CENTRAL BUILDING RESEARCH INSTITUTE, ROORKEE-247667 (INDIA)

BUILDING RESEARCH NOTE

B.R.N. 7

PRECAST STONE MASONRY BLOCK WALLING SCHEME

INTRODUCTION

In some parts of the country, stone is available in abundance and forms the chief walling material. Walls are conventionally made in the form of random rubble masonry and the thickness is generally 380 to 450 mm. At some places, even 300 mm thick random rubble masonry walls have been constructed with slightly higher cost as it requires more skilled labour and time. The thickness are however, massive which are mainly dictated by practical considerations and to some extent structural considerations. The amount of mortar, which has low compressive strength compared to stone is about 35 percent of masonry and often the joints are not properly filled. Such walls are generally pointed on the external face to provide stone texture while the internal face is plastered. Average thickness of the plaster required is 20 to 25 mm because of the unevenness of stones. The construction besides requiring excessive content of materials and time it calls for more skilled labour.

The Central Building Research Institute has carried out studies for reducing the thickness and the level of skill normally required in random rubble masonry walling. Precast stone masonry blocks using stone spalls and lean cement concrete with natural stone texture on one face of the block (Fig. 1) has been developed. These blocks can be easily produced at construction site of factory with semi-skilled workers and minimum machinery. The technique has been successfully used for load bearing and non-load bearing walls upto 3 storeys by various organisations in different parts of the country where stone is easily available. At a few places, factories have been established by entrepreneurs where, these blocks are readily available just like other building materials/ components.

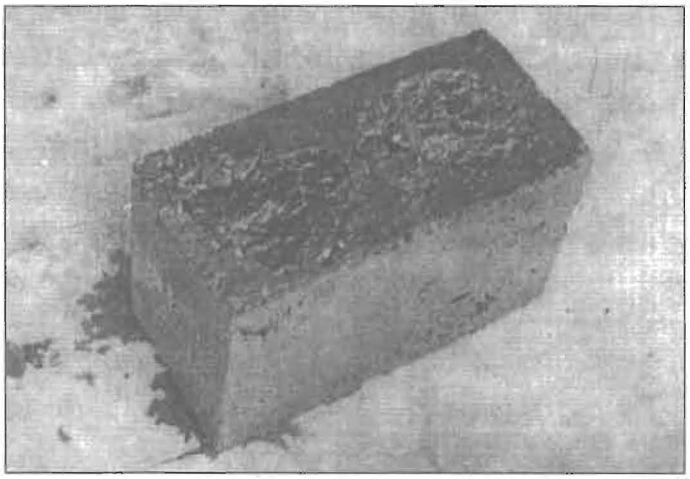


Fig. 1 Precast Stone Masonry Block

This note describes the methods of production and physical properties of the blocks, economic data of materials and labour and construction details.

SIZE OF BLOCKS

Considering ease in handling and other requirements, nominal length and height of the block are kept 300 mm and 150 mm respectively with three widths as 200 mm, 150 mm and 100 mm. Actual block dimensions are kept short by 10 mm to accommodate mortar joint. These blocks weigh from 90 to 180 N. To get stone texture on the outer face of wall, the blocks are cast such that the bottom face during casting forms the exposed face when laid in wall i.e., the width of block is kept as the height of moulds and the height of block is kept as width of the mould. Different textures, such as, exposed pebble or crushed aggregate can also be formed on one face by putting them on the top face during casting. Recommended dimensions of blocks and moulds of single block are given in Table-1.

TABLE - 1

Size of Blocks and Internal Dimensions of Single Moulds.

Sl. No.	Block Size (mm)						Mould Dimensions (mm)		
	Nominal			Actual			Internal		
	L	B	H	L	B	H	L	B	H
1.	300	200	150	290	190	140	290	140	190
2.	300	150	150	290	140	140	290	140	140
3.	300	100	150	290	90	140	290	140	90

Apart from the sizes mentioned above, 1/3, 1/2, 2/3 and 3/4 length of blocks are also made for breaking the joints in alternate courses. These blocks can be cast in the same moulds by putting a partition of 4 mm thick steel plate or separate moulds can be made. Further, to accommodate vertical reinforcement against seismic forces in walls, special blocks of 290 × 90 × 140 mm and 190 × 90 × 140 mm with a semi circular recess on one face (Fig. 2) can be made.

PRODUCTION OF BLOCKS

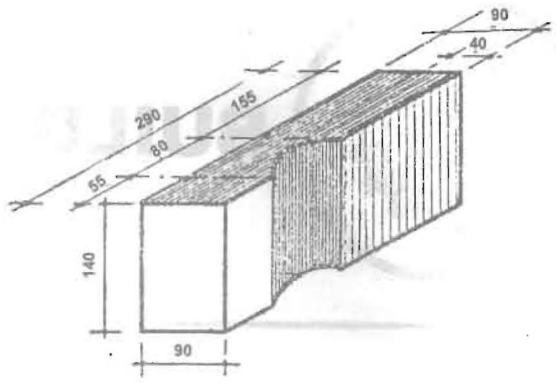


Fig. 2 Special block with recess for vertical reinforcement

Moulds

The blocks are cast either in individual steel moulds of fixed type (Fig. 3) or split type (Fig. 4) or gang moulds of six blocks (Fig. 5). For mass production of blocks, Gang moulds of multi-pockets for 72 blocks as shown in Fig 6. or 48 pockets with special sizes of blocks as shown in Fig 7 can be used. A flat mould of 1800 mm × 1800 mm size consisting of metallic strips running in orthogonal directions was fabricated to produce the nominal size of 300 mm × 200 mm × 150 mm blocks.

