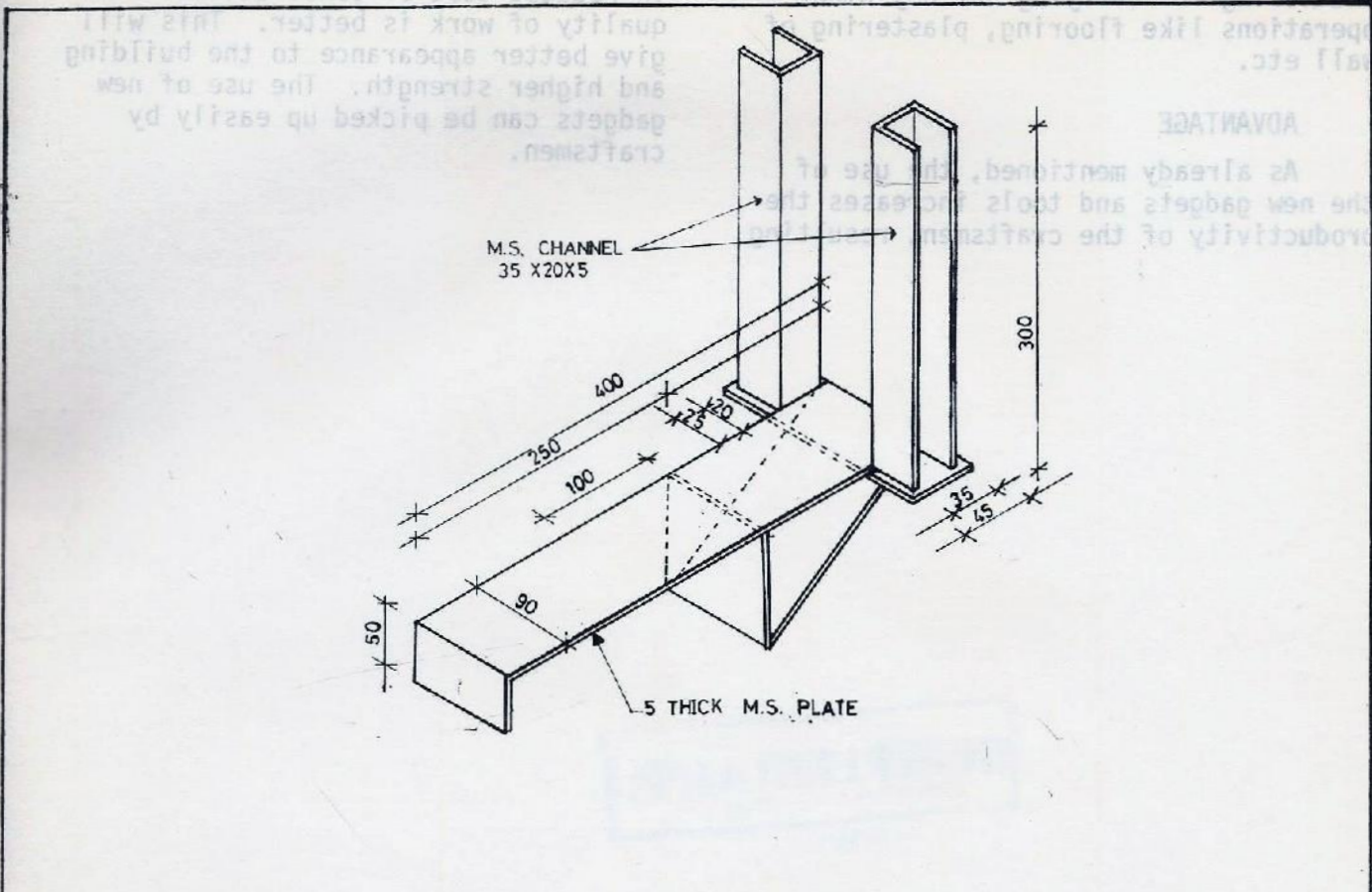


FIG.16 WALL BRACKET FOR SLAB FORMWORK.

