BUILDING RESEARCH NOTE 69

SOLID CONCRETE BLOCK MASONRY SCHEME

Introduction

Concrete can be converted into precast masonry units of suitable size to be used for walling. Use of such blocks is more appropriate in a region where bricks are costly, poor in strength and are not available. Depending upon the structural requirements of masonry units, concrete mix can be designed using available ingredients. The blocks can be cast to desired shape and size to facilitate construction of wall of requisite thickness and appearance. A thickness as low as 15 cm is feasible for a load bearing wall and 10 cm for a non-load bearing wall, adopting solid concrete blocks.

A series of lean concrete mixes were developed at the Central Building Research Institute, using gap-graded concrete with 50 mm coarse aggregate and fine aggregate.

Pilot-scale trials and field applications have proved that the newly produced masonry unit has significant techno-economic potential. This Building Research Note describes, in brief, the manual production process of solid concrete masonry blocks, their physical properties, design and construction details, material and labour constants, involved in production and assembly of the blocks.

The Block

It has been observed that a block weighing about 16 to 18 kg. can be handled by a mazdoor or a mason. The Institute had been promoting the use of precast stone masonry block, weighing about 18 kg. of a nominal size of 15×20×30 cm. The masonry units described in this Building Research Note also is of the same size and weight. The dimensions allow the designer to use the same block for wall thicknesses of 15 cm, 20 cm or even 30cm only by changing its face and orientation. This does not impose any structural problems within the masonry units, as the strength of block is fairly consistent in all directions.

Although the nominal size of the block is 30×20×15 cm. the actual size is 29×20×14 cm. These dimensions are assumed for commonly occuring 20 cm wall thickness. Thus each block with 10 mm thick horizontal and vertical joints, occupy effective modular measurements of 30×20×15 cm.

PRODUCTION OF BLOCKS

Casting Platform

The blocks are produced on a smooth, level and hard surface of 30 mm thick 1:3:6 cement concrete platform simultaneously finished smooth with 1:3 mortar. A base of brick soling of 12 cm thick lean concrete 1:8:16 may be used as a subgrade. The platform shall be cast in bays of 2m² to avoid random surface cracks. A casting platform of about 80 m² (10×8 m preferably) is required for production of 500 blocks per day.

• CENTRAL BUILDING RESEARCH INSTITUTE • ROORKEE 247667 • UTTAR PRADESH • INDIA

Mould

A battery of single moulds fabricated with mild steel plate is used to cast the blocks. Steel moulds yield clean, sharp-edged blocks with prefinished faces. It is advisable to use 8 to 20 moulds arranged in a row with no gap in between to form a battery. Each mould is provided with two handles made of M.S. rod to facilitate lifting of the mould.

Concrete Mix

Properly selected, clean ingredients of concrete should be used in appropriate proportions. Mixing of concrete should be done preferably in a mixer. Basically two types of mixes are proposed to cater for situations (i) where coarse sand is available and (ii) where coarse sand is not available. Although it is advisable to do precise mix design with the available ingredients at a place, the following two mixes could be followed in general with local modifications.

Aggregate Composition A

28% fine sand
(FM 1.35). (BD* 1295)
28%, 10mm aggregate
(FM 3 40). (BD 1422)
44%, 50mm aggregate
(crushed or broken). (BD 1367)

Aggregate / Cement	Water / Cement	Cement Consumption per m^3 of concrete
18	1.60	2.20
12	1.14	3.28
9	0.90	4.33

*BD-Bulk density (kg/m^3)

Aggregate Composition B

56% coarse sand (FM 3.1).
(BD* 1650)
44%, 50mm aggregate
(crushed or broken).
(BD 1367)

Aggregate / Cement	Water / Cement	Cement Consumption per m^3 of concrete
18	1.20	2.40
12	0.85	3 60
9	0.65	4.65

Release Agents

Before starting and also after completion of the work, the platform and the moulds are cleaned properly. Lubricating oil is applied inside the moulds and on the area of platform under the moulds, to act as release agent.

This helps in an easy, clean release of blocks and avoids the breakage of platform. The blocks may also be cast over alkathene sheet for easy release from the casting floor.