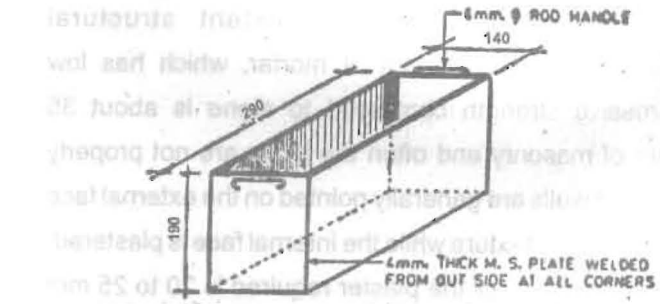


Fig. 3 Fixed type steel mould (Dimension in mm)

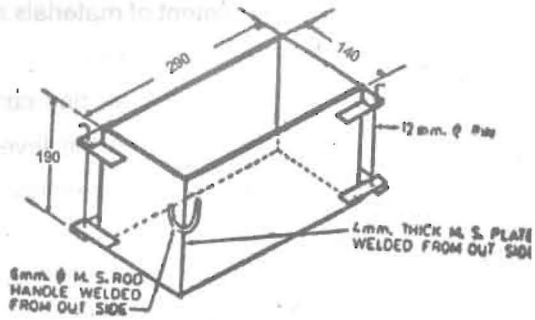


Fig. 4 Split type mould (Dimension in mm)

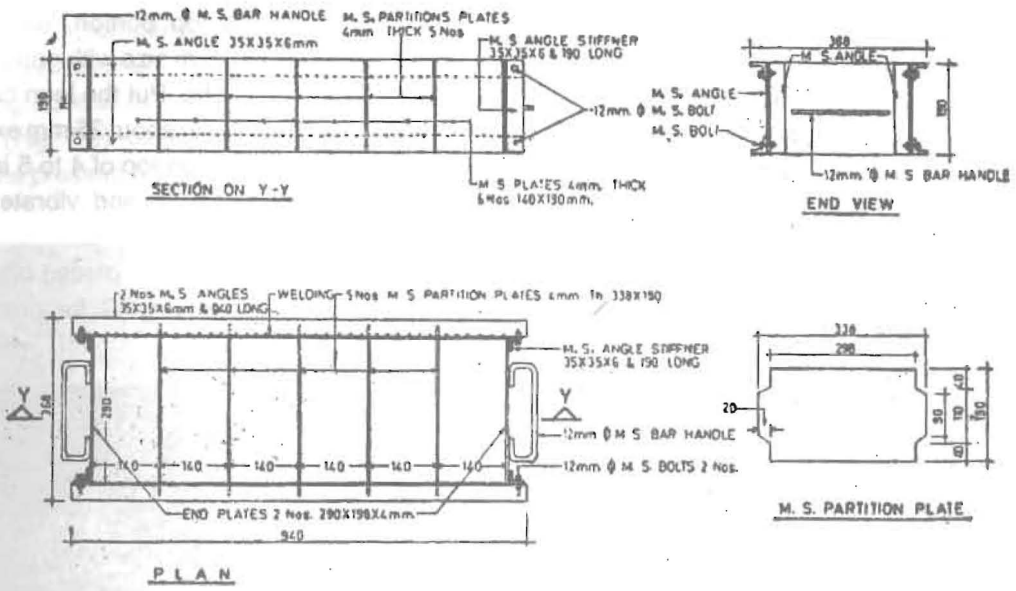


Fig. 5 GANG MOULD OF SIX BLOCKS

The size of mould for 48 blocks was 1200 mm × 1200 mm with provision of extra slots for producing special blocks of lower sizes.

Casting Platform

A smooth flat and hard surface is required for casting the blocks. The casting platform is made with 30 mm thick 1:3:6 cement concrete, finished smooth with neat cement, and laid over a base of either brick soling (70 mm) or lean concrete 1:8:16. A casting platform of about 80 sq.m. is required for production of 500 blocks per day with the group of single moulds or 600 to 700 blocks with the use of the gang moulds.

Materials

The stone blocks are made of lean cement concrete and stone pieces 50 to 250 cm, obtained either from querry or by breaking river boulders so that at least one face is a flat surface. The stones should be hard, sound, durable and free from impurities.

10 mm and down crushed stones or natural aggregate, free from impurities, conforming to IS 383-1970 should be used. Since the concrete used is lean, and lacks in fine particles with loss of plasticity and work ability. The sand should have fine particles, 15-20% passing IS Sieve No 300 micron and 5-15% passing IS Sieve No. 150 micron.

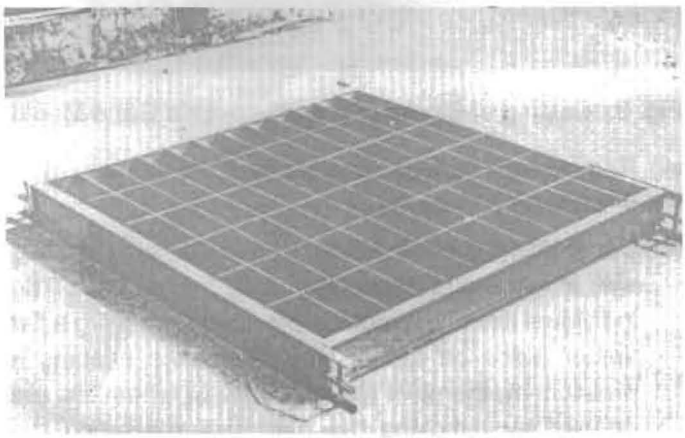


Fig. 6 Gang Mould for Casting 72 Blocks

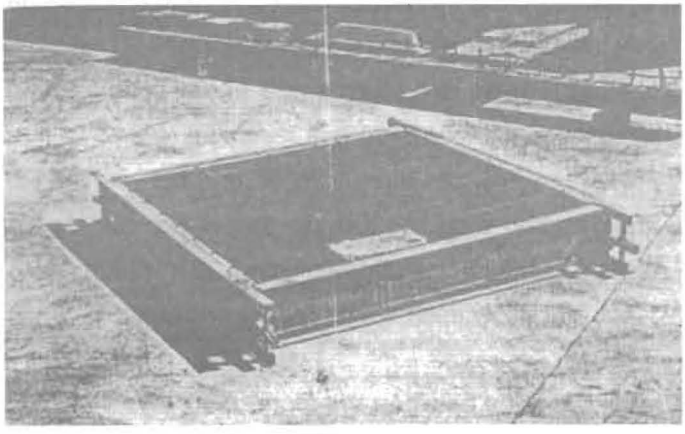


Fig. 7 Gang Mould for 48 Blocks with provision of special sizes

At places where such sand is not available, the proportioning of sand and aggregate should be suitably adjusted by a few trials to have good workability and plasticity at green stage. In areas where flyash is available and is conforming to IS : 3812 - 1981. This may be used as substitute for the fine particles of sand. Grading of the combined aggregate should be such that the fineness modulus is between 3.6 and 4.

Cement should be ordinary portland cement or portland pozzalana cement complying with relevant indian standard.

Water should be free from harmful chemicals and salts to avoid efflorescenece.

