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Cement Economy in Buildings

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The recommendations made in the Digest have been based on the work done in the Institute and reports of Committees appointed by N.B.O., and the Planning Commission. Some of the recommendations present a departure from the standard practice and would normally be recommended only after experience over an adequate serviceable life has been gained. The present conditions however justify such a departure even though it may involve some element of extra care and control in construction.

Introduction

In spite of the fact that the target set for cement production at the end of the Third Plan records a substantial increase over that achieved in the Second Plan, the bulk of the present supply is likely to be diverted for essential constructions connected with defence requirements, leaving very little for civilian use such as residential buildings, civic amenities, commercial establishments, school, etc. It is therefore imperative to effect utmost economy in the consumption of cement so that the available supplies can be utilised to maximum advantage. This Digest describes some of the ways and means of effecting saving in cement consumption in the construction of residential buildings.

Foundation Concrete

In the case of poor soils or framed structure with heavy loads and columns, systematic examination of the bearing capacity of the soil can often lead to significant economy in foundations†. For residential buildings, not more than three storeys high, the use of cement in foundation concrete can be eliminated except in areas with excessive soluble salts or in areas with high sub-soil water-level. The specifications suitable for foundation beds are given in Table I. Concrete normally used for foundations is of the proportion 1 : 3 : 6 or 1 : 4 : 8. Since the load in most of the buildings is small, cement concrete 1 : 5 : 10 may be used for residential buildings upto two storeys. The use of this mix in normal foundation work results in a saving of 18.6 per cent in cement as compared to a 1: 4: 8 concrete.

Masonry in Basement

Rich cement mortar used in damp proof course can be advantageously replaced by other materials e.g.,

TABLE I

Mortars for Foundation Concrete

Partly based on the Report of the Experts Committee (NBO) on Economy in the use of Cement in Building Construction

S. No.	Situation	Type of Mortar (By volume)	I.S.I. Grading of Lime*	Percentage Saving in Cement**	Remarks
1.	Dry sub-grade with sub-soil water-level never within 8'—0" of the foundation level	(i) 1 lime, 2 sand	A	100	Normally suitable for buildings not more than three storeys high. The quantity of mortar to be used will depend on the grading of aggregates.
		(ii) 1 lime, 1 surkhi and 1 sand	B, C or A	100	
		(iii) 1 lime, 2 surkhi	B or C or A	100	
		(iv) 1 cement, 3 lime and 12 sand	B or C	76.4	
		(v) 1 cement, 5 sand		37.8	Normally suitable for buildings upto two storeys and the corresponding concrete mix will be 1 : 5 : 10
2.	Moist sub-grade with high sub-soil water. Usually 8'—0" or less below foundation level	(i) 1 cement, 4 sand		23.6	The corresponding concrete mix will be 1 : 4 : 8 and 1 : 3 : 6 respectively.
		(ii) 1 cement, 3 sand		—	

†Building Digest No. 11, Bearing Capacity of Soils

*I.S.I. grading of lime :—
Hydraulic lime—A
Semi-hydraulic lime—B
Non-Hydraulic lime—C

**Compared to concrete with cement mortar 1 : 3 (1 cement : 3 sand)

TABLE II

Mix Proportions for Masonry Lime Mortars

(Based on IS : 1625-1862)

S. No.	Sub-grade Condition	*Type of loading	Proportions of mix** Lime	Cement	Pozzolana	Sand or Pozzolana aggregate	Remarks
			A. MASONRY IN FOUNDATION AND PLINTH				
(i)	Dry	Light	1 C	—	1	2	Pozzolana is essentially a silicious material which while in itself possessing no cementitous properties will in finely divided form and in the presence of water react with calcium hydroxide at ordinary temperature to form compound possessing cementitious properties, e.g., surkhi (IS : 1344-1959) Cinder, Coal ash, fly ash, etc.
			1 B or A	—	—	3	
		Medium	3 C	1	3	9	
			3 B	1	—	12	
		or	1 C	1	2	4	
		Heavy	1 B	1	—	6	
(ii)	Moist, but no soluble sulphates present	Light Medium or Heavy	1 B	1	—	6	
(iii)	Moist soluble sulphate present	Light Medium or Heavy	1 B	1	—	6	
			B. MASONRY WALLS IN SUPERSTRUCTURE				
	TYPE OF WALL						
(i)	Solid wall	Light	1 C	—	1	1 to 2	
		or	1 B		—	2 to 3	
		Medium	**8 to 9B	4 to 3	—	36	
		Heavy	2 B	1	—	9	
		Very Heavy	1 B	1	—	6	
(ii)	Cavity wall		1 B	1	—	6	
			C. MASONRY IN TALL CHIMNEYS				
	TYPE OF WALL AND LOADING						
(i)	Generally		1 A	—	—	2 to 3	
(ii)	For heavy or Very heavy loading		2 B	1	—	9	
			D. POINTING TO MASONRY				
(i)	In all Cases		1 A	—	—	1	
			6 B	1	—	7	

