

Chapter Eight

SPECIAL SANDS

Zircon Sand

The sample was obtained from Quilon in Kerala State. It is a by-product of manufacture of monazite from the sands occurring in the area.

In the present investigation, no distinction has been attempted between its use for moulding or facing purposes.

The sand sample in the as-received state was white in colour with slightly greyish tinge. It had a specific gravity of 4.7 and an initial moisture content less than 0.1 per cent. It belonged to the fine grade. Microscopic examination showed the sand grains to be mostly subangular to rounded in shape. Size grading and fineness characteristics of the sand are shown in Tables 119(a) & 119(b) and Fig. 28.

Chemical analysis of the sand showed the major constituents to be zircon and silica (Table 120). Petrological examination of the sand revealed the presence of 99 per cent zirconium silicate, the rest being rutile, ilmenite, sphene and apatite.

For improving the moulding characteristics of the sand, it was bonded with different bonding agents. Mixture 1, prepared by using 2 per cent Bihar bentonite alone as the binder, showed maximum permeability (64) and green compressive strength (11.3 lb./sq. in.) at 0.4 and 0.3 per cent moisture content respectively (Table 121). Dry compressive strength increased with increase in moisture content. The sand mixture was found to be very friable in the green state up to a moisture content of 0.5 per cent. With increase in moisture content, both friability and permeability decreased. Due to high plasticity of the mixture, it was not possible to prepare test specimens beyond 1.5 per cent moisture.

With a view to reducing friability in the moisture content range at which permeability is high and to further improving the physical characteristics, the addition of higher amounts of Bihar bentonite (3 per cent) was tried (Mixture 2). The sand mixture obtained was non-friable at and above 0.6 per cent moisture content. The permeability was, however, slightly impaired, the maximum value being 62 at 0.6 per cent moisture. Maximum compressive strength (16.9 lb./sq. in.) was obtained at 0.4 per cent moisture. Dry compressive strength showed a steady increase from 13.7 lb./sq. in. at 0.3 per cent moisture to 225 lb./sq. in. at

TABLE 119(a)—ZIRCON SAND: SIZE GRADING

U.S. SIEVE EQUIVALENT NO.	% RETAINED	U. S. SIEVE EQUIVALENT NO.	% RETAINED
6	Nil	70	0.04
12	Nil	100	1.01
20	Nil	140	45.21
30	Nil	200	48.02
40	Nil	270	5.38
50	Nil	Pan	0.36

TABLE 119(b)—ZIRCON SAND: FINENESS CHARACTERISTICS

Clay, %	0.1
Clay class	A
Grain fineness No.	124.5
Grain class No.	3
Max. retention on 140 and 200 mesh sieves, %	93.23

TABLE 120—ZIRCON SAND: CHEMICAL ANALYSIS

CHEMICAL CONSTITUENT	AS-RECEIVED	AFTER WASHING
ZrO ₂ , %	66.62	66.25
SiO ₂ , %	29.96	30.96
Al ₂ O ₃ , %	1.88	1.92
Fe ₂ O ₃ , %	0.85	0.71
$\left. \begin{array}{l} \text{TiO}_2 \\ \text{MgO} + \text{CaO} \\ \text{K}_2\text{O} + \text{Na}_2\text{O} \end{array} \right\}, \%$	Traces	Traces
Loss on ignition, %	0.11	0.09

2.3 per cent moisture. Due to high plasticity of the mixture, it was not possible to prepare test specimens above 2.3 per cent moisture (Table 122). With further increase in bentonite content up to 5 per cent (Mixture 3), marked improvement was noticed in permeability in the moisture range 0.4–0.8 per cent (Table 123). The friability also was considerably reduced. The high temperature characteristics of Mixture 2 were studied by firing standard test pieces at different temperatures (Table 124). The sintering range was found to be 1500–1550°C.