Concrete Mix

Concrete mix should be lean and generally of proportion 1:5:8 (cement : sand : coarse aggregate) having a slump of 15 to 20 mm for producing blocks of compressive strength more than 60 kg/cm^2. However, different mix proportions of 1:3:6, 1:4:7, 1:5:8 can be used as per necessity. Slightly over sanded concerate mix is suggested to provide better finish to the blocks. It is to be noted that with the use of stone spalls, there is saving in cement with higher compressive strength and lower drying shrinkage.

Casting of Blocks

i) Clean the platform and moulds properly. Apply any lubricating oil (grease and kerosene 1:4 by weight) inside the moulds in the beginning once a day. Also apply it on the platform where the blocks are to be cast.

ii) Place group of individual moulds or gang moulds side by side in a row with gap for demoulding.

iii) Arrange large size stone spalls at the bottom of the moulds such that there is a minimum gap of 15 mm between any two stone pieces and between stone pieces and mould to provide proper concrete in the gaps. Generally two stone pieces 100 to 120 mm size are placed in each single mould or pocket of Gang Mould.

iv) Fill the gaps between the stone pieces and moulds with lean concrete by trowelling and roding up to top of the stone pieces.

v) In the remaining top portion, arrange small stone pieces of 50 to 70 mm size with gap of about 15 mm in between every stone. Put the lean concrete on top of each mould/pocket to about 25 mm extra height.

vi) Put a plate vibrator on top of 4 to 5 individual moulds filled up with concrete and vibrate for satisfactory compaction. (Fig. 8)

The plate vibrator can be placed on the single Gang Mould as shown in Fig. 9 for production at mass construction site.

Fig. 8 Compaction by plate vibrator

Fig. 9 Casting of Blocks with multi-pockets Gand Mould

vii) Remove any surplus concrete over the mould and finish level with trowel.

viii) Demoulding is started 5 to 10 minutes after casting with single moud depending upon the weather. The individual fixed type moulds are lifted by placing a flat timber piece on top of block cast and keeping it pressed by thumb (Fig. 10). Split type moulds are opened by removing the pins and separating the sides. The six blocks gang mould can be demoulded by opening the bolts and nuts from the end pieces and

first removing longitudinal side plates and subsequently the partition plates (Fig. 11). The gang mould can also be lifted up along with its partition plates by placing special frame work of steel plates and G.I. pipe (Fig. 12) over the cast blocks and keeping the same pressed while pulling up the mould.

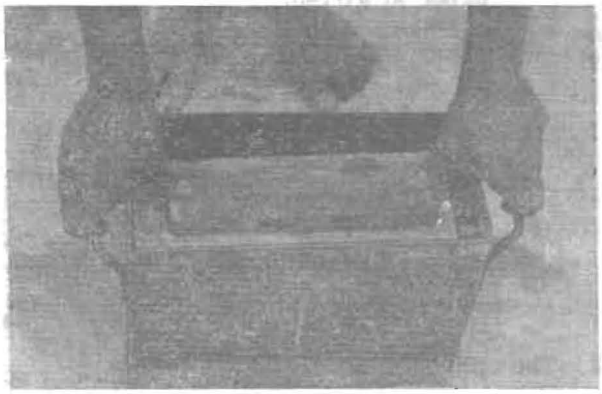


Fig. 10 Pulling of fixed type mould

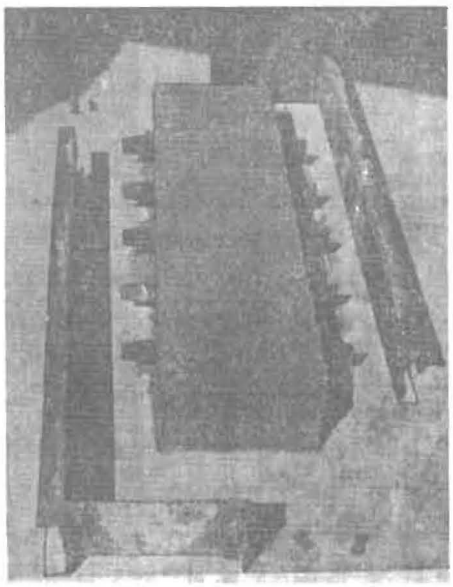


Fig. 11 Demoulding gang mould of six blocks

ix) The opened single moulds are rearranged in a row and subsequent casting continued in the same way as described above.

x) Casting of special blocks is done in the same way by using partition plates and recess or cut piece as the case may be.

xi) To remove the metalic strips in the 72 blocks Gang Mould during demoulding after casting an innovative scissor clamp was developed (Fig. 13) which grips the metalic strips automatically from the top flat cast surface of the concrete without any damage to the edges of the blocks.

xii) After 24 to 48 hours depending upon weather, the blocks are slightly pushed to break bond and afterwards lifted. These are taken for curing and stacked on level ground having layer of sand such that each days production is accommodated in single or double layer. Stacks of blocks upto 5 to 6 are arranged over the blocks which have been cured for 3 days. These blocks are cured by frequent sprinkling of water over the stacks for 2 weeks and air cured for another 2 to 4 weeks depending upon weather so that the blocks are dry before they are laid in the wall (Fig. 14).

xiii) For quality control, three blocks out of every 1000 be tested for compressive strength after providing proper capping as per test procedure laid down in IS 2185-1979.

PHYSICAL PROPERTIES

Compressive Strength

Stone Masonry Block is a hetrogeneous unit consisting of stone spalls of different shapes, sizes, texture and lean cement-concrete. The bond of concrete with stone spalls is influenced by grading and type of sand and coarse aggregate as well as the texture of stone. Bond is also affected by the consistency of concrete and the manner it is compacted. The bond of concrete with stone spalls, its proportion and quality in the block and position of placement of the stone pieces greatly influence the performance of the block under load. Because of so many variables the strength varies considerably. The variation can, however, be narrowed down to ± 20 percent if the blocks are cast by compaction of concrete by vibration. In view of above, it is desirable to cast a few blocks at site using trial concrete mixes with local materials. These