Concreting

The moulds are filled up thoroughly by using a trowel, and compacted with a surface vibrator. Pressure is exerted on the handles of the vibrator to impart the vibrations more effectively. Moulds of the compacted blocks are lifted up in the same sequence of concreting and are arranged further in the row for reuse. Filling of the moulds is done in two stages. Vibration should be stopped as soon as their is occurrence of slurry under the mould sides. The top is finished with the slurry formed at the surface and that available under the sides. A palte vibrator with a frequency of 3000 VPM is often used. It is however, advisable to use a high frequency vibrator of 5000-6000 frequency, if available. In remote areas without any power supply, the concrete blocks may be cast by using a vibrator run by a 1 KW portable generator. For mass production of these blocks, it is recommended to use the concrete block making machine developed by CBRI, for which a Building Research Note is available

Curing and Stacking

The blocks are cured on the casting yard for first 24 to 48 hours, depending on the weather conditions.

Handling before this period may damage the blocks. Half kg of calcium chloride per bag of cement may be used in extreme cold weather to achieve this handling strength. The blocks lifted from the casting yard are stacked on a nearby level ground over a layer of sand to ensure a full surface contact. Each day's production is accommodated in not more than two tiers of blocks. The blocks are cured for three weeks by frequent sprinkling of water. This is followed by two to three weeks of air drying It must be ensured that the block is fully dry before use in masonry, to avoid shrinkage cracks.

Physical Properties of the Block

The physical properties of the block are mainly governed by the nature of ingredients and their proportioning. Trials were done on two aggregate-compositions/'A' and 'B' as indicated under heading 'Concrete Mix'. and physical properties were found out for different aggregate cement ratios. and their optimum water cement ratios. The compressive strength, water absorption, drying shrinkage and moisture movement were determined as per respective Indian Standards and the results are tabulated below :

Aggregate Composition	A	A	A	B	B	B
Aggregate cement ratio	18	12	9	18	12	9
Water cement ratio	1.60	1.14	0.90	1.20	0.85	0.65
Cement Consumption (bags/m^3)	2.20	3.28	4.33	2.40	3.60	4.65
Av. density (kg/m^3)	2240	2346	2360	2453	2480	2480
Av. compressive strength (kg/cm^2)	72	108	148	100	145	176
Water absorption (%)	4.9	4.7	4.3	4.5	4.5	4.3
Drying shrinkage (%)	0.026	0.027	0.036	0.016	—	0.040
Moisture movement (%)	0.022	0.027	0.036	0.016	—	0.040
Initial rate of absorptions (gms/200cm^2)	11	—	—	13	—	—

(All figures are based on laboratory trials)

Thermal Performance

The thermal performance of solid concrete masonry block, for various wall thickness is tabulated below :

Wall thickness (cm)	U value Kcal/hr/°C/m^2)	Thermal Performance Index (TPI)
10	3.750	186
20	2.668	132
30	2.288	96
40	1.931	71
25cm thick cavity wall with 5 cm cavity between two walls of 10cm	1.790	95

For non-industrial buildings specified U-value is less than 2 Kcal/hr/°c/m^2 and Thermal Performance Index is less than 100. Thus the figures in bracket satisfy the thermal requirements. Theoritically a wall thickness of 30cm and above as well as a 10-5-10 cavity wall with solid concrete blocks offer satisfactory thermal insulation. However in practice only the south-west wall has a severe exposure to the sun, if no sunshading device is provided. Only such severely exposed wall be of 30cm, all other external walls may be 20cm thick.

Dimensional Tolerance

Deviation in the block length should not be more than (±) 5mm and that in the height and width of the block should not be more than (±3mm). These tolerance limits can be achieved without any difficulty with the help of steel moulds fabricated to an accuracy of ± 3.0mm in length and ± 1.5mm in height and width.

Structural Design

Masonry Strength

The wall made of solid concrete masonry blocks is designed like any other masonry wall. The values of basic permissible stresses given in IS : 1905-1980. "Structural Safety of Building Masonry Wall" hold good for solid concrete masonry blocks also. (Although the actual values achieved are about 30% higher).

Provision of vertical reinforcement at corners and openings to impart desired protection to the structure in seismic regions can easily be made by using special blocks with recess.

