UTILIZATION OF BALCRETE FOAMING AGENT

Part II.—Production of Cellular Concrete (with Cement-Sand Mixtures)

MOHAMAD ASLAM, *Paints and Plastics Research Division*

AND

S. TEHZIBUL HASAN AND MOHAMMAD JEHANGIR, *Building Materials Research Division,*

Central Laboratories, Pakistan Council of Scientific and Industrial Research, Karachi

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This paper deals with the preparation and the physical properties of moist cured cement sand cellular concrete made with fine and coarse sands, respectively from Ravi and Malir river beds, in different proportions, using an ordinary non-tilting drum concrete mixer. The values for thermal conductivity, moisture penetration, compressive and flexural strengths have been determined for cellular concrete of various densities. It has been found that cellular concrete made with Ravi sand up to cement/aggregate ratio of 1:2 may be used for partition and insulation tiles, whereas with Malir sand it may be precast *in situ* on inaccessible roofs on account of its poor compressive strength.

Introduction

Moist cured cement-sand cellular concrete has been reported to have good thermal insulation, but modest compressive strength (as low as 60 p.s.i.). Aggregates generally used for this purpose are dense siliceous sands. Most of the Graf's[1] moist cured cellular concrete contained sands having 10-20% passing No. 100 sieve and less than 5% passing No. 200. In the same work for concrete of identical density and cement content, sand grading had little effect upon compressive strength except for concrete containing the finest sand which had markedly lower strength. Coarse aggregates are not recommended when the gas generating process is employed. The ratio of cement to aggregate in the commercial products of Europe varies from 1:1 to 1:4, the greater the proportion of aggregate, the higher is the denstity for a material of adequate strength. Use of Jumna or Solani sand (ground to pass 170 mesh with a maximum residue of 10 per cent) has been reported for cellular concrete using cement and aggregate ratio of 1:1. The use of 'Balcrete' foaming agent for cellular concrete (neat cement) has been reported earlier.[2] Its use for the preparation of moist cured cement-sand cellular concrete and the physical properties of the products are presented in this paper.

Preparation and Density Control of Cellular Concrete

Dalmia's portland cement (manufactured by dry process) and river sands from Ravi and Malir beds have been used in the present investigation. Chemical composition of the sands are reported in Table 1 and the grading of the aggregates in

TABLE 1.—CHEMICAL PROPERTIES OF MALIR AND RAVI SANDS.

Chemical Composition	Malir Sand	Ravi Sand
SiO_2	36.5 - 37.5	80.50
Al_2O_3 / Fe_2O_3	3.1 - 3.9	13.61
CaO / MgO	32.9 - 33.6	2.07
Ignition loss	27.2	2.85

Fig. 1. Ordinary non-tilting concrete mixer (capacity 6 cu. ft., speed of 10-12 r.p.m.) has been used for the preparation of cellular concrete. The method of preparation in general is described below:—

The requisite quantity of water and the foaming agent are placed in the mixer which is then run for three minutes to generate the foam. Cement and sand are then gradually added to the foam and mixing is continued altogether for about 15 minutes when a uniform slurry is obtained which is poured into the wooden moulds. The moulds are removed after 18-24 hours to avoid breakages.

The density control of cellular concrete is very important and can be achieved by adjusting the quantities of the foaming agent and water in respect of cement. The relationship between the density and water/cement ratio with varying percentages of foaming agent for different cement/

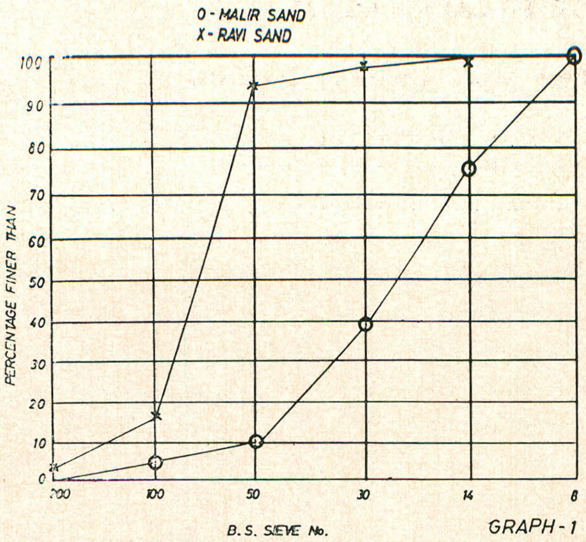

Fig. 1.—The grading of Ravi and Malir river bed sands.

aggregate ratios with Ravi sand is shown in Fig. 2 and with Malir sand in Fig. 3.