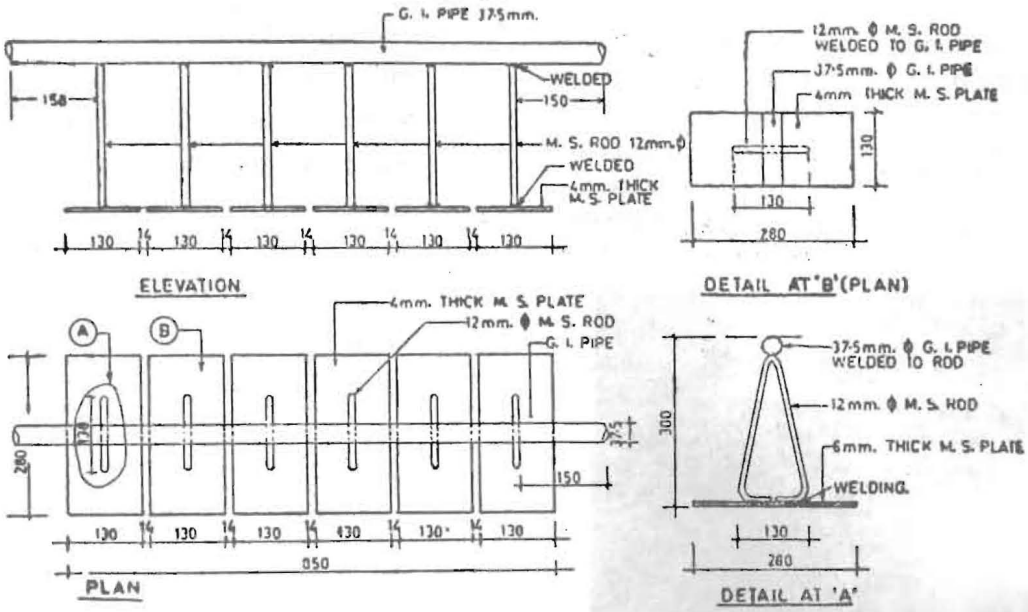


Fig. 12 Pressing device for pulling up gang mould

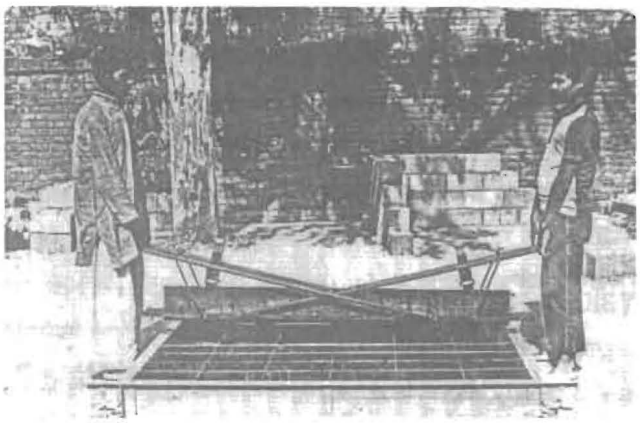


Fig. 13 Demoulding with removal of metalic strips using auto-grip scissor clamps.

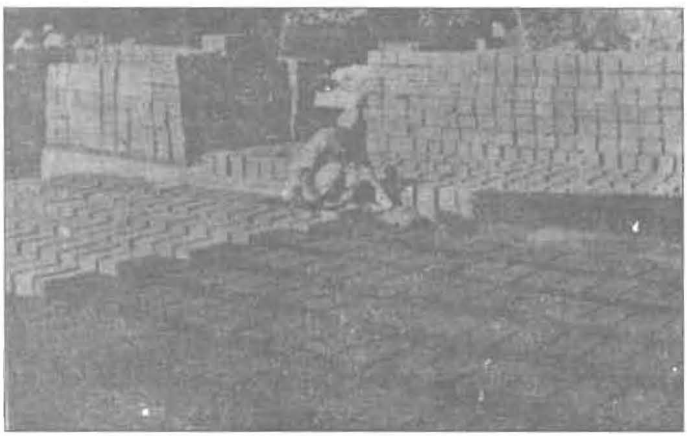


Fig. 14 Stacking of cast blocks

should then be tested to arrive at the actual compressive strength. From this data concrete mix should be decided to get the blocks of desired strength. For general guidance compressive strength of blocks tested in the laboratory is given in Table - 2.

Table 2 - Compressive strength of Stone Massonry Blocks

Sl. No.	Concrete mix Prop. by vol Cement :	Block Dimension in mm	Average Compressive strength (N/mm2)	
			Manual compaction*	Compaction by Vibration**
1.	1:3:6	290×190×140	100	125
2.	1:4:7		85	110
3.	1:5:8		70	90

* Standard deviation 20 and Coefficient of variation 25%

** Standard deviation 15 and Coefficient of variation 13%

Water Absorption

The tests carried out in the laboratory on blocks cast with 1:5:8 cement concrete mix have shown that water absorption of 6% and 4% are for manually compacted and vibrator compacted blocks respectively.

Drying Shrinkage

Drying shrinkage for similar blocks ranges between .033 to .038 per cent.

Moisture Movement

Moisture movement for the same type of blocks ranges between .021 and .028 per cent. These values are within the specified values of IS Code.

Tolerance

Maximum variation in the length should not be more than ±5mm and maximum variation in height and width not more than ± 3 mm.

Structural Design

Wall made of these units is designed like any other masonry wall. Masonry is now designed on stress concept and Indian standard code of Practice No. IS:1905-1987. "Structural use of unreinforced masonry" gives the values of permissible stresses in masonry corresponding to various combination of bricks and mortar composition. The same values may be considered for the design of stone block masonry. A large number of 3 storeyed buildings with load bearing walls have been constructed with these units in Andhra Pradesh, Madhya Pradesh and hilly areas of Uttar Pradesh. Provision of vertical reinforcement at corners and openings for seismic forces can be easily provided by using special blocks with recess. This type of construction is far superior against seismic forces compared to random rubble masonry.

Masonry Construction

Most of the construction features for buildings with these blocks are similar to those of conventional block laying but with a few differences which should be kept in mind to obtain the best results. These are described below :

i) Cutting of these blocks is not possible. Buildings should thus be planned to suit block dimension i.e. all lengths of walls, openings, spaces between openings, etc. should be in multiples of 100 mm and all heights, in multiples of 150 mm.

