POSSIBLE APPLICATIONS OF CLIFTON SAND IN BUILDING INDUSTRY

Part I.—In Thermal Insulating Materials

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This paper describes the possible uses of the Clifton sand as a thermal insulating material in building industry. The cellular concrete having a density of 30 lbs. per cubic foot made by incorporation of 25% of this sand with Portland Cement has a thermal conductivity of a cork. When bonded with ordinary clay, it can be advantageously used for the manufacture of insulating bricks suitable for use in buildings and secondary lining of high temperature furnaces. Bricks made by binding the sand with sodium silicate give very high strengths and can meet the requirements for heavy floors. As such it can be used as a filling material for ground floors under plinth and in cavity wall constructions.

Introduction

Thermal insulating materials reduce the rate of heat transfer, and thus serve the dual purpose of keeping heat in a structure during cold weather and keeping it out in hot weather. Mica or micaceous substances are known to be used for the manufacture of insulating bricks, slabs, tiles or like products. This is usually accomplished by mixing pulverised mica with a binder such as clay, sodium silicate, gum, etc. with or without the addition of organic matter, and firing to a temperature of about 800°—1200°C., depending upon the nature of the binder used. A black and lustrous coastal sand found over a ten-mile stretch along the Clifton beach is reported[1] to have 43-45 percent micaceous material, and the grading resembles that of fine dune sand. The high content of micaceous material, large proportion of shell fragments, fine grading and the presence of injurious sea salts render this sand unsuitable for ordinary constructional purposes, but specialized uses may be possible for it. The results of a study carried out on the application of Clifton sand for thermal insulating materials are presented in this paper.

Cellular Light-Weight Concrete

In an earlier communication,[2] the use of fine Ravi river sand to the extent of 3 parts to 1 part of Portland cement for the production of cellular light-weight concrete has been reported. The use of Clifton sand, the grading of which is shown in Figure 1, has therefore been investigated for this purpose, and it is found that one part of this sand can be used with two parts of cement. The effect of Clifton sand on the physical properties of cellular concrete is shown in Table 1. In all these experiments, the foam was generated first with the help of a rotating cylinder inside a vessel containing foaming agent and water. Cement or cement-sand mixtures were later added in the vessel and mixed with the foam till a uniform slurry was obtained. The compressive strength was determined on 2″ cubes and for dry strength the wet cubes were dried in an oven at 100–110°C., for 24 hours. The co-efficient of thermal conductivity was determined as described previously by Ahsanullah, Ahmad and Chotani.[3] The thermal conductivity gives a comparison of thermal insulation as the heat transfer in a solid without continuous pores is only by conduction.

The addition of 20 to 50 percent by weight of unwashed Clifton sand to Portland cement considerably reduces thermal conductivity of (neat) cement cellular concrete. This material having a density of 30 lbs. per cubic foot and containing 25 percent Clifton sand has a thermal conductivity of the same order as that of cork. The micaceous material in this sand reduces the strength and therefore it cannot be used to the same extent as Ravi sand. However, the reduction of strength with sand in the above mentioned proportion is not very important, because plain or unreinforced cellular concrete is used only by the sides of the walls or on top of roofs where the actual stresses are always much below the permissible stresses for the material.

Clifton Sand as Insulating Material with Various Binding Agents

(*a*) *Sodium Silicate.*—Excellent bonding of Clifton sand was achieved by using sodium silicate. The effect of varying proportions of this binder on compressive and flexural strengths and on thermal conductivity has been investigated and the data are presented in Table 2. The increase of sodium silicate from 15 to 50 percent by weight of unwashed sand increased the comrpessive strength from 406 to 2,180 lbs. per sq. inch, flexural strength from 40 to 862 lbs. per sq. inch and coefficient of conductivitiy from 0.27×10^{-3} to 0.47×10^{-3} cal/cm/°C.

(*b*) *Portland Cement.*—The strength and thermal conductivitiy of cement and Clifton sand mortars are given in Table 3. The increase of binding agent again results in the increase of strength and thermal conductivity. For comparison, the conductivity of (1 : 3) cement and Malir sand mortar is found to be 0.77×10^{-3}. The low strength and conductivity of Clifton sand and cement mortars is mainly due to the high micaceous content of the sand.

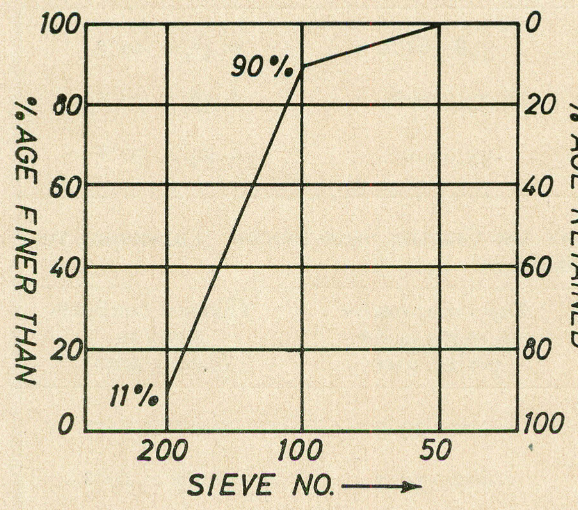

Fig.—1. The Sieve Analysis of Clifton Sand.

