MOULDING CHARACTERISTICS OF MIANWALI SAND

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(Received July 6, 1965)

An attempt has been made to study the suitability of Mianwali sand for light and medium castings. The study includes the complete evaluation and the moulding characteristics of the sand.

Sands of various grain shapes and sizes, depending upon their geological history, occur in nature and are generally found associated with various alkaline and metallic oxides. These sands may be suitable for one use or the other, but the sands employed for moulding purposes should allow a good deal of compromise between the compression strength, permeability and refractoriness, etc., which ensures their suitability for ferro, non-ferro, light and heavy castings.

Prior to the selection of a sand for a particular casting, the complete data[1,2] regarding its dry and green strength, permeability, refractoriness and the nature of the binding material is required. The shape and the size of the grains are of particular interest, as these have a strong bearing on the strength characteristics of the mould. For instance, angular or subangular grains produce better moulds, as they pack together more rigidly, as compared to the round grain and, therefore, render extra mechanical strength to the moulds when the same amount of binder is used.

Besides the study of the grain shape and the size, the information regarding the compressive strength, permeability and refractoriness is a prerequisite for the selection of a particular sand for the moulding purpose. The compression strength, both green and dry, are responsible to hold the sand mould in a compact form during casting, while the permeability regulates the escape of air and gases, and thus obviates the formation of blow holes in the cast. The proper refractoriness is essential to have a clean and smooth surface of the cast, as it prevents the softening or the fusion of the mould.

This study deals with the moulding characteristics of Mianwali White sand. Representative samples of sand and bentonite, both belonging to the Salt Range area, were taken from the foundry section of PITAC, Lahore, for investigation. The sand belongs to the Permian and Mesozoic deposits and is of shallow water marine origin.

Experimental

The sand samples were tested by the standard methods specified by the American Foundrymen's Society (AFS). The various characteristics of the prepared samples were determined on the Dietert equipment.

The size distribution[3] of the grains was determined by classifying the as-received as well as the washed sand with sieves of U.S. Standard.

The sand was washed according to the AFS standard method[4] to find out the AFS clay content and the clay grade. The percentages of the sand retained on different sieves, have been plotted against the respective sieve numbers and the results of the size distribution have been interpretted with the help of cumulative curves (Fig. 1).

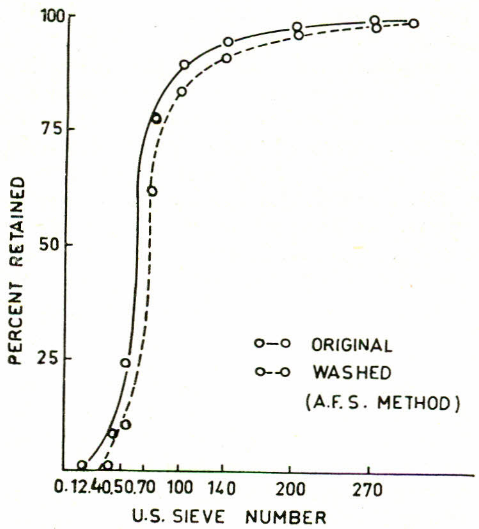


Fig. 1.—Cumulative grading curves of Mianwali sand.

Besides the complete chemical analysis (Table 1), the spectrographic analysis and the petrographic examination were also conducted to find out the impurities in the sand.

TABLE 1.—CHEMICAL ANALYSIS OF MIANWALI SAND.

Chemical constituent	As received %	After washing by A.F.S. Method %
SiO_2	97.00	98.50
Al_2O_3	1.93	0.87
Fe_2O_3	0.08	0.03
CaO	0.20	0.16
MgO	0.12	0.10
K_2O	Nil	Nil
Na_2O	0.32	0.15
Loss on ignition	0.30	0.10

Photomicrographs of different grades of the sand were taken to study the shape of the grains. As the bulk of the sand is retained on three adjacent sieves (No. 50, 70 and 100), the photomicrographs, therefore, represent the shapes of the majority of the grains.

(2×2 inch diameter) were prepared in the standard rammer. These were then subjected to the standard sand testing apparatus.[5] The results are represented in Figs. 2,3 and 4.