The rate of production is the same as reported earlier for neat cement in the previous publication.[2] The consumption of the foaming agent per 100 cubic feet for different compositions of moist cured cellular concrete are given in Table 2.

TABLE 2.—EFFECT OF INGREDIENTS ON FOAMING AGENT REQUIREMENT.

Proportions by weight		Water/ cement ratio	Density	Amount of foaming agent	
Cement	Aggregate			By weight of cemen —	Per 100 cu. ft. of concrete
	Ravi sand				
2	1	1.0	20–25	2.0	32 lbs
2	1	0.6	50–55	2.0	72 lbs
1	1	1.2	25–30	2.0	30 lbs
1	1	0.6	55–60	2.0	60 lbs
1	2	1.2	35–40	2.0	26 lbs
1	2	0.7	60–70	2.0	45 lbs
	Malir sand				
1	1	1.1	30–40	2.0	40 lbs
1	2	1.1	40–50	2.0	32 lbs
1	3	1.3	40–50	3.0	36 lbs
1	4	1.4	50–60	3.0	36 lbs
1	5	1.7	50–60	3.0	30 lbs
1	6	2.0	50–60	3.0	24 lbs

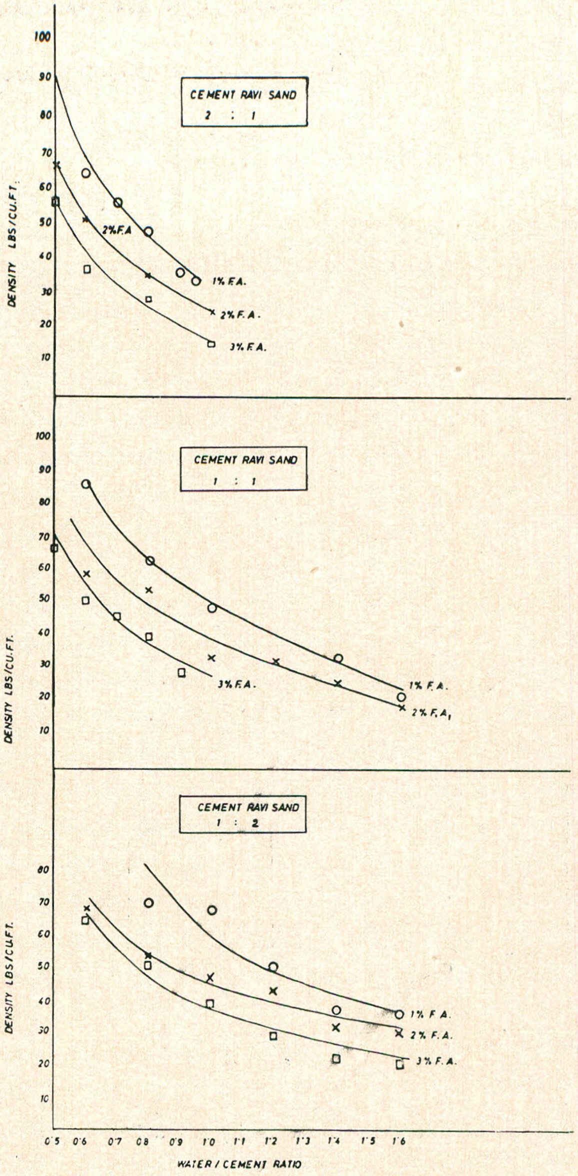

Fig. 2.—The effect of variation in the proportion of the foaming agent used and water/cement ratio on density of cellular concrete (with Ravi sand).

Physical Properties of the Cellular Concrete

Bricks made for testing the physical properties have been moist cured and strengths reported are for specimens 28 days old and tested in a room dry condition.

Compressive strength was determined on 4″ cubes, while flexural strength on 18″ × 4″ × 4″ bricks at a span of 15″. The relationship between density and compressive strength for different compositions of cellular concrete with Ravi and