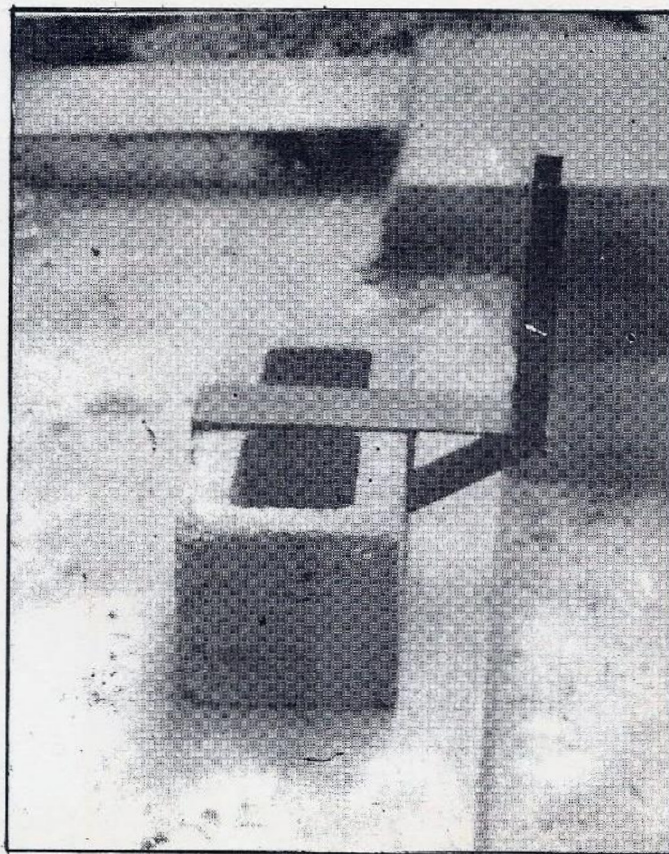


FIG. 17, WALL BRACKET FOR SLAB SHUTTERING

shuttering for carrying out any other operations like flooring, plastering of wall etc.

ADVANTAGE

As already mentioned, the use of the new gadgets and tools increases the productivity of the craftsmen, resulting

in reduced cost of construction. The quality of work is better. This will give better appearance to the building and higher strength. The use of new gadgets can be picked up easily by craftsmen.

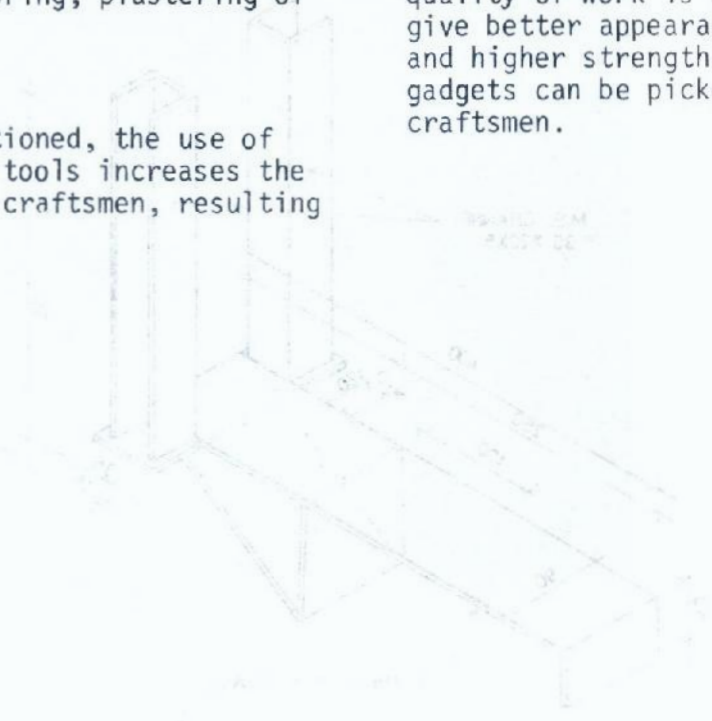


FIG. 1 WALL BRACKET FOR SLAB FORMWORK

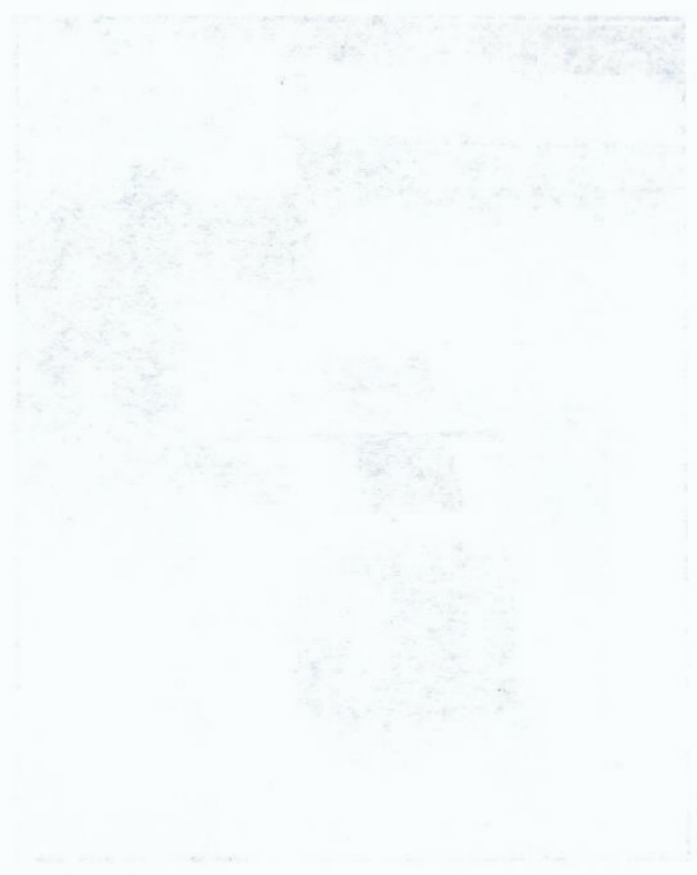


FIG. 2 WALL BRACKET FOR SLAB FORMWORK

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