BUILDING DIGEST

CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

THE YIELD OF MORTAR AND CONCRETE MIXES

Introduction

The yield of a mortar or a concrete mix is defined as the volume of compacted mortar or concrete obtained by mixing known quantities of cement, aggregates and water. This information is used to calculate the quantities of materials required to make a unit volume of mortar or concrete and further to estimate the materials required for the particular item of a job.

A comparison of the material requirements for different mixes as specified by various organisations functioning at a place, has revealed that there is a variation to an extent of about 10 per cent in them. Also due to the absence of any published study of the yield on a rational basis, it was considered worth while to investigate this scientifically. This digest describes the methods used for the assessment of yield, the effect of the fineness modulus and the type of aggregates.

Methods for the Assesment of Yield

There are two methods viz. Absolute volume and Density method which are commonly used to measure the yield. In the case of Absolute volume method the specific gravities of the individual materials constituting the mortar or concrete are to be determined. The absolute volume occupied by the individual material in a mix of mortar or concrete is then calculated by dividing the weight of each material in a batch by its specific gravity and then by the density of water. Finally, the yield of mortar or concrete is obtained by adding the absolute volumes occupied by different materials in the mix. In this method it is assumed that the concrete or mortar is thoroughly compacted and dense. In other words it does not take into account the fact that there is always a certain amount of air in concrete or mortar, nor that some of the water is absorbed by the aggregates. In the case of density method the weight of certain volume of freshly mixed mortar concrete is taken to determine its density. The total weight of the ingredients mixed to produce the mortar or concrete is then divided by this density to arrive at the yield per batch. In view of the drawbacks of the absolute volume method mentioned above and also since IS : 1199-1959 "Methods of Sampling and Analysis of Concrete" prescribes the density method for finding the yield of concrete, the same was adopted for arriving at the consumption of materials in different mixes of mortar and concrete. The procedure of the density method as given in the above said Indian Standard was followed in arriving at the results.

Before finding the consumption of material in different mixes of mortar and concrete it was considered advisable to find the effect of the size and type of the aggregates on the yield.

Effect of the Fineness of Aggregates

There is variation in the grading of aggregates specified by different organisations for use in mortar and concrete. In order to find the effect of the fineness of aggregates on the yield of mortar and concrete it was, therefore, decided to adopt the gradings specified by ISI as these also covered the different ranges specified by various organisations. The gradings of sand for use in mortar for brick work and plastering are given in IS : 2116-1965 and IS : 1542—1960 respectively. According to these standards the minimum and maximum fineness moduli specified for use in mortars for brickwork are 1.15 and 2.95 respectively while for plastering these are 1.25 and 2.95. In the case of concrete the range of fineness moduli of fine aggregate is 1.35 to 4.00 while that of the coarse aggregate is 6.05 to 7.65 as given in IS : 383–1963. A systematic study of the effect of the fineness of fine aggregate on the yield of mortar and concrete mixes has shown that the yield is more to an extent of about 2 per cent in the case of mixes wherein a fine aggregate having maximum fineness modulus as given above is used instead of the minimum one. Further, in the case of concrete mixes the difference becomes 4 per cent when both the fine and coarse aggregates with F.M. 4.0 and 7.65 respectively are used instead of those having F.M. 1.35 and 6.05.

Effect of the Type of Aggregate

In the case of concrete, generally, two types of coarse aggregates are used viz. rounded aggregate (shingle or gravel) and crushed aggregate (stone ballast). Yield studies with both the types of aggregates have shown that there is a variation to an extent of 5 to 7 per cent (5 per cent for leaner viz 1:6:12 and 7 per cent for rich mixes viz. 1:2:4). The yield being more in the case of concrete wherein rounded aggregate is used. Further, the tests have shown that, for the same workability of concrete, the strength difference due to the use of rounded and crushed aggregate is negligible.

Constants for Mortars and Concrete

Mortars

The different mortars for which the yield studies were carried out are straight cement-sand, lime-sand, lime-surkhi and cement-lime-sand mortars. The mixes studied for these mortars were those commonly adopted in different departments. The fineness modulus of sand used was 1.26 and all the materials were conforming to the respective ISI specifications. The results of all the mixes in terms of materials required per m^3 are given in table-1, The flow of mortar in all the cases was kept within the prescribed limits of 110 ±5 per cent and was attained by varying the water cement ratio.

Concrete

In this case the yield studies were carried out for cement and lime concrete. Rounded aggregate (shingle or gravel) was used for all the mixes of cement concrete and brick-ballast alongwith lime-surkhi mortar for lime concrete mixes. All the materials used were conforming to the respective ISI specifications. In the case of cement concrete, coarse sand (F. M. 2.87) alongwith shingle (20 mm nominal gauge) was used for all rich mixes upto 1:3:6 since in practice these mixes are mostly used for R. C. C. works. For all the other mixes, fine sand having a fineness modulus of 1.26 was used alongwith shingle (40 mm nominal gauge). Constants per m^3 of the concrete as obtained from the yield results for different mixes are shown in table-2. The compaction factor was kept 0.85± 0.02 for all the mixes.