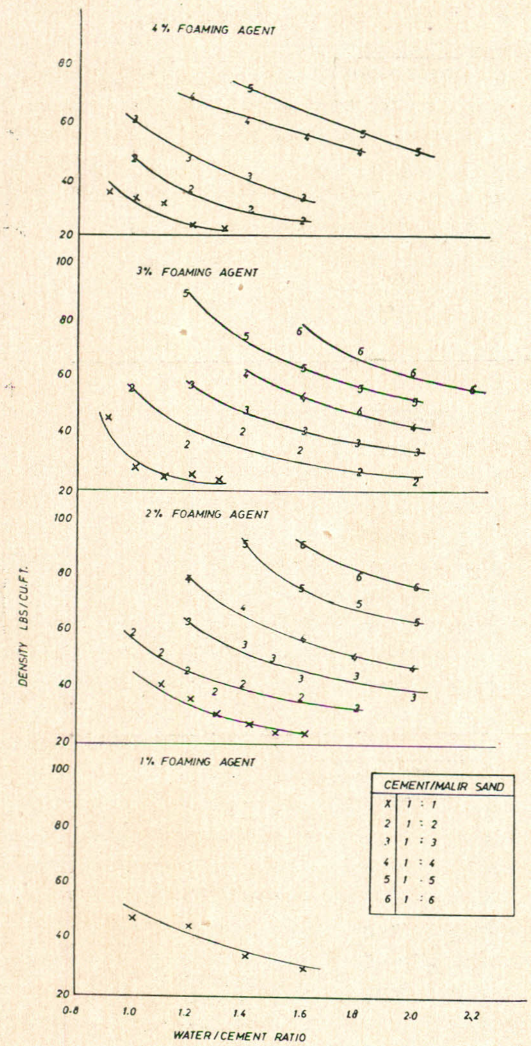

Fig. 3.—The effect of variation in proportion of foaming agent used and water/cement ratio on density of cellular concrete (with Malir sand).

Malir sand are shown in Figs. 4 and 5 and results of the flexural strength in Fig. 6. Compressive strengths of 100-500 p.s.i. are reported for European moist cured 1 : 4 cement-sand cellular concrete having density range of 50-80 lbs. per cu.ft. In this density range, compressive strength has been reported in Indian work, for moist cured 1:1 cement-crushed sand mixture from 100 to 400 p.s.i. In the present work, with Ravi sand compressive strength of 100-500 p.s.i. are attained for density range of 35-55 for 1:½, 40-65 for 1:1, and 45-75, for 1:2 cement-sand concretes. Very poor compressive strength is obtained with Malir sand. Results of flexural strength for moist cured cement-sand cellular concrete are not available in

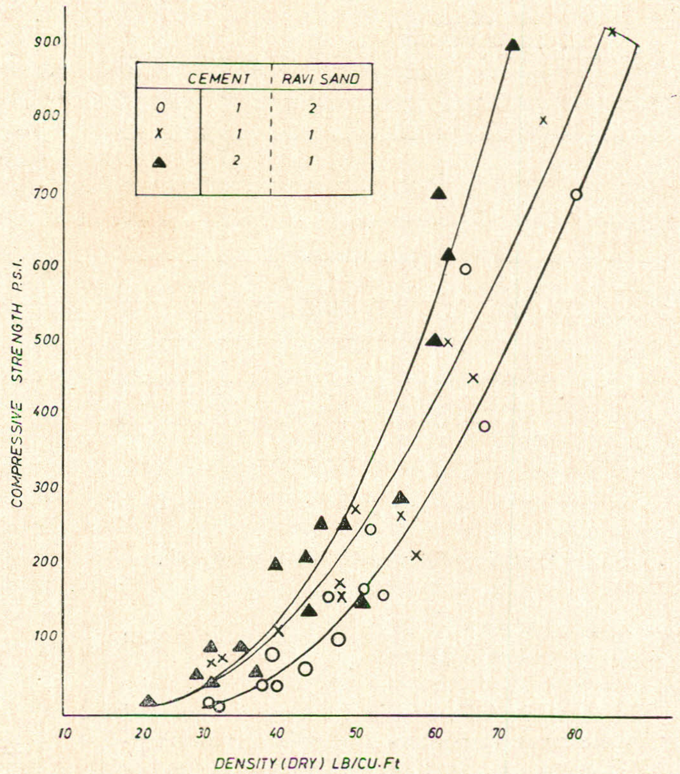

Fig. 4.—The compressive strength of moist-cured cellular concrete (with Ravi sand).