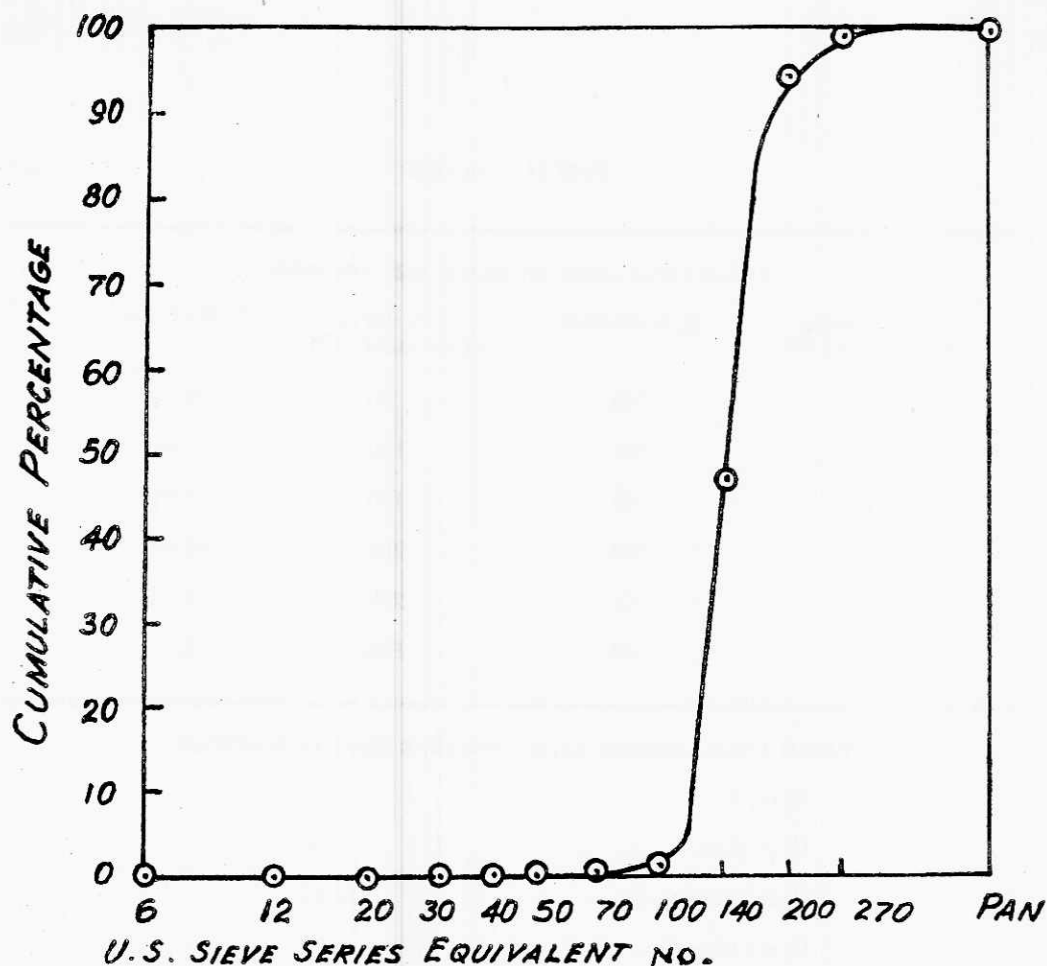


FIG. 28—ZIRCON SAND: CUMULATIVE GRADING CURVE

TABLE 121—BONDED ZIRCON SAND (MIXTURE 1): MOULDING CHARACTERISTICS AT DIFFERENT MOISTURE CONTENTS

	MOISTURE, %					
	0.3	0.4	0.5	0.7	1.0	1.5
Green permeability No.	58	64	55	45	38	28
Green compressive strength, lb./sq. in.	11.3	10.8	9.6	5.4	4	2.5
Green shear, lb./sq. in.	2.7	3.2	2.5	1.4	0.9	0.5
Mould hardness No.	86	85	85	88	90	86
Flowability, %	78	80	82	78	73	68
Shatter index	70.2	65.4	61.4	48.2	45.6	41.2
Dry compressive strength, lb./sq. in.	18.5	22.0	31.0	57.0	67.0	75.0
Dry shear, lb./sq. in.	10.0	11.0	12.7	21.7	27.5	35
Bulk density after compression, g./cc.	2.661	2.680	2.729	2.797	2.827	2.875

TABLE 122—BONDED ZIRCON SAND (MIXTURE 2): MOULDING CHARACTERISTICS AT DIFFERENT MOISTURE CONTENTS

	MOISTURE, %						
	0.3	0.4	0.6	0.8	1.0	1.3	2.3
Green permeability No.	45	50	62	50	45	37	25
Green compressive strength, lb./sq. in.	15.7	16.9	16.0	12.0	9.8	6.1	3
Green shear strength, lb./sq. in.	3.5	4.7	3.5	3.0	2.2	1.4	0.8
Mould hardness No.	84	75	77	78	80	87	86
Flowability, %	85	88	87	87	81	78	63
Shatter index	46.4	71.8	71.9	78.9	78.7	63.6	56.2
Dry compressive strength, lb./sq. in.	13.7	35.3	56.0	77.0	92.3	156	225
Dry shear, lb./sq. in.	4.5	9.3	14.5	18.5	30.5	41.5	49
Bulk density after compression, g./cc.	2.719	2.632	2.651	2.875	2.671	2.739	2.778