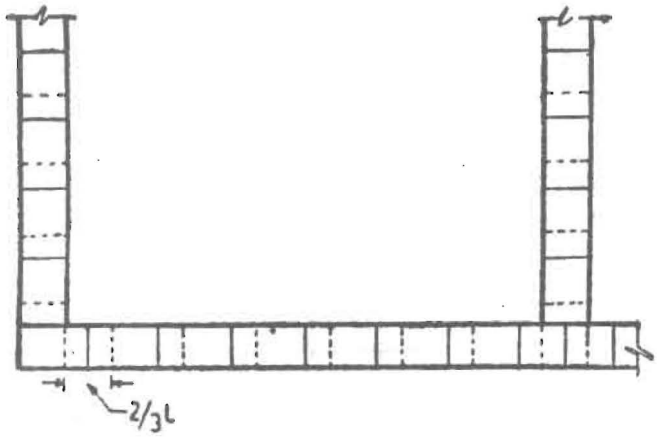
ii) Blocks of required strength should be cast by proper selection of concrete mix out of the mixes recommended.

iii) Mortar for laying the blocks should not be leaner than cement : sand (1:6) and where good quality lime is available lime : surkhi or lime : cinder (1:3) or ALPM : sand (1:2) or composite mortars may be used.

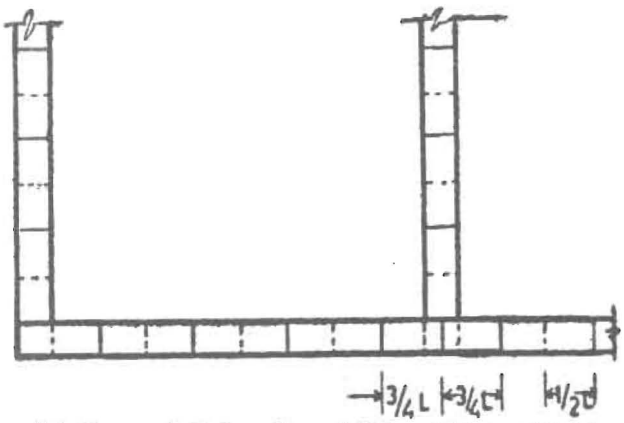
iv) The blocks, after being cast, should be water cured for two weeks and air cured for another two to four weeks. They should be dry before being used and in no case these shall be laid in masonry within one month of their being cast.

v) The blocks should be dry at the time of being laid in the wall. Wetting may generally not be necessary. Consistency of the mortar used should be adjusted to suit suction of the block rather than the blocks being wetted to suit the mortar. However in hot and dry climate the blocks should be wetted on the surface only by sprinkling water in order to reduce suction of moisture from mortar.

vi) For breaking of vertical joints in alternate courses, smaller length blocks (depending upon the wall length) should be used. Masonry bonds for various wall thicknesses at corners and junctions are shown in Figs. 15 to 18 and as described below :

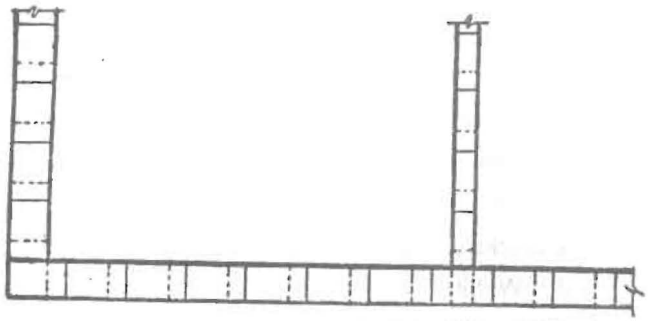


(a) Corner & T-Junction of 200 × 200 mm Wall

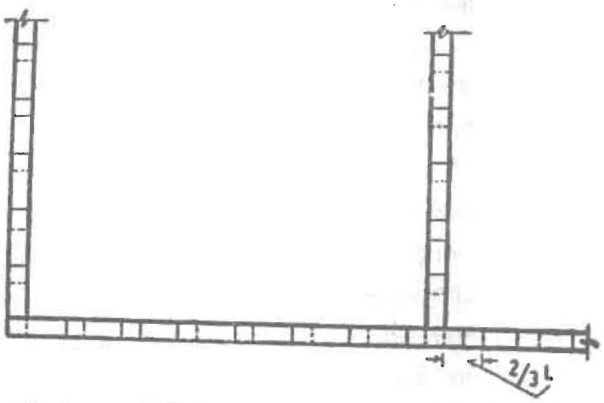


(b) Corner & T-Junction of 150 × 150 mm Wall

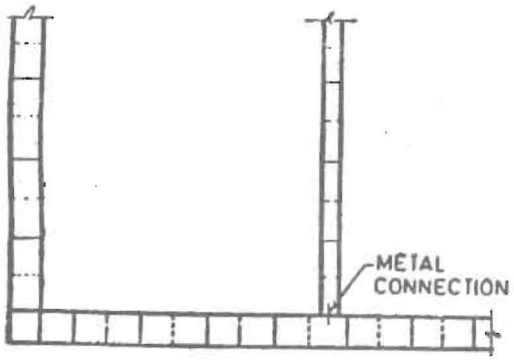
Fig. 15



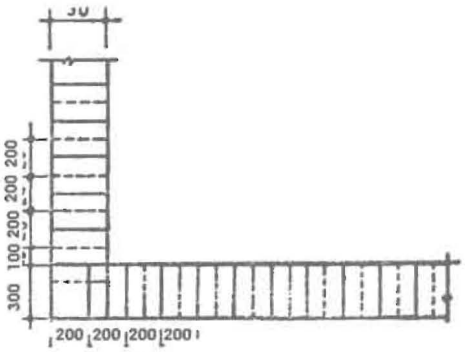
(c) Corner & T-Junction of 200 × 100 mm Wall



(d) Corner & T-Junction of 100 × 100 mm Wall



(e) Corner & T-Junction of 150 × 100 mm Wall



(f) Corner of T-Junction

Fig. 15 Details of Bonds in Stone Masonry Block Walling

a) At T junction of 200 mm with 200 mm and 150 mm with 150 mm walls, a vertical joint at the centre line of cross wall is provided in alternate courses by providing 2/3 size blocks in case of 200 mm thick walls as shown in Fig. 15 (a) and 15 (b) respectively.

b) In case of T junction of 200 mm × 100 mm and 100 mm × 100 mm walls, the joints are staggered by using 1/3rd and 2/3rd length blocks in alternate courses as shown in Fig. 15 (c) and 15 (d) respectively.

c) For 200 mm to 150 mm and 150 mm to 100 mm wall junctions, where block to block bonding is not practicable, bonding is achieved by providing 200 mm long 6 mm dia. bars in alternate courses. Arrangement for 150 to 100 mm wall junction is shown in Fig. 15 (e). For embedding the metallic ties, only cement mortar is used.

d) Bonding for 300 mm with 300 mm wall is shown in Fig. 15 (f).

e) Arrangement of the blocks in the walls with pillasters are shown in Fig. 16 and Fig. 17.

f) Bonding for 200 mm thick wall with special blocks with groove for vertical reinforcement at corners and openings is shown in Fig. 18.