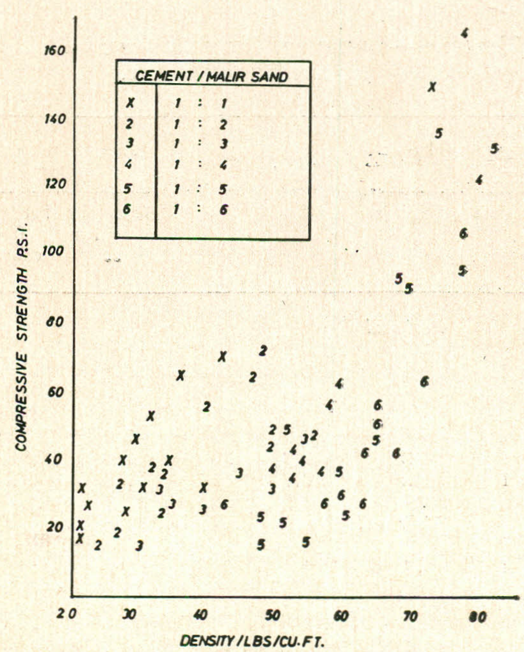

Fig. 5.—The compressive strength of moist-cured cellular concrete (with Malir sand).

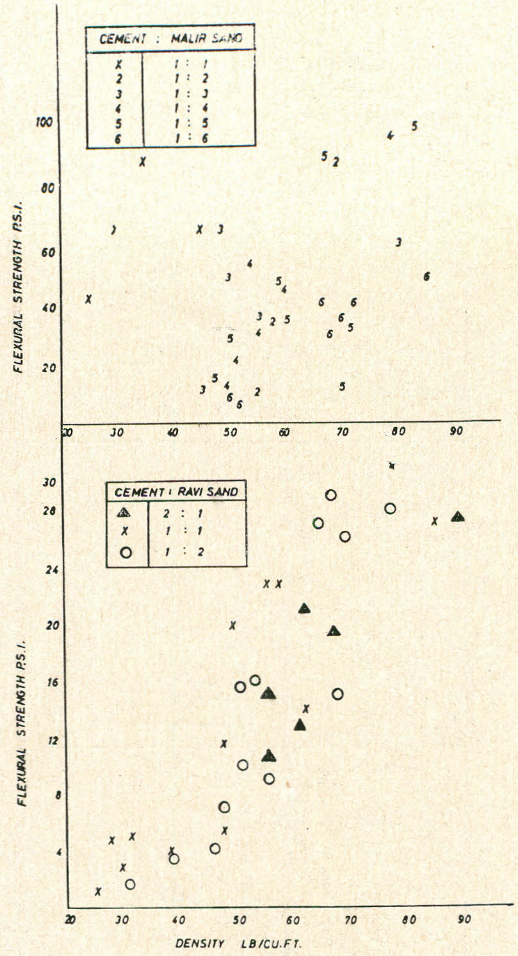

Fig. 6.—The flexural strength of moist-cured cellular concrete.

the literature. Flexural strength of cellular concrete with Ravi sand is poor but still good enough for the stresses which may develop during the handling of the precast blocks. The flexural strength with the use of Malir sand is comparatively better. The ratio of flexural to compressive strength for cellular concrete containing Ravi sand varies from 0.03 to 0.09 and for cellular concrete containing Malir sand from 0.3 to 1.0.

The thermal conductivity values for moist-cured cellular concrete for various compositions are reported in Table 3. The method used for determining the coefficient of thermal conductivity was that described previously by Ahsanullah, Ahmad and Chotani.[3]

Moisture penetration through the cellular concrete has been measured by a simple device shown in Fig. 7. The plastic tube with both ends open is placed on the top of the sample to be

TABLE 3.—THERMAL CONDUCTIVITY DATA FOR MOIST-CURED CELLULAR CONCRETE.

Aggregate used	Mix by weight	Density lbs. per cu. ft.	Thermal conductivity C.G.5 units x-10-3
Malir sand	1 : 1	25.0	0.20
	1 : 1	32.0	0.23
	1 : 2	36.0	0.24
	1 : 4	57.0	0.28
	1 : 4	62.0	0.32
	1 : 5	57.0	0.28
	1 : 6	62.0	0.31
Ravi sand	1 : 1	41.0	0.27
	1 : 1	50.0	0.29
	1 : 1	70.0	0.42
	1 : 2	41.0	0.27
	1 : 2	45.0	0.30
	1 : 2	62.0	0.36

tested and the bottom edge sealed with beeswax to prevent any leakage of water. The water is poured to the level indicated and the top covered to prevent evaporation losses. The time for the fall of water level is recorded for each division and the results are given in Fig. 8. This test gives a uniform hydrostatic pressure on the entire surface to be tested. The pressure gradually decreases as the water falls in the tube. The usual water absorption test was not considered important since the pressure of water varies on sides and is different in intensity on top and bottom of the sample. This method is considered better for studying the water repellant properties of the material under uniform pressure of the water.