The AFS standard test pieces, having the varying percentages of bentonite and moisture content

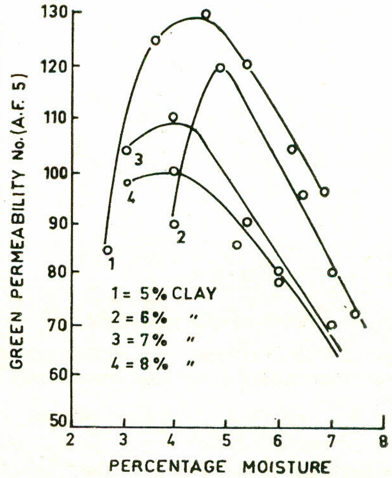
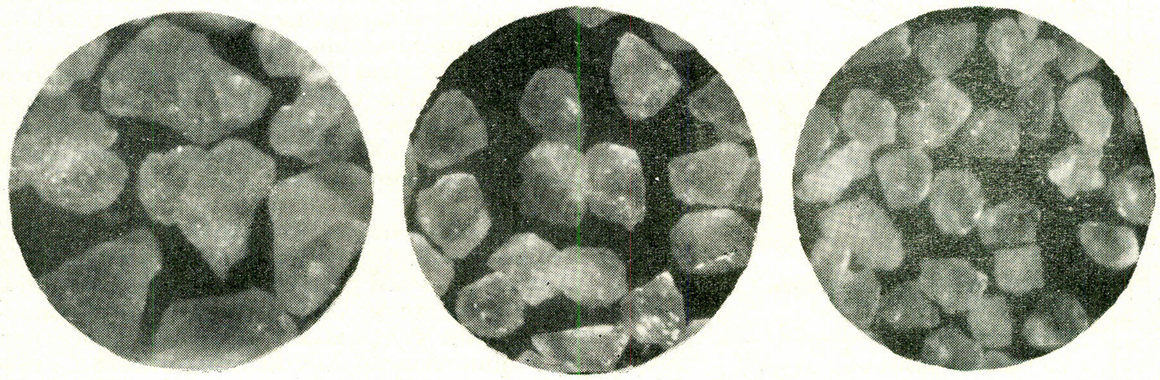


Fig. 2.—Relationship of green permeability No. and percentage moisture for sand bonded with different clay contents.



(a) (b) (c)

Photomicrographs ($\times 50$) showing the shape of the sand grains retained on (a) 50 Mesh; (b) 70 Mesh and (c) 100 Mesh.

To study the moulding characteristics of the sand, different percentages of bentonite (5-8%) were added to the sand samples and the dry mixing was carried out in a laboratory sand mixer for two minutes. The varying volumes of tempering water were then added and the mulling was continued for about ten minutes. The mixtures thus produced, were then stored in air tight containers for about four hours. The mixtures were then aerated and the test pieces were respectively fired at 1200°,[6] 1300°C. and 1350°C., to study the refractoriness. Besides, the test pieces of smaller dimensions were fired in the tube furnace at 1450°C., and 1550°C., as no furnace of bigger dimension was available for this study. The surface characteristics of the fired test pieces were then studied at the room temperature. In addition, crushing strength and volume change of these pieces were determined. The results are given in Tables 2, 3, 4 and 5.

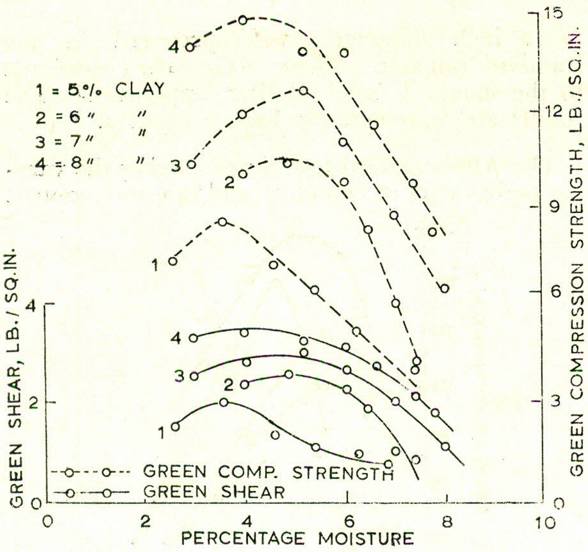


Fig. 3.—Relationship of green compression strength, green shear and percentage moisture for sand bonded with different clay contents.

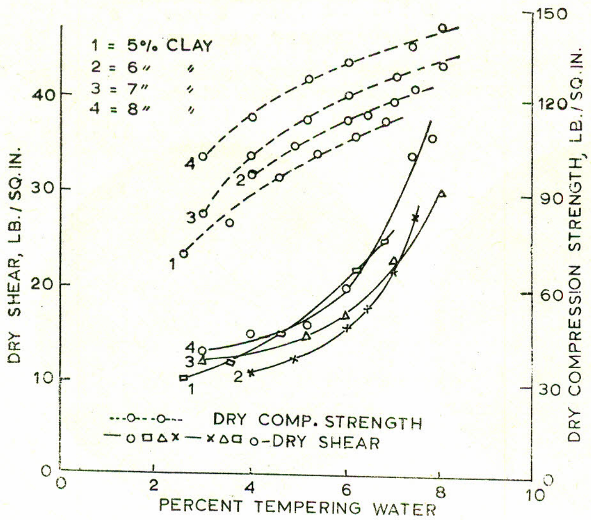


Fig. 4.—Relationship of dry compression strength, dry shear and percentage of tempering water for sand bonded with different clay contents.

