Effect of Fineness of *Surkhi* on the Strength and Watertightness of Masonry

by
B. K. JINDAL
Central Building Research Institute
Roorkee

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B. K. JINDAL
Central Building Research Institute
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The paper raises an important issue with regard to the need for striking a balance between the degree of fineness to which surkhi *for use in structural mortars should be ground for obtaining the desired properties of strength and watertightness and the high cost involved in the fine grinding of the material. Making a study of the strength and watertightness of brick masonry built in 1 : 2 lime* surkhi *mortar, the author advocates the use of a comparatively coarser* surkhi *of specific surface 500-1 000 cm²/g in place of a combination of fine aggregate and fine* surkhi *of specific surface 2 250 cm²/g conforming to IS : 1344-1959 Specification for* surkhi *for use in mortar and concrete — Ed.*

● *Surkhi* of fineness conforming to the 'Indian Standard Specification for *surkhi* for use in mortar and concrete' (IS: 1344-1959)[1], that is of a fineness of 2 250 cm²/g, is generally not available in the market, the chief reason being the lack of suitable equipment for grinding. Earlier investigations[2,3] had shown that addition of sand to lime-*surkhi* mixes (2 250 cm²/g) did not reduce the strength of brick masonry materially but on the other hand improved watertightness. Naturally, the fineness to which *surkhi* should be ground so as to give the desired properties of strength and watertightness to brickwork in lime-*surkhi* mortars assumes importance as grinding costs money. In view of this, the effect of fineness of *surkhi* was studied in detail and the results are reported briefly.

1. MATERIALS

1.1 A *surkhi* sample conforming to IS : 1344-1959, except for the fineness requirement, was used throughout this study. Six samples (A, B, C, D, E and F) of fineness ranging from 350 to 3 000 cm²/g were prepared from the main *surkhi* sample. The particle size distribution of the first three samples is given in Table 1.

TABLE 1 SIEVE ANALYSIS OF *SURKHI* SAMPLES A, B AND C

B.S. Sieve No.	Percent Retained *Surkhi* Sample		
	A	B	C
(1)	(2)	(3)	(4)
7	0	0	0
14	10	0	0
25	20	10	0
52	30	30	20
100	30	45	35
Fineness Modulus	1·90	1·35	0·75

The fineness modulus of the samples A and B is 1·90 and 1·35, respectively and is corresponding to the limits (1·15 to 2·95) specified for sand for use in mortars[4]. These samples may be called coarse *surkhi*. All the remaining samples are termed as fine *surkhi*.

1.2 In the preparation of mortars, Class C lime conforming to 'IS : 712-1956 Specification for building lime' was used. Locally available second class bricks having an average strength of 1 800 lb/in² (127 kgm/cm²) were used in fabricating 18 in (45 cm) brick masonry cubes and 9 in (22·5 cm) thick assemblages. Twelve bricks were tested for the compressive strength in accordance with IS : 1077-1957 'Specification for common burnt clay building bricks'. The strength varied from 1 670 to 1 930 lb/in² (118 to 136 kgm/cm²).

2. EXPERIMENTAL PROCEDURE

2.1 Fabrication of Masonry Cubes — Specially made steel plates were employed for the fabrication of 18 in (45 cm) masonry cubes. The plates rested on iron studs of one inch size welded to their bottoms. Provision for levelling was made at the four corners of each plate.

2.1.1 The steel plate resting on the studs was levelled in two directions. A coat of mould oil was applied to the plate before fabrication of the cubes to prevent mortar from adhering to the plate. A layer of ½ in (1·25 cm) thick cement-sand mortar of 1 : 1½ proportion (by weight) was spread on the plate. The cube was fabricated on

the bedding mortar, using the lime-*surkhi* mortar under test. The bricks were bedded keeping the frog up. The same mason was employed throughout the job for uniformity in workmanship. The fabrication was well supervised and the quality of workmanship was of a high order. On the top of the cube again, ½ in (1·25 cm) thick cement-sand mortar of 1 : 1½ proportion (by weight) was applied and carefully levelled in two directions at right angles. The sides of the masonry cubes were then pointed flush with the same mortar. All cubes were fabricated inside the laboratory and cured under wet gunny bags till testing after 28 days. For compressive strength of the mortar, the 2 in cube specimens cast from the various mixes were stored with the corresponding masonry cube to simulate the same curing conditions.

2.2 FABRICATION OF ASSEMBLAGES FOR WATER PERMEABILITY TEST — Brick masonry assemblages, 18 in × 9 in × 12 in (45 cm × 22·5 cm × 30 cm) size were prepared using the lime-*surkhi* mortar under test. After seven days' curing under wet gunny bags, the assemblages were left exposed to the atmosphere under a shed till the time of testing after three months.

2.2.1 The mix composition of the mortar used in preparing the masonry cubes and assemblages was 1 : 2 lime-*surkhi* by volume. Three specimens were prepared for each fineness of *surkhi*.

2.3 TESTING OF MASONRY CUBES — The masonry cubes were tested in a 500-ton capacity compression testing machine. The cubes resting on the base plates were carefully lifted on to the bottom platen of the testing machine. Three-ply plywood sheets were kept in between the specimen and the platen to cover up any irregularities on the surface. Specimens were carefully centred and load was then applied at the rate of 250 lb/in² (17·6 kgm/cm²) per minute. For each specimen, load at first crack and ultimate load was recorded. The average load was calculated after rejecting test values showing a variation greater than 15 percent.