It has been observed that the rate of penetration is considerably influenced by the nature of cellular structure. For very fine porous structure, the cellular concrete seems to possess a certain amount of water-repelling property, and with medium type of structure, it is of the same order as normal concrete. The use of Malir sand gives coarse structure and makes it practically porous. It is further to be observed that the water repelling properties is practically dependent upon the fineness of structure and not on the cement/aggregate ratio.

Conclusion

On the basis of the foregoing results, moist cured cement cellular precast concrete blocks

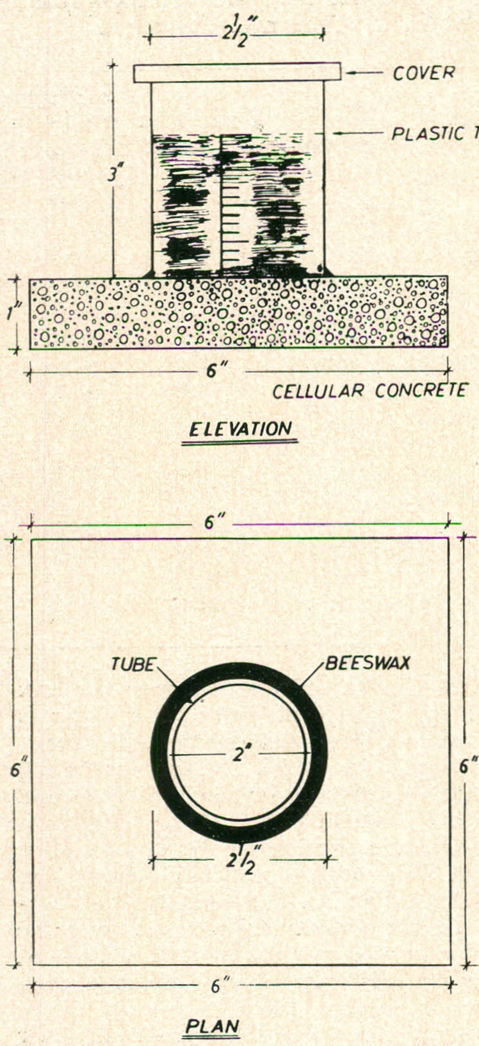

Fig. 7.—Device for penetration mater penetration.

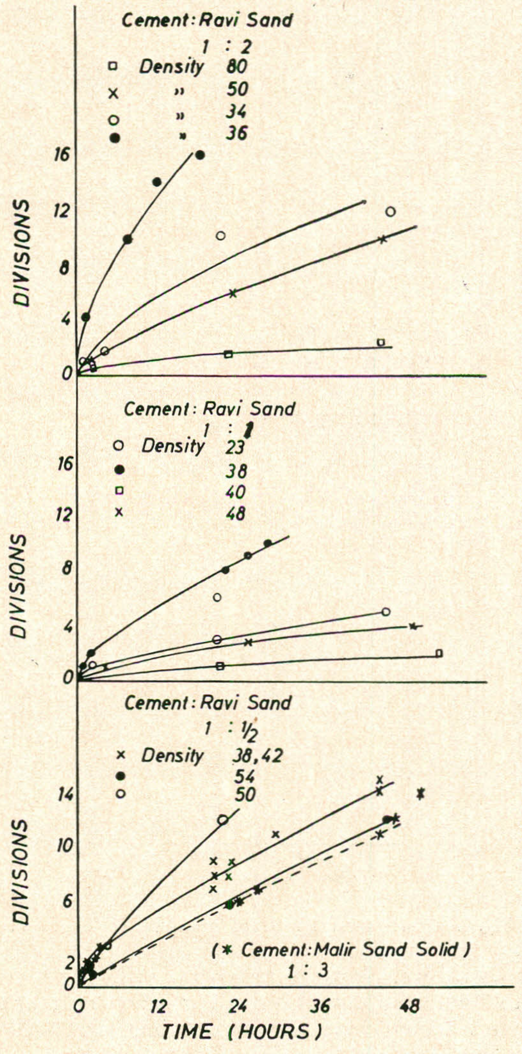

Fig. 8.—The water-penetration properties of moist-cured cellular concrete.

made with Ravi sand using ordinary non-tilting concrete mixture can be safely handled and used for the purpose of partition and insulation tiles. With a coarser aggregate, like Malir sand, it may be *cast-in situ* on the top of inaccessible roofs so as to take full advantage of its insulation properties. It can also be used for the roof and floor fills. The moisture penetration tests indicate the possibility of its use as a water repellant material but this aspect needs further examination.

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