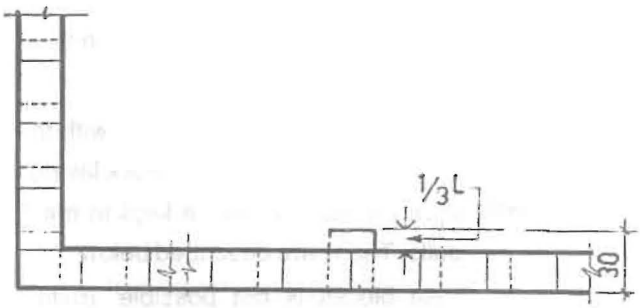


Fig. 16 300 mm Pillaster with 200 mm Wall.

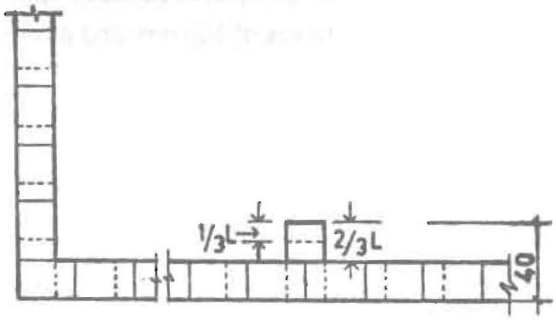


Fig. 17 400 mm Pillaster with 200 mm Wall.

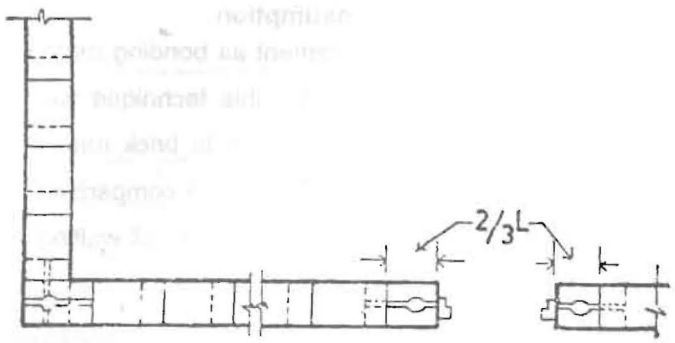


Fig. 18 Bonding at Corner and Door Opening for Vertical Reinforcement

vii) Bearing of lintel should be 100 mm on either side. To match the top level of precast lintel with the block height, in situ concrete of required thicknes should be provided at the bearing ends.

viii) Double scaffold should be used without holes in the masonry for supporting the scaffolding.

ix) Mortar joint on the external face should be finished with pointing. To cover any services between exposed stone pieces and surrounding concrete, sufficiently wide layer of mortar should be applied and finished level. Internal face may or may not be plastered. In case of plaster, the mortar used may be 1:6 (C:S), 1:1:6 or 1:1:6 (Cement : Lime : Sand) of 10 mm thickness.

x) The plugs for fixing service pipes and electrical fittings etc., should preferably be inserted at the joints in the masonry. Where large openings are required for sanitary fittings, full block be left without mortar during wall construction. In case of opening is required after construction, a full block should be taken out and the gap filled with lean cement concrete after providing the fittings through the wall. Space for nitches or fixing electric switch board etc. should be created by using thinner blocks (100 mm).

FUNCTIONAL PERFORMANCE

Thermal Performance

Thermal performance of stone masonry block walling of various thicknesses is given in Table 3.

Table 3 - Thermal Performance of Stone Masonry Block Walls

Sl. No.	Wall Thicknes (mm)	U-Value Kcal/hr/°C/m²	Thermal Perf-ormance Index (T.P.)
1.	100	3.750	186
2.	200	2.668	132
3.	300	2.288	(96)
4.	400	(1.931)	(71)
5.	100 Block + 50 Air Gap + 100 Block with ties	(1.790)	(95)

Specified values for heat Insulation of non-industrial buildings is 2.00 K Cal / hr / °C / m² and thermal performance index should be 100 as per IS 3792-1978. The figures in bracket satisfy the thermal standard. It may be seen that only 300 mm and above thick stone masonry block walling or cavity wall of 100 mm leaves provide the required thermal insulation. However for other walls these values can be improved by providing light colour whitewash treament on external face and shading arrangements. Thus only the external wall facing west be either made 300 mm thick or protected by shading with verandah etc. while all other external walls be made 200 mm thick.

Rain Penetration Test

Wall Panels of 2.5 m × 1.25 m and 0.2 m thickness made with 1:6 cement sand mortar pointed on external face with 1:3 cement sand mortar and internal face plastered 12 mm thick with 1:6 cement sand mortar were subjected to spray of water at the rate of 4.5 litres / minute and a pressure of about 1.05 N/mm² as per Technical paper 47, Division of Building Research, National Research Council, Ottawa, Canada For comparison 230 mm brick wall panel built in 1:6 cement sand mortar internally plastered with 1:6 cement sand mortar 12 mm thick and pointed externally with 1:3 cement sand mortar was also subjected to same test. The results are given in Table 4.

Table 4 - Rain Penetration Test on wall panels

Duration in hrs.	Wet area % of Block Masonry Wall	Wet Area % of Brick Wall
1	2	3
0.5	First appearance of dampness at a point	First appearance of dampness at a point
1	Small patch	Very small patch
2	8	6
4	18	24
6	23	47
8	58	60
12	68	77
13½	71	81
32	Full Panel	Full Panel

It may thus be seen that the performance of stone masonry block walling against rain penetration is similar to that of brick wall when the bricks are of compressive strength 12 N/mm^2 and water absorption 12%. Rain penetration can be checked by plastering the external face and or taking the measure of filling the junctions between exposed stone pieces and lean concrete with 1:6 cement sand mortar. In areas of high rainfall, it is advisable to plaster inner face with integral water proofing compound mixed in the mortar in order to check dampness on the internal face.

COST ECONOMICS

To work out cost of construction with this technique, basic data giving the requirement of labour and materials, both for production of blocks and for masonry construction is given in Table 5. By putting the prevailing rates, the cost of walling at any place where stone is easily available can be calculated. This construction system provides an economy of 15 to 20% in the walling cost against conventional methods of construction, viz., random rubble masonry.