(*c*) *Ordinary Clay.*—Clifton sand was mixed with different proportions of clay suitable for brick-making, moulded under a pressure of ½ ton per sq. inch and fired at 1000°C. in an electric muffle furance. The results are presented in Table 4. Bricks made with 50 percent clay by weight of sand have a thermal conductivity of 0.27×10^{-3} and compressive strength of 612 lbs. per sq. inch. Further reduction in the proportion of clay does not result in improved insulation but results in decreased strength. Further studies, particularly in relation to the effect of hand moulding, lower firing temperature and use of the magnetic fraction rather than the whole sand on strength and conductivity of these burnt bricks are in progress.

Conclusion

The present study shows that Clifton sand bonded with ordinary clay can be advantageously used in the manufacture of insulating bricks suitable for use in buildings and secondary lining of high temperature furnaces. The relative proportions of clay and sand can be adjusted to suit the desired strength and conductivity. Another useful application of this sand is in the field of foam concretes, where it can be used to the extent of 50% by weight of Portland cement. This gives better thermal insulation than neat cement or cement-Ravi sand mixture. At a density of 30 lbs. per cubic foot, it has the same thermal conductvity as cork.

TABLE 1.—EFFECT OF CLIFTON SAND ON STRENGTH AND INSULATION PROPERTIES OF CELLULAR CONCRETE.

S. No.	Proportions by wt.		Water-cement ratio	Foaming agent by wt. of cement	Dry density (lbs/c.ft.)	Mould required for (initial set)	Compressive strength in lbs/sq. inch at						Thermal conductivity in c.g.s. units
							3 days		7 days		28 days		
	Portland cement	Clifton sand					Dry	Wet	Dry	Wet	Dry	Wet	
1	1	—	0.7	0.25%	42	5-6 hrs.	316 0 ±27.8	275.0 ±16.6	383.3 ±11.1	358.3 ±44.0	557.6 ±46.2	404.6 ±16.2	0.25 × 10-3
2	1	—	0.7	0.50%	31	6-8 hrs.	275.0 ±16.6	266.6 ±11.1	316.6 ±38.8	296.5 ±20.3	475.3 ±70.9	326.0 ±32.8	0.20 × 10-3
3	I	1/4	0.9	0.25%	30	6-8 hrs.	116.6 ±11.1	109.5 ±5.0	150.0 ±0.0	141.3 ±7.0	255.1 ±23.7	243.3 ±4.23	0.14 × 10-3
4	I	1/2	1.0	0.25%	50	4-5 hrs.	114.0 ±15.0	80.0 ±7.0	120.0 ±20.0	91.6 ±11.1	184.0 ±40.0	165.3 ±38.9	0.18 × 10-3

TABLE 2.—STRENGTH AND INSULATION PROPERTIES OF CLIFTON SAND BONDED WITH SODIUM SILICATE.

S. No.	Sodium Silicate by wt. of clifton sand	Dry compressive strength in lbs. per sq. inch.	Dry flexural strength in lbs. per sq. inch.	Thermal conductivity in (c.g.s.) units
1	15 per cent	406 ± 37.0	40 ± 7.0	0.27×10^{-3}
2	25 ,, ,,	1070 ± 53.3	469 ± 11.0	0.37×10^{-3}
3	50 ,, ,,	2180 ± 129.0	862 ± 51.0	0.47×10^{-3}

TABLE 3.—STRENGTH AND INSULATION PROPERTIES OF CEMENT AND CLIFTON SAND MORTARS.

S. No.	Portland cement by wt. of Clifton Sand	Wet compressive strength in lbs. per sq. inch at 14 days	Wet flexural strength in lbs. per sq. inch at 14 days.	Thermal conductivity in (c.g-s-) Units
1	50 percent	716 ± 78.0	358 ± 61.0	0.40×10^{-3}
2	25 ,, ,,	366 ± 22.0	73 ± 18.0	0.38×10^{-3}
3	15 ,, ,,	155 ± 13.0	33 ± 3.0	0.24×10^{-3}

TABLE 4.—STRENGTH AND INSULATION OF KARACHI CLAY AND CLIFTON SAND BRICKS. (PRESSURE $\frac{1}{2}$ TON SQ. IN) FIRED IN MUFFLE FURNANCE AT 1000°C.

S. No.	Proportion by wt. of		Dry compressive strength in lbs. per sq. inch	Thermal conductivity in (c.g.s.) units
	Karachi clay	Clifton sand		
1	1	4	200 ± 33.3	0.27×10^{-3}
2	1	2	612 ± 55.7	0.27×10^{-3}
3	1	$\frac{1}{2}$	—	0.33×10^{-3}
4	1	$\frac{1}{4}$	—	0.40×10^{-3}
5	1	0	—	0.56×10^{-3}

The sodium silicate sand bricks gave better strengths than those bonded with Portland cement and will meet the requirements of heavy floors. This material would, however, require a bituminous coating for proper water proofing. Cement and Clifton sand mortars are also promising, and could be used in place of ordinary cellular concrete for thermal comfort. An insulation layer of Clifton sand bonded with cement or sodium silicate can be easily provided on curved surfaces like shell roof structures. Of course, this sand can also be used without any binder as a filling material for ground floors under plinth and in cavity wall constructions.

References

1. M. Azeem, Pakistan J. Sci. Ind. Research, **1**, 57 (1958).
2. Mohamad Aslam, S. Tehzibul Hasan and Mohammad Jehangir, Pakistan J. Sci. Ind. Research, **5**, 112 (1962).
3. A. K. M. Ahsanullah, Mubarak Ahmad and A. H. Chotani, Pakistan J. Sci. Ind. Research, **1**, 53 (1958).