Table–1 **Material Constants in Mortars**

Mix (by volume)	Constants per m^3 of mortar			
	Cement (bag)	Slaked lime*(m^3)	Surkhi (m^3)	Sand (m^3)
Cement-Sand mortars				
Cement-Sand				
1 : 3	8.48	—	—	0.90
1 : 4	6.79	—	—	0.96
1 : 5	5.60	—	—	0.99
1 : 6	4.65	—	—	0.99
1 : 7	4.06	—	—	1.01
1 : 8	3.57	—	—	1.01

Table 1. [Continued]

Mix (by volume)	Constants per m^3 of mortar			
	Cement (bag)	Slaked lime*(m^3)	surkhi (m^3)	Sand (m^3)
Lime Mortars				
Lime-Sand				
1 : 2	—	0.45	—	0.90
1 : 3	—	0.33	—	0.99
Lime-Surkhi Mortars				
Lime–Surkhi				
1 : 2	—	0.50	1.00	1.00
1 : 3	—	0.37	1.11	1.11
Composite Mortars				
Cement-Lime-Sand				
1 : 1 : 6	4.48	0.16	—	0.96
1 : 2 : 9	3.02	0.21	—	0.96

Note:—1. Fineness modulus of sand=1.26

2. Water cement ratios adopted are for the percentage flow of 110±5

*3. When lime is used in the form of putty, the volume 'V' of slaked lime contained in one metre cube of lime putty can be found by the formula

$$V=\frac{G(W_p-1000)}{(G-1)D}$$

where W_p=Weight of putty in kg/m^3

G=Specific Gravity of Slaked lime

D=Bulk Density of Slaked lime.

Table 2--**Material Constants in Concrete**

Cement Concrete

Mix (by volume) Cement : Sand : Shingle	Fineness modulus		Constants per m^3 of concrete		
	Fine Agg.	Coarse Agg.	Cement (bag)	Sand (m^3)	Shingle* (m^3)
1:1:2	2.87	6.50	9.76	0.35	0.70
1:1½:3	2.87	6.50	7.33	0.39	0.78
1:2:4	2.87	6.50	5.84	0.41	0.82
1:3:6	2.87	6.50	4.15	0.44	0.88
1:4:8	1.26	6.90	3.20	0.45	0.90
1:5:10	1.26	6.90	2.52	0.45	0.90
1:6:12	1.26	6.90	2.10	0.45	0.90

*1. In rich mixes upto 1:3:6, the normal size of shingle used is 20 mm while for others it is 40 mm.

2. For arriving at the constants/m^3 using crushed aggregate (stone-ballast) an allowance of 5-7 percent is to be added in the constants given above.

Lime Concrete

Item	Size of coarse agg.	slaked lime (m^3)	Surkhi (m^3)	Brick aggregate (m^3)
Lime concrete with brick aggregate and 40% lime mortar 1:2 (1 lime : 2 surkhi)	25 mm nominal gauge	0.22	0.44	1.10
Lime concrete with brick aggregate and 50% lime mortar 1:2 (1 lime : 2 surkhi)	—do—	0.26	0.52	1.04

Concluding Remarks

There is a wide variation in the prevailing constants of mortar and concrete mixes in different organisations functioning at a place. The constants established at this Institute should be of use in avoiding these variations. Further, to affect economy in the use of materials for cement concrete, round aggregate (shingle or gravel) should be preferred especially at a place where it is available at par with the crushed aggregate.

There is a demand for short notes summarising available information on selected building topics for the use of Engineers and Architects in India. To meet the need, this Institute is bringing out a series of Building Digests from time to time and the present one is the 83rd in the series. Readers are requested to send to the Institute their experience of adopting the suggestions given in this Digest.

UDC	69.003.12: 691.53:691.32
SfB	Ba7

Prepared by : *Surinder Singh & G. C. Sofat*
Edited and Published by : *P. L. De,*
Central Building Research Institute,
Roorkee. U.P.
September 1970

Security Printers, Saharanpur (India)

CENTRAL BUILDING RESEARCH INSTITUTE
ROORKEE U.P. (INDIA)

LIST OF PUBLICATIONS OF CBRI

Sl.	Title of publication	Cost	Available from
1.	Climatological & Solar Data for India (2nd Revised Edn)	Rs. 30.00	M/s Sarita Prakashan, 175 Nauchandi Grounds, Meerut.
2:	Use of Fly ash in building Industry.	Rs. 2.50	The Institution of Engineers, 8 Gokhale Road, Calcutta-20.
3.	Selection & Design of Prestressed Concrete Sections for Flexures.	Rs. 3.00	Indian Concrete Journal. Cement House, Queens Road, Fort. BOMBAY-1
4.	Monograph on Soil Stabilisation by P.L.De.	Rs. 5.00	Indian National Society of Soil Mechanics and Foundation Engineering, Curzon Road, NEW DELHI
5.	Building Digests (No. 1-18)	Re. 1/- each Rs. 18/- for bound volume.	M/s Today & Tomorrow Printers, 22B/5 Original Road, Karol Bagh, NEW DELHI-5
6.	Building Digests (No. 19-36)	—do—	M/s Security Printers, 159 Bomanji Road, Saharanpur.
7.	Proc. of the Symposium on Site Investigations for Foundations. Ist Vol. 2nd Vol.	 Rs. 20.00 Rs. 9.00	M/s Sahu Cement Service, PNB House, 5 Parliament St. NEW DELHI-1
8.	Proc.Symp. on Bearing Capacity of Piles. Ist Vol. 2nd Vol.	 Rs. 15.00 Rs. 8.00	—do—

NOTE : The above publications can be purchased directly from the addresses given.