2.4 TESTING OF ASSEMBLAGES FOR WATER PERMEABILITY — The water permeability test of assemblages was carried out according to the method adopted by Palmer and Parsons[5]. For conducting the test, the assemblage was so turned that the vertical face 18 in × 12 in (or 45 cm × 30 cm) was uppermost and in a horizontal position. The assemblage was elevated so that the bottom surface could be observed and the leakage collected for measurement. A galvanized iron sheet frame 13 in × 9 in × 3 in (or 32·5 cm × 22·5 cm × 7·5 cm) was sealed (watertight) to the uppermost face. Water was then poured in and maintained at a depth of one inch (2·5 cm) throughout the test. The time of the fall of first drop through the bottom surface was recorded. The subsequent leakage was collected and measured at different intervals till the amount of leakage became almost constant.

3. RESULTS AND DISCUSSION

3.1 The compressive strength of 1 : 2 lime-*surkhi* mortar and brick masonry cubes prepared from it are given in Table 2. The results show that while the strength of mortar increases with the increase in fineness of *surkhi*, there is hardly any increase in the strength of masonry when *surkhi* samples having a surface area greater than 500 cm²/g are used in preparing 1 : 2 lime-*surhki* mortars. Apart from other factors, the strength of masonry depends upon the bond strength between the bricks and mortar. The bond strength of 1 : 1 : 2 lime-*surkhi*-sand has been found to be greater than that of 1 : 2 lime-*surkhi* using finely ground *surkhi* because the latter undergoes a higher drying shrinkage. In coarse *surkhi*, the coarse fraction acts as an inert matter which offsets the excessive drying shrinkage caused by its finer fraction acting as a pozzolana and, therefore, it produces better bond and imparts good strength to the masonry.

TABLE 2 STRENGTH OF MORTAR AND BRICK MASONRY (18 in CUBE OR 45 cm CUBE AT 28 DAYS

Surkhi Sample	Fineness (cm²/g)	Compressive Strength (lb/in²)	
		Mortar	Brick Masonry
A	347	187	580
B	498	219	672
C	1 007	252	615
D	1 520	330	632
E	2 280	431	569
F	3 020	504	650

3.2 Resistance of the masonry to the penetration of moisture can be studied by different methods[6]. The two methods selected for the investigation on the permeability of brick masonry were Palmer and Parsons test and spray test. In the light of the results obtained[3,7], it was not considered necessary to carry out the spray test which is also expensive. The method described by Palmer and Parsons alone was adopted.

3.3 The permeability data (*see* Fig. 1) show that watertightness of masonry is reduced by using very fine *surkhi*, that is, of specific surface greater than 1 000 cm²/g. Very coarse *surkhi*,

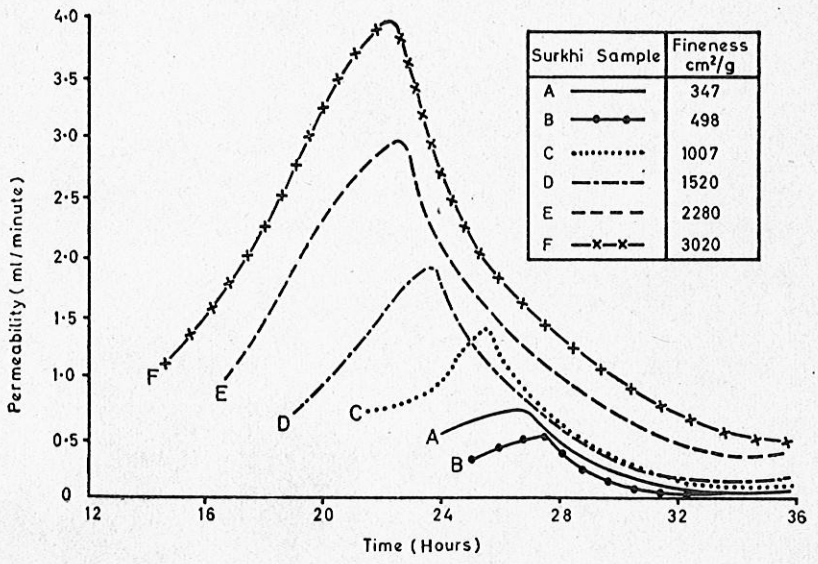

Fig. 1 *Permeability of brick masonry*

such as sample A, has also resulted in good watertightness of the brick masonry assemblages. The data clearly show that the use of *surkhi* having a fineness (2 250 cm²/g) as specified in IS : 1344-1959 is not advantageous. Earlier work had shown that a 1 : 1 : 2 lime-*surkhi*-sand mix had resulted in greater watertightness compared to a straight 1 : 2 lime-*surkhi* mortar (the *surkhi* used had a fineness of 2 300 cm²/g). It is felt that excessive drying shrinkage of the straight 1 : 2 lime-*surkhi* mortar leads to internal fissures which in turn reduce the resistance to the penetration of water. Addition of sand will offset the excessive shrinkage and improve the resistance to the penetration of water. Naturally the question arises why *surkhi* should be ground very fine in the first instance if sand is to be added subsequently. It would appear logical not to grind *surkhi* very fine as the cost of grinding is considerable.

4. CONCLUSIONS

4.1 The data show that as far as the strength and watertightness of brick masonry built in 1 : 2 lime-*surkhi* mortar are concerned, there is no advantage in grinding *surkhi* finer than a specific surface of 1 000 cm²/g. On the other hand, use of a very coarse *surkhi* (F M 1·90) is also not desirable. *Surkhi* for use in lime-*surkhi* mortars for brickwork should have a specific surface of 500 to 1 000 cm²/g. The fineness modulus should be in the range 0·75 to 1·35. The desired fineness can be easily obtained by using B.S. Sieve No. 14 (IS Sieve No. 120) below the grinder.

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