*Light loading—4 kg/cm²; Medium loading—4-6 kg/cm², Heavy loading—6-8 kg/cm².

**The proportion shall be such that the sum of lime and cement is equal to 12.

polythene film, tarfelts, aluminium foils, bitumen or pitch coatings. The plastics or bitumen impregnated d.p.c. materials can withstand the effects of settlement of a structure to a considerable degree and provide a more satisfactory impermeable barrier to rising moisture. To ensure better performance these sheeting materials should be laid according to manufacturer's instructions. The replacement of 1½ in. cement concrete (1:2:4) d.p.c. by black polythene film (Gauge 400) laid on a ¼ in. thick cement mortar (1 : 4) can result in an appreciable saving in cement.

In low-cost houses where the foundation is always dry it is of advantage to leave the vertical joints of two brick course unfilled. This reduces the capillary rise of moisture and may well replace a d.p.c. in moderate conditions of exposure.

In areas with low average rain fall, foundations and plinth masonry of single storeyed building can be lain in well burnt bricks in mud mortar and pointed in cement : lime mortar (1 : 6 : 7). The resultant saving in cement is nearly 94 per cent as compared to ordinary brick work laid in cement mortar (1: 6).

Table II gives the recommendations for mortars in foundation masonry and plinth.

Masonry in Superstructure

The strength of brick work depends upon a correct balance of the strengths of bricks and mortars. In fact, for a particular strength of bricks, there is an optimum mix of mortar which gives the best results and richer mixes have hardly any advantage. For example, pillars built with bricks of less than 3,000 lb/sq. inch compressive strength in cement-lime-sand mortar (1 : 1 : 6) have been found to have as much as 96% of the compressive strength of pillars built in cement-sand-mortar (1 : 3) although the compressive strength of cement-lime-sand mortar was only 60 per cent of the compressive strength of straight cement-sand mortar. Mortars rich in cement are also liable to shrinkage cracks leading to moisture penetration. Lime mortars or cement-lime-sand mortars possess on the other hand all the desirable qualities of a masonry material i.e., good workability, adequate strength, good adhesion, and durability. These can therefore be used in all masonry constructions in place of straight cement-sand mortars.

In certain parts of North India, the superstructure in single story houses is built with well burnt bricks laid in mud mortar and protected from rain by ordinary pointing or plastering. This too ensures a considerable saving in cement. However, use of mud mortar in certain conditions can result in increase in the thickness of walls and involve higher consumption of bricks which is also a scarce material.

Long walls can be constructed in pillar and panel construction with pillars in cement-lime-sand mortar (1 : 1 : 6) and panels in mud mortar with cement-lime pointing. Similarly, the use of cement mortar in partition wall can be eliminated with consequent saving in cement. Stone masonry can also be laid in cement-lime-sand mortar (1 : 2 : 9) or (1 : 3 : 12) in conjunction with crushed stone or coarse sand of suitable gradation.

The use of cavity walls can serve the dual purpose of effecting saving in the consumption of bricks and cement. For example, an 11 inch cavity wall laid in cement-lime-sand mortar (1 : 1 : 6) can substitute a 13½ in. solid brick wall laid in cement mortar (1 : 6), resulting in 30 per cent savings each in brick and cement. Besides, the cavity walls offer greater resistance to rain-penetration and provide better thermal insulation as compared to solid brick walls.

In Table II on page 32, the recommendations for masonry in supperstructure have been given. It will be observed that mortars recommended for pointing are not necessarily rich in cement.

Renderings

Cement plasters of various compositions are usually specified for internal and external renderings. Straight cement-sand plasters are vulnerable to defects such as crazing and cracking with consequent penetration of rain-water. In many parts of the country, where rainfall is not excessive, external plastering can be substituted by pointing alone provided roofs and chhajjahs are correctly detailed and well burnt bricks are used. Plastering below damp proof course may be done in cement-lime-sand mortar (1 : 1 : 6). In internal plastering it is preferable to use lime mortars or cement lime sand mortar. A list of alternative specifications for plaster on walls and ceilings are given in Table III on page 34.