TABLE 123—BONDED ZIRCON SAND (MIXTURE 3): MOULDING CHARACTERISTICS AT DIFFERENT MOISTURE CONTENTS

	MOISTURE, %					
	0.3	0.4	0.6	0.8	1.2	1.6
Green permeability No.	38	40	44	55	42	32
Green compressive strength, lb./sq. in.	20.2	21.6	23.5	18.5	14.0	10.6
Green shear, lb./sq. in.	5.6	6.7	6.0	4.9	4.1	3.4
Mould hardness No.	91	98	87	87	85	80
Flowability, %	79	83	85	78	74	69
Shatter index	67.5	70.9	75.7	93.7	92.7	95.9
Dry compressive strength, lb./sq. in.	33	48	66	97	151	223
Dry shear, lb./sq. in.	10.3	15.0	18.7	25.5	28.3	31.0
Bulk density after compression, g./cc.	2.690	2.670	2.651	2.534	2.632	2.690

Suitability for Cores. The following synthetic sand mixtures were prepared and tested for their moulding characteristics:

Mixture 1: Zircon sand, 93 ; wheat flour, 1.5 ; Bihar bentonite, 3 ; and water, 2.5 per cent.

- Mixture 2: Zircon sand, 92.5 ; wheat flour, 1.5 ; Bihar bentonite, 3 ; and water, 3 per cent.
- Mixture 3: Zircon sand, 91.75 ; wheat flour, 1.5 ; Bihar bentonite 3 ; water, 3 ; and double boiled linseed oil, 0.75 per cent.
- Mixture 4: Zircon sand, 92.5 ; dextrine, 1.5 ; Bihar bentonite, 3 ; and water, 3 per cent.
- Mixture 5: Zircon sand, 91.75 ; dextrine, 1.5 ; Bihar bentonite, 3 ; water, 3 ; and double boiled linseed oil, 0.75 per cent.
- Mixture 6: Zircon sand, 92 ; Bihar bentonite, 5 ; and water, 3 per cent.
- Mixture 7: Zircon sand, 96.25 ; sodium silicate (sp. gr., 1.4), 3 ; and water, 0.75 per cent.
- Mixture 8: Same as in Mixture 7 ; carbon dioxide passed for 4 min. under 30 mm. Hg pressure.

In the case of compositions in which no oil was used the mixing procedure was the same as for moulding sands. But when linseed oil was one of the components, the following procedure was adopted:

The sand was first dry-milled for 2 min. and after scraping, water was added and the mixture milled for 2 min. again. It was then scraped, oil added and the mixture milled for 5 min. with scraping at 2 min. intervals. Thus, the total milling time was 9 min. In those cases where sodium silicate was one of the constituents the same milling schedule was adopted except that water was replaced by sodium silicate solution and oil by water.

The tensile strength, transverse strength core hardness (scratch hardness) and dry permeability of the different mixtures were also determined, in addition to the dry compressive strength. The data obtained are shown in Table 125.

TABLE 124—ZIRCON SAND BONDED WITH 3% BIHAR BENTONITE: HIGH TEMPERATURE CHARACTERISTICS

(Vol. of test pieces before firing, 6.284 cu. in.; after firing, 6.284 cu. in.; soaking period, 2 hr)

FIRING TEMP. °C.	CHARACTERISTICS OF TEST PIECES AFTER FIRING	COMPRESSIVE STRENGTH AFTER FIRING lb./sq. in.
1000	Slightly friable; metallic sound when struck	300
1100	do.	320
1200	do.	320
1300	do.	368
1350	Slightly darker colour	498

TABLE 125—ZIRCON CORE SAND MIXTURES: MOULDING CHARACTERISTICS

MIX- TURE No.	TENSILE CORE STRENGTH <i>lb./sq. in.</i>	TRANSVERSE CORE STRENGTH <i>lb./sq. in.</i>	DRY COM- PRESSIVE STRENGTH <i>lb./sq. in.</i>	DRY PER- MEABILITY No.	CORE HARDNESS No.	SURFACE CHARAC- TERISTICS
1	17.5	2	180	40	38	friable
2	27.5	4	>280	31	70	—
3	7.5	2	120	34	38	very friable
4	30	6	>280	30	67	—
5	5	2	105	35	30	very friable
6	25	5	>280	36	65	—
7	50	9.5	>280	90	60	—
8	70	10.5	>280	95	65	—

The oil-sand compositions were very friable and did not possess the requisite characteristics of a core sand. But other mixtures appeared to be quite satisfactory except that the permeability was very low. The permeability was improved in mixtures containing sodium silicate.

Conclusion. Any of the core mixtures tested except those containing linseed oil are quite suitable for core sand mixtures. Bonding with sodium silicate solution and treatment with carbon dioxide give markedly higher permeability value and the resulting sand mixture is suitable for making cores of small section castings in which fine surface finish is desired. Linseed oil adversely affects the bonding properties and should, therefore, not be used when the sand is used either as a mould facing or for cores.