Masonry Construction

Mortar Composition

Commonly used 1 : 6 cement sand mortar is compatible to solid concrete blocks. However, it is preferable to use 1 : 2 : 9 composite mortar if good quality lime is available. The composite mortar has a quality of autogenous healing of shrinkage cracks. In any case the mortar should be such that the minimum flow after suction should be 60% to 70% of that before suction.

Masonry Bonds

Typical 'T' and 'L' junctionos occuring generally in various combinations of wall thickness are illustrated in figure 6 (a) to 6 (h). Alternate courses are clearly indicated in the sketches. The figures illustrate two typical wall to pillaster junctions. These also indicate how bonding for 20cm thick wall with special grooved blocks is provided, which facilitates introduction of vertical reinforcement at openings and corners, wherever desired.

Field Applications

1. At Dehradun, 330 residential quarter (LIG & EWS) have been constructed by MDDA at Dallanwala site

2. A 2000 metre long boundary wall of CBRI colony and 40 metre long boundary wall of Director's residence.

3. For the construction of 8 NV schools and 1000 residential quarters in Rajasthan, where 80 lakhs blocks where used in place of 4 crore bricks.

Basic Data for Material and Labour Requirements

PRODUTION OF BLOCKS

	Item	For 30×20×15 (29×20×14 nominal)		For 30×15×20 (29×15×14 nominal)		For 30×10×15 (29×10×14 nominal)	
(a)	Mould (one)						
	MS Plate 4mm thick (m)	0 15		0·12		0·08	
	Fabrication charges including cost of handle (Lump sum Rs.)	20		16		13	
(b)	Casting of blocks (Aggr : cement=18)	Mix A	Mix B	Mix A	Mix B	Mix A	Mix B

(i)	Material (100 blocks)					
	* Cement (bags)	1.787	1.950	1.340	1.460	0.893	0.975
	* Coarse sand (m^3)	—	0.590	—	0.444	—	0.295
	* Fine sand (m^3)	0.345	—	0.260	—	0.172	—
	* Coarse aggr. 50mm (m^3)	0.527	0.570	0.392	0.427	0.261	0.285
	* Coarse aggr. 10mm (m^3)	0.314	—	0.236	—	0.157	—
(ii)	Labour (100 blocks)						
	* Mason (mandays)	0.33		0.28		0.25	
	* Unskilled (mandays)	1.66		1.43		1.25	
(iii)	Casting platform, mould oil etc. lump sum in Rs. (100 blocks)	1.60		1.30		1.00	

OBSERVED PRODUCTION

By a gang of 1 mason and 8 unskilled workers	900	1000	1100

(This includes casting, curing & handling on site)

MASONRY WORK

(i)	Material for 1 m^3 ($30 \times 20 \times 15$ Size)			
	* Number of blocks	115		
	* Mortar 1:6 (m^3)	0.1		
(ii)	Labour (For 1 m^3) in substructure			
	* Mason (Mandays)	0.65		
	* Unskilled (Mandays)	1.30		
(iii)	Labour (For 1 m^3) in superstructure, upto 2nd floor level	20 cm wall (5 cm^2)	15 cm wall (6.66 m^2)	10 cm wall (10 cm^2)
	* Mason (Mandays)	0.75	0.80	1.00
	* Unskilled (Mandays)	1.60	1.60	2.00

— In cost of production of blocks, the labour included casting, lifting, curing and stacking of blocks within a lead of 10 meters.

— Cost of scaffolding, T&P, water, contractor's profit and overheads are to be added extra.

— The labour for transportation of blocks from stacking yard to construction site has been included for a lead of 50 metres. For every additional 50 metres lead 0 40, 0.30 and 0.20 mandays of unskilled worker for 100 blocks may be added for 20 cm, 15 cm and 10 cm. thick blocks respectively.

— In general the requirement of fractional blocks is as follows, although it will very with the type and size of the building.