Floors

In ground floors, the base course can be laid in lime concrete thereby entirely eliminating the use of lean cement concrete. For wearing course stone slabs can be used in areas where stone is plentiful. In multistoreyed residential buildings, the roof slab can serve as floor without any additional wearing course; if the slab is finished immediately after laying. The practice of using additional neat cement mortar on top of the R.C.C. slab in order to obtain better finish is generally not successful as the mortar usually peels off after some time. Suitable finish can be obtained by control on water content and use of screed vibrators.

Roofs and Lintels

The N.B.O. report on Low Cost Housing, gives some specifications for flat roofs which economise in the use of cement. The use of shell in roofing residential houses has shown considerable promise. The doubly curved shell units developed* in the Institute economise about 45 and 40 per cent in the consumption of cement and steel respectively as compared to the conventional 4-inch R.C.C. slab. These shell units can also be cast in lime-surkhi concrete leading to further economy in cement. On large housing project, the construction

*D.C. Shell Brochure —CBRI Publication.

TABLE III

Recommended Plaster Specifications

(Extracted from IS : 1661-1960)

S. No.	Situation	Mix				Class of Lime (IS:712-1956)	Thickness	Remarks
		Cement	Lime	Pozzolana	Sand			
1.	External plaster below damp proof course	1	1	—	6	'B' or 'C'	10 to 15 mm	Single coat on low or medium cost buildings in areas of moderate rainfall-1300 mm/yr. & sub-soil water within 2·5 m. Below the ground surface
2.	External plaster above damp proof course	1	2	—	9	'B' or 'C'	10 to 15 mm	
			1		2 to 3	'A'		
			1	1	1 to 2	'B' or 'C'		
3.	Internal plaster in all low or medium cost houses	1	3		12	'B' or 'C'		
		1	2	—	9			
			1	—	2 to 3	'A'		
			1	1	1 to 2	'B' or 'C'		

can be speeded up by precasting them while the walls are being built. These units were recently employed on a very large scale for the construction of 1,500 houses in a housing project and the construction was completed in the record period of seven months.

The Institute has also developed other types of flat roofs of a composite nature (partly precast and partly cast in-situ) which offer suitable alternatives to R.C.C. slab for spans upto 14 ft. The roofs comprise of precast curved hollow units of guna tiles encased in concrete and precast doubly curved tiles of plain cement concrete. The savings in cement consumption as compared to a 4-inch R.C.C. slab are 28 and 24 per cent respectively. Besides these roofs also economise in steel consumption ranging from 36 to 63 per cent*.

The use of prestressed beams and R.C.C precast slabs either plain or ribbed as evolved by Hindustan Housing Factory (New Delhi) also leads to considerable economy in cement consumption. Where terraces are not intended for sleeping purposes, the use of sloping roof can be considered.

At places where the use of 1½-inch cement concrete laid in panels over a layer of lime concrete is common, the top 1½ inch cement concrete can be substituted by natural slab stone laid in cement mortar (containing waterproofing compound). Where R.C.C. lintels (precast or cast in-situ), have adequate (approx. 35 per cent of the span) masonry on top and sides, advantage can be taken of this masonry and the lintel designed as a composite element consisting of concrete and brick work. Work carried out in U.K., and the Institute has indicated that most of the lintels in residential buildings need only be 1½ to 3 inches thick, reinforced with 3 nos, ¼ to 3/8 inch dia M.S. bars placed in the centre. These designs besides resulting in 50 to 75 per cent economy in cement can be readily precast and speed up the construction.

Miscellaneous

Cement need not be used, while the shortage lasts, in approach roads, etc., and tarmac or gravel can be a good substitute. All ornamental finishing involving the use of cement can be avoided. It is well known that prefabricated or prestressed concrete components are economical in the use of scarce materials and their use in appropriate circumstances deserves consideration in the present situation.

Some economy in cement may be effected by carefully planning the layout of sewers and drains. In good hard soil, pipes can be laid in lime concrete. Cement concrete surrounds need not be used unless they are essential for structural stability.

Even where cement concrete has to be used some economy in cement is possible by scientifically designing the concrete mixes and employing quality control at the site. More care in use and storage of cement will not only save cement but should result in a better job. Adequate attention to storage conditions at site will help the supplies to go farther by preventing deterioration. Details of suitable design for cement storage can easily be obtained from the advisory services of cement companies.