Comparison of Cement Consumption

These blocks are cast with cement as bonding material and thus it is often thought that this technique would consume more cement as compared to brick masonry walling or random rubble stone walling. A comparison of consumption of cement for different types of walling is given in Table 6.

It may be seen that 200 mm thick stone masonry block walling plastered on one side and pointed on the other consumes only about 10% more cement as compared to 230 mm brick wall plastered on both faces. In case, the internal face of stone masonry block walling is not plastered cement consumption will, more or less, be the same as that in brick masonry. But as compared to random rubble masonry walling, this technique provides a saving of about 25% in cement.

Advantages

Stone block masonry has the following advantages :

1. It does not call for heavy capital investment
2. The use of stone spalls saves cement consumption and also provides strength to the blocks even with lean concrete mix which works as a binder only. It also reduces the cost of blocks.
3. Because of prefabrication consistency and better quality of units are achieved.
4. Wall thickness is reduced to 150 or 200 mm only, thereby saving of materials and cost both in foundation and super structure. It also makes larger usable floor area as compared to random rubble masonry walling.
5. The blocks being of larger size, productivity in laying is increased and wall is built at a faster rate.
6. One face of the block being in stone texture, it gives natural stone appearance of rubble masonry and various architectural aesthetics. It has also been possible to make hexagonal blocks with stone texture (Fig. 19).
7. Internal plaster can be eliminated with proper care during production and laying. However, if plastering is done, the thickness required is only 10 to 12 mm.
8. As against random rubble masonry, this walling

Table 5 - Basic Data for Material and Labour Requirements

ITEM	Nominal Thickness of Block		
	200 mm	150 mm	100 mm
1	2	3	4
Nominal size block (mm)	300 × 200 × 150	300 × 100 × 150	300 × 150 × 150
Actual size of block (mm)	290 × 190 × 140	290 × 140 × 140	290 × 90 × 140
Concrete mix proportion by volume (Cement : Sand : 10 mm and down graded coarse aggregate)	1:5:8	1:5:8	1:5:8
PRODUCTION			
(a) Mould			
i) Fixed open box type No	1	1	1
M.S. Plate 4 mm thick (m^2)	0.16	0.12	0.08
Fabrication & welding charges L.S. (Rs.)	20	15	13
ii) Split type No.	1	1	1
M.S. Plate 4 mm thick (m^2)	0.17	0.13	0.09
12 mm dia pin 250 mm long No.	2	2	2
Fabrication & welding charges L.S. (Rs.)	25	20	16
iii) Gang Mould of six No.	1	1	1
M.S. Angle 35 × 35 × 6 mm (Meter Length)	4.5	4.3	4.15
MS Plate 4 mm thick (m^2)	0.85	0.63	0.45
12 mm dia M.S. Bolts 30 mm long (Nos.)	8	8	8
Fitter (Man days)	1.5	1.25	1.1
Welder (Man days)	1	1	1
Helper (Man days)	3	2.5	2
(b) Casting of Blocks (No.)	100	100	100
i) Materials			
Cement (Bags)	1.55	1.15	0.78
Sand (m^3)	0.28	0.21	0.15
Coarse aggregate (m3)	0.44	0.33	0.23
Stone pieces (m^3) (Stack volume)	0.37	0.27	0.15
ii) Labour*			
Mason (Man days)	0.30	0.25	0.20
Unskilled worker (Man days)	2.12	1.75	1.40
Production per day by gang of one mason and 7 unskilled workers (Nos.)	330	400	500
Sundries :			
Cost of casting platform and mould oil etc. L.S. Rs. (for 100 blocks)	1.10	0.90	0.70
MASONRY WORK (10 m^2) :			
Materials :			
Precast Stone Masonry blocks (nos.)	222	222	222
Mortar (m^3)	0.20	0.15	0.10
Labour for foundation and plinth :			
Mason (Man days)	1.30	1.1	0.90
Unskilled worker (Man days)	2.60	2.2	1.80
Extra for super structure upto floor two level :			
Mason (Man days)	0.20	0.18	0.10
Unskilled worker (Man days)	0.50	0.40	0.20

* The above labour includes casting, lifting, curing and stacking the blocks within a lead of 10m.

Note : (1) The cost of scaffolding, T&P, water, contractor's profit and overheads are to be added extra.

(2) The labour for transportation of blocks from stack to construction site has been included for a lead of 50 m only. For every additional 50 m lead 0.40, 0.30, 0.20 man days of unskilled worker may be added for 100 nos. of 200 mm, 150 mm and 100 mm thick blocks respectively.

provides improved performance against rain water penetration/seepage.

During last 20 years, more than 50,000 houses and other buildings have been constructed with these units in almost all parts of the country, specially in Andhra Pradesh, Himachal Pradesh, J & K, Kerala, Madhya Pradesh, Rajasthan, West Bengal and hilly areas of Tamil Nadu and Uttar Pradesh. Some buildings where stone masonry block walling has been used are shown in Figures 20 to 24.

Table 6 - Cement consumption for alternative walling-10 m^2

Item	Cement Consumption (bags)		
	230 mm thick brick wall	200 mm thick precast stone masonry block wall	300 mm R.R. stone wall
1. Blocks	...	3.44	...
2. Mortar (CM/1:6)	2.95	0.91	4.95
3. Plaster (20 mm in CM 1:6)	0.75	0.75	...
4. Plaster (20 mm in CM 1:6)	1.15	...	2.24
5. Pointing (in CM 1:3)	...	0.20	...
Total	4.85	5.37	7.19