1/2 blocks	8 to 10%
2/3 blocks	3%
1/3 blocks	2%
3/4 blocks	2%

Performance Against Rain-Water Penetration

Laboratory tests were conducted on wall-panels, by nsing simulated rainfall to find out their resistance to water penetration. Occurrence of second damp patch was considered as the failure criteria. Thus the "Ultimate Equivalent Rainfall" was found out, from which "Safe Rainfall' was computed by applying a factor of safety equal to two. Specimens with three commonly adopted specifications were tested. Brick wall panels were tested side by side for comparison. The test results indicated that the water penetration takes place through joints, mainly the vertical joints. It is therefore advisable to take extra care in placing mortar along the vertical joint surfaces. In general the solid concrete block masonry should be provided with 12 mm thick plaster on external face to avoid dampness, however in the hot and dry regions with low rainfall, naked walls can be provided. Performance of the 20 cm, externally plastered solid concrete block masonry was found to be better than 23 cm brick wall with identical specifications.

Note : Blended sand of fineness modulus of 1.8 was used for making cement mortar.

Advantages

The Solid Concrete Block Masonry has following advantages.

1. It is a labour intensive appropriate technique and hence does not call for heavy capital investment.
2. It is suitable for site oriented production. Thus transportation cost can be eliminated
3. Quality control is easy.
4. The wall thickness is reduced to 20 cm for load bearing wall and 10 cm for partition walls, thereby reducing the cubic contents of the material, obviously resulting into saving in substructure as well as superstructure. It also offers larger floor area for the same plinth area as compared to conventional random rubble masonry or even non modular brick walling.
5. Internal plaster can be eliminated with proper care during production and laying. When plastered, the thickness of the plaster required is also lesser as compared to that in the case of brick wall.
6. Can be produced in remote areas without power supply by using a portable 1 KW Generator.

Do's and Dont's

1. Plan the building to a 10 centimeter mould to avoid cutting of the blocks.
2. Check the accuracy of the new moulds before starting the production. Check accuracy of the angles of the moulds every day, before starting the work.
3. Keep strict watch on quality and the proportions of ingredients used in concrete.
4. **Modify the mix to suit the local sand and coarse aggregate. Confirm results of the trial mixes before commencement of the production of blocks. It is a must.**
5. Do not forget to use release agent or alkathene sheet on the plateform before casting.
6. Clean the moulds, alkathene sheet and, the production floor as soon as the day's production is enclosed
7. Do not disturb the freshly cast blocks before 24hrs, in any case.
8. Do the temporary stacking near the casting yard on the level ground provided with sand cushioning. Each day's production is accommodated in not more than 2 tiers.
9. Cure the blocks by sprinkling water for three weeks and than air dry for two to three weeks depending upon weather conditions
10. Do not use a partially dry block in the masonry.
11. Do not soak the block before using in the masonry. It should be only surface wet. So, a light water spray, about half an hour before use is enough.
12. Do not use harsh mortar in masonry.
13. Fill up the vertical joints with extra care.
14. Provide control joints at appropriate locations for walls more than 10 metre long.