Conclusion

To illustrate the saving likely to result by adopting some of the alternative specifications mentioned results of a case-study of a semi-detached double-storeyed residential building in Western U.P. are given in Table IV. A saving of nearly 42.2 per cent in the consumption of cement is reported from the study.

*Inexpensive Roofs for Small Houses—Building Digest No. 5

TABLE IV

Comparative Consumption of Cement

Particulars: Element	Particulars: Item	Quantity	Original Specification	Quantity of Cement in cwts.	Recommended Alternative specification	Quantity of cement in cwts.	Cement Savings in cwts.
(A) Foundation and Plinth	Concrete in foundation	474 cft.	C.C. 1 : 5 : 10	35.50	Concrete without cement (Table I)	Nil	35.50
	B.B. work in foundation	672 cft.	C. mortar 1 : 6	24.36	Without cemet (Table II)	Nil	24.36
	D.P.C.	63 sft.	1½" thick of C.C. 1 : 2 : 4	2.25	Alkathene over 1/4" thick C. mortar 1 : 4	0.40	1.85
(B) Superstructure	B.B. Work	1716 cft.	C. mortar 1 : 6	62.21	Mortar without cement	Nil	62.21
	B.B. work in 4½" thick walls	1524 sft.	C. mortar 1 : 3	31.03	Lime cement mortar 1 : 2 : 9	12.93	18.10
	B.B. work in window projections	16 sft.	C. mortar 1 : 3	0.32	-do-	0.14	0.18
	Stone work	9 cft.	C. mortar 1 : 6	0.44	same as original	0.44	Nil
(C) Staircase	Steps and landings	50 cft.	Cement concrete 1 : 2 : 4	8.50	same as original	8.50	Nil
(D) Roofing	Railing walls	20 cft.	-do-	3.40	-do-	3.40	Nil
	Slab work	775 cft.	-do-	131.75	R. C. C. slab for 1st floor & D.C. tiles for roof	116.75	15.00
	Beams	75 cft.	-do-	12.75	same as original	12.75	Nil
(E) Flooring	Flat brick floor	164 sft.	C. mortar 1 : 3	0.87	-do-	0.87	Nil
	1" P.C.C. floor	348 sft.	C. concrete 1 : 2 : 4	4.93	-do-	4.93	Nil
	1½" P.C.C. floor	150 sft.	-do-	3.20	-do-	3.20	Nil
	Terrazzo floor	187 sft.	3/8" thick (1 : 2) on P.C.C. 5/8" (1 : 2 : 3)	4.30	-do-	4.30	Nil
	-do-	868 sft.	3-4/8" thick (1 : 2) on P.C.C. 1 1⅛" thick (1 : 2 : 4)	26.90	-do-	26.90	Nil
(F) Finishings	¾" thick cement dado	30 sft.	Cement mortar 1 : 3	0.75	Same as in original	0.75	Nil
	Terrazzo dado	286 sft.	3/8" thick (1 : 2) on C. mortar 3/8" thick	9.32	-do-	9.32	Nil
	Pointing to tiles	840 sft.	C. mortar 1 : 3	4.20	Lime cement mortar 1 : 6 : 7	1.50	2.70
	Internal plaster ¾" thick	4000 sft.	C.M. 1 : 6	48.00	Lime cement mortar 1 : 3 : 12	22.40	25.60
	External plaster ½" thick above D.P.C.	2800 sft.	-do-	24.00	Lime C. mortar 1 : 2 : 9	17.50	6.50
	External plaster below D.P.C.	553 sft.	-do-	4.74	Same as in original	4.74	Nil
	Flush pointing to Brick work	60 sft.	C. mortar 1 : 3	0·52	Lime cement mortar 1 : 6 : 7	0.20	0.32
(G) Miscellaneous	Chullah	1 No.		1.00	Same as in original	1.00	Nli
	Lintel work	25 cft.	R.C.C. 1 : 2 : 4	4.25	R.C.C. 1 : 2 : 4 (Provide 3" lintels)	2.50	1.75
	Chajjas	49 cft.	-do-	8.33	Same as in original	8.33	Nil
TOTAL CONSUMPTION OF CEMENT				457.82 Or 22.89 ton		263.75 or 13.19 tons	194.07 or 9.70 tons

APPROXIMATE SAVING IN CEMENT: 42.4%