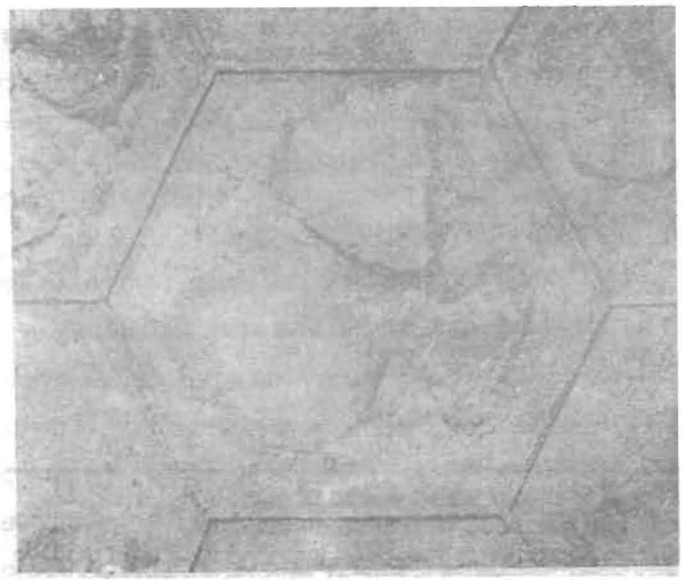


Fig. 19 Wall with Hexagonal Blocks

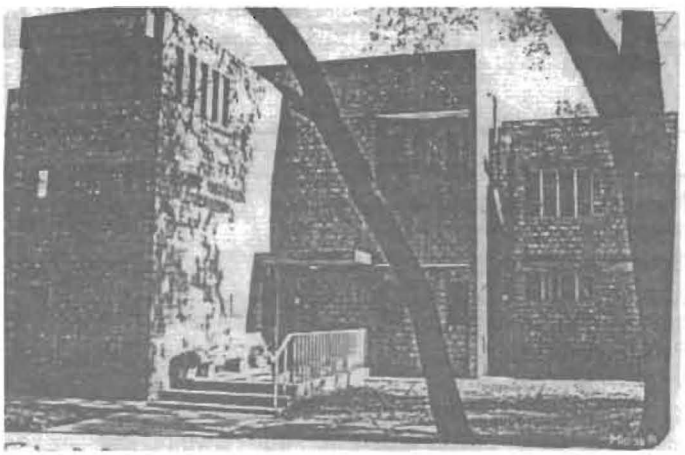


Fig. 20 Building with Stone Masonry Blocks & Bricks

Fig. 21 Industrial Building

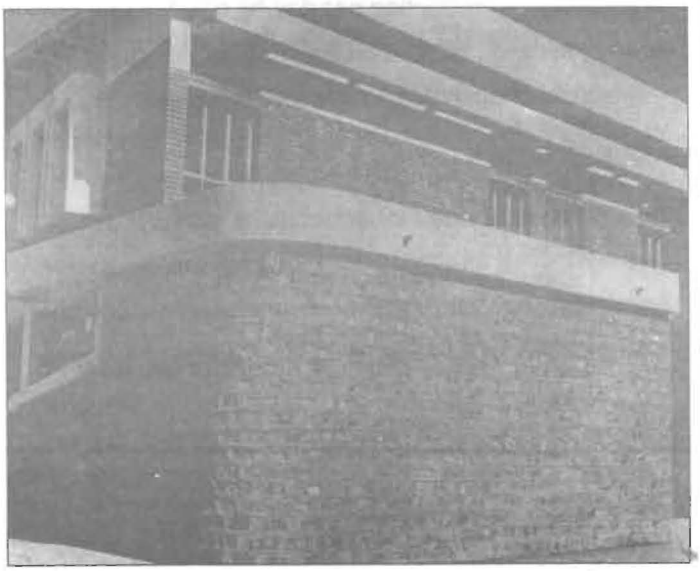


Fig. 22 Workshop Building with Curved Wall

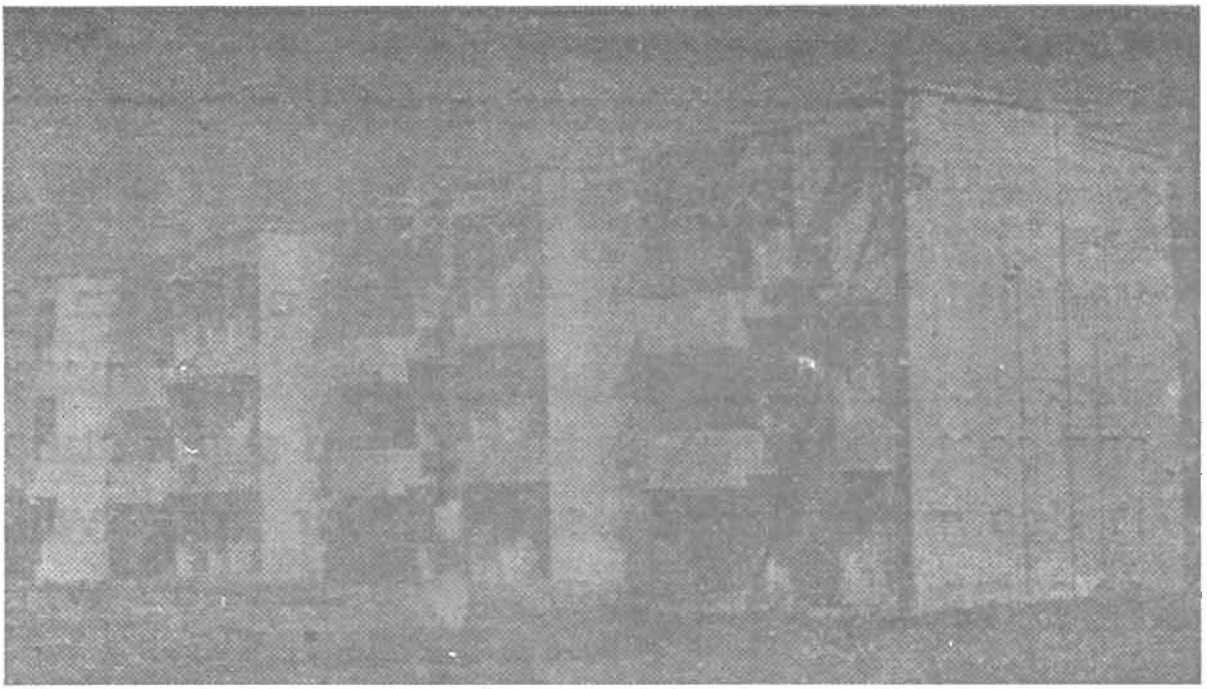


Fig. 23 Three storey Residential Building.

Fig. 24 Shopping Centre in Shantinagar (CBRI) Colony.

Prepared by	:	J.S. Sharma, S.P.S. Bedi, B.K. Jindal and G.C. Sofat	Published by	:	Central Building Research Institute Roorkee - 247 667
Revised by	:	B.N. Hira	E-mail	:	director@cbrimail.com
Printed	:	August 2004	Website	:	www.cbri.org

Edited by : Dr Atul Kumar Agarwal & Shri Dinesh, Scientists, Printed at: Paramount Offset Printers 7, Avas Vikas, Roorkee Ph. 261778, 264117