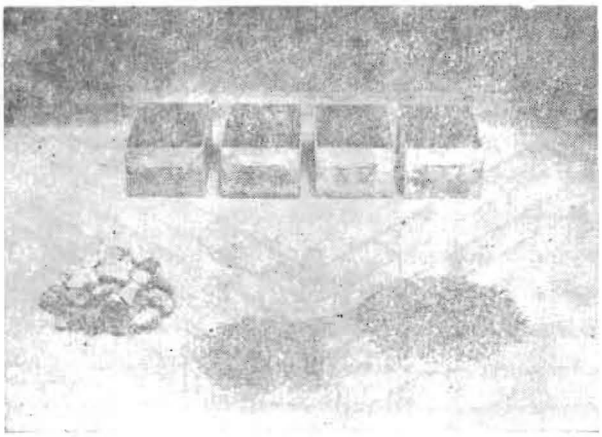

Fig. 1 Materials and Moulds

Fig. 4

Figs. 2, 3 & 4 Different Stages of Casting

Fig. 2

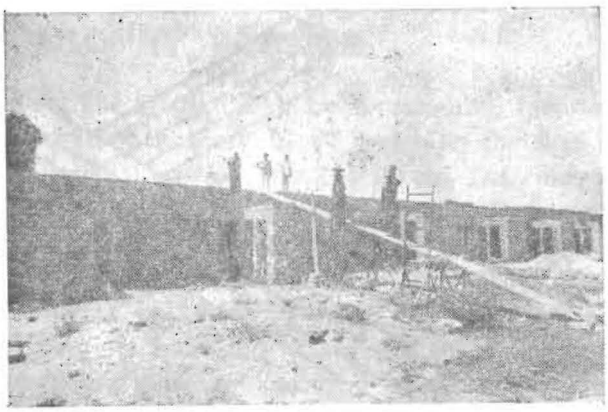

Fig. 5 Construction Site at Dallanwala, Dehradun

Fig. 3

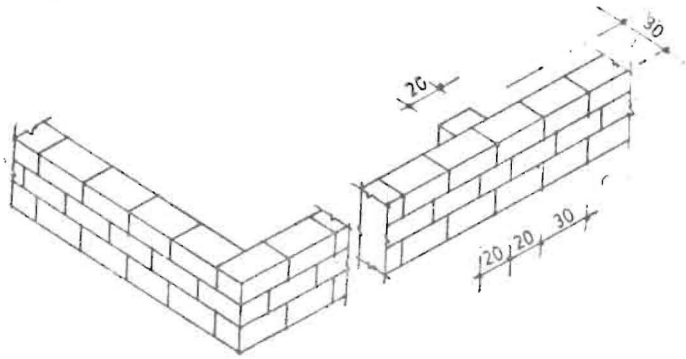

Fig 6a 30cm Pillaster with 20 cm Wall

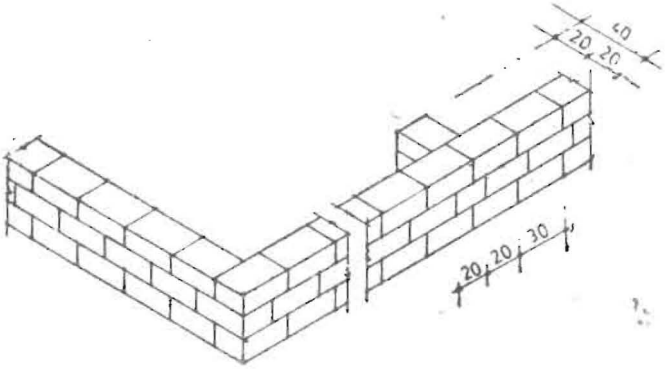

Fig. 6b 40cm Pillaster with 20cm Wall

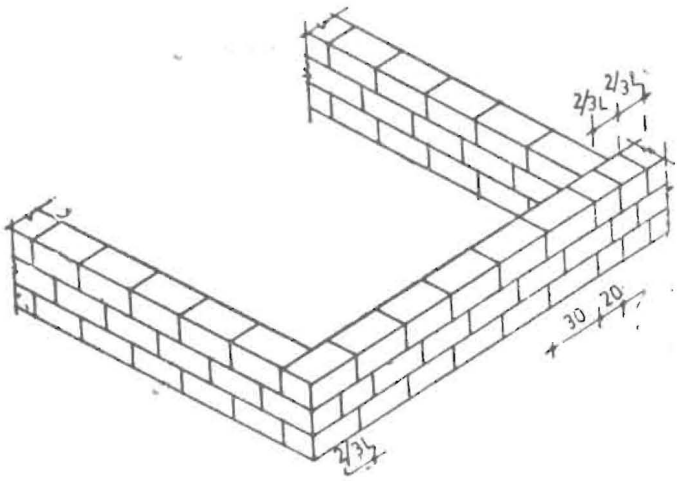

Fig. 6c Corner T-Junction of 20×20cm Wall

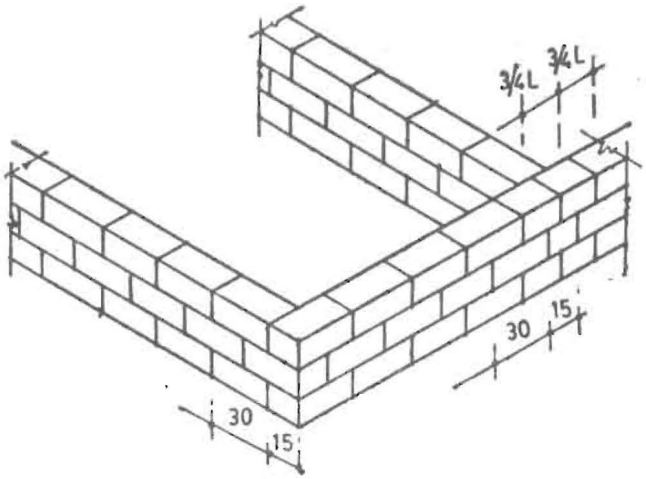

Fig 6d Corner & T-Junction of 15×15cm Wall

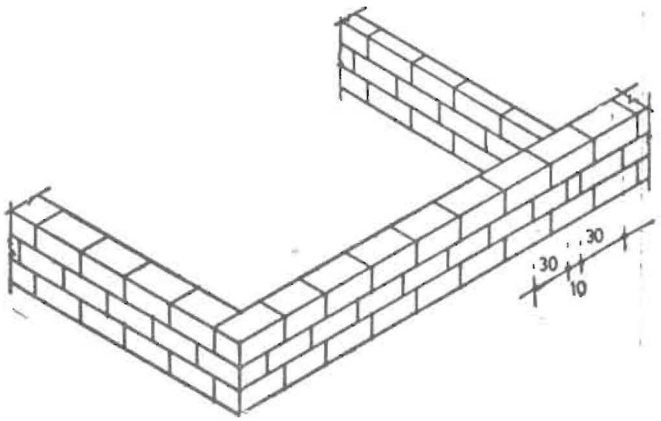

Fig 6e Corner & T-Junction of 20×10cm Wall

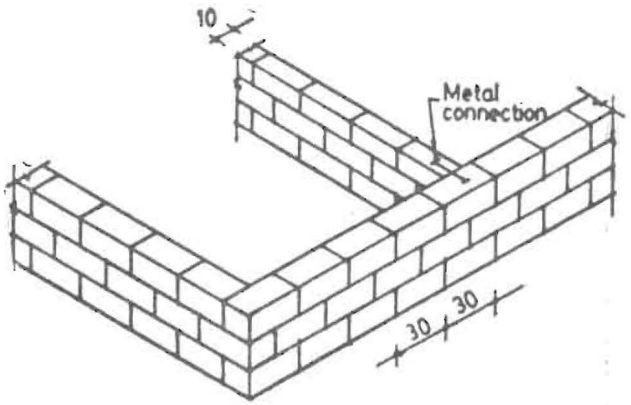

Fig 6g Corner & T-Junction ,of 15×10cm Wall

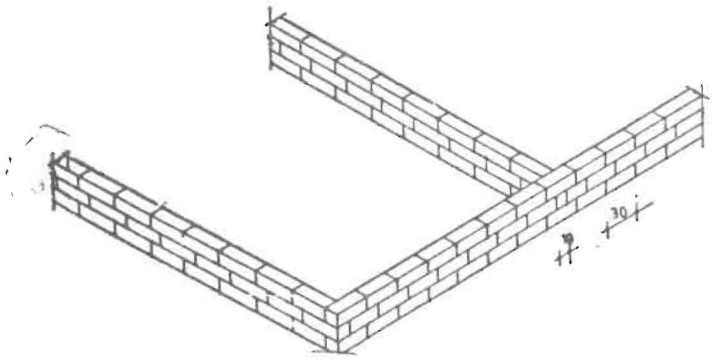

Fig 6f Corner & T-Junction of 10×10cm Wall

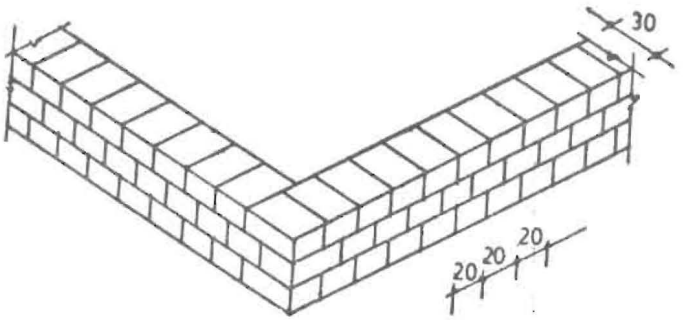

Fig. 6h Corner of 30×30cm Wall

Prepared by :
Dhanesh Chandra and N.N. Bhise

Published by :
Central Building Research Institute,
Roorkee (U.P.) INDIA
July, 1994

Printed at :
Jain Printing Press Main Bazar, Roorkee
Copies : 2000