Discussion

The petrographic examination shows that the sand, forming the basis of this work, consists mainly of quartzite grains, a very small proportion of which is more or less coated with limonite. Other minerals, i.e., muscovite, haematite and tourmaline are also present in minute quantities.

The spectrographic analysis indicates the presence of titanium in traces. The chemical investigation, represented in Table 1, gives a clear indication of its being a good silica sand. In addition, the photomicrographs of different grades of sand (as received) reveal the grains of sub-angular shape.

The mechanical grading of the sand as received shows the presence of 3 percent of clay belonging to AFS clay class "C". The major percentage of the grains is retained on sieves No. 50, 70 and 100. The slopes of the cumulative curves (Fig. 1), being steeper, indicate, that the maximum volume of the sand is retained on the middle sieves, and the sand, therefore, can successfully be used as such, even without any grading. In addition, cumulative curves reveal that it is, a medium grained silica sand. This is, further supported by the AFS fineness number (63). The AFS grains class number is 5; and the amount of fines are approximately 10 percent.

The observations graphically represented in Figs. 2,3 and 4, indicate that the green permeability, (Fig. 2) and green compression strength (Fig. 3), initially increase with the increase of moisture, attain a maximum value, and then decrease with the increase of the moisture. However, the dry compression strength (Fig. 4) shows a different trend and continues to increase with the increase of tempering water. It is, therefore, essential to adjust the moisture content in such a way, as to yield the best combination of these properties. The careful study of these graphs indicate that the incorporation of 5 to 8 percent binder and 3 to 6 percent moisture content would yield the optimum values.

High temperature tests carried on the sand bounded with 5% to 8% bentonite, recorded in Tables 2, 3, 4 and 5 respectively, indicate the effect of temperature on volume change and refractoriness of the composition. From the above tests it is quite evident that the firing at 1200°C. produces a rough and friable texture. The pieces fired beyond 1300°C. are quite compact and smooth. In the light of the above observations it can be concluded that the composition having 3 to 6 percent moisture and 5 to 8 percent binder would not behave properly for metal casting below 1300°C. Besides, the test pieces, smaller in dimensions, fired at 1450° and 1550°C., indicate the smooth texture and an overall increase in the volume. From this it can be concluded that the sintering point will lie beyond 1550°C.

In the light of the moulding characteristics of the sand under study, it is concluded that the compositions containing 4 to 6 percent moisture

TABLE 2.—HIGH TEMPERATURE TESTS ON THE SAND BONDED WITH 5% BENTONITE (A.F.S. STANDARD PIECES RAMMED BY 3 BLOWS WERE USED: SOAKING TIME, 2 HOURS; VOLUME OF EACH TEST PIECE BEFORE FIRING). (6.248 CU. IN).

Temperature of firing °C.	Tempering water used %	Volume of test piece after firing cu. in.	Surface characteristics of the test piece after firing	Crushing strength of fired piece lb./sq. in.
1200	3.6	—	Brick red in colour, highly friable, possessed negligible crushing strength	—
1200	5.6	—	Colour brown, surface very rough and highly friable	—
1200	6.8	—	Colour same as above, rough texture, highly friable	—
1300	3.6	6.448	Brown in colour, fairly compact but rough texture, a little friable in the middle, more friable on the corners	700
1300	5.6	6.558	—Same as above—	650
1300	6.8	6.586	—Same as above—	500
1350	3.6	6.330	Light brown in colour, dull sound produced when struck, showed a little friability on rubbing.	950
1350	5.6	6.661	—Same as above—	500
1350	6.8	6.680	More compact, dull sound, less friable, light brown in colour	1000

TABLE 3.—HIGH TEMPERATURE TESTS ON THE SAND BONDED WITH 6% BENTONITE (A.F.S. STANDARD PIECES RAMMAD BY 3 BLOWS WERE USED: SOAKING TIME 2 HOURS: VOLUME OF EACH TEST PIECE BEFORE FIRING) (6.284 CU. IN).

Temperature of firing °C.	Tempering water used %	Volume of test piece after firing cu. in.	Surface characteristics of the test piece after firing	Crushing strength of fired piece lb./sq. in.
1200	4.0	—	Brick red in colour, rough texture, high friability, possessed no crushing strength.	—
1200	6.0	—	—Same as above—	—
1200	7.0	6.582	—Same as above—	—
1300	4.0	6.664	Light brown in colour, fairly compact texture, low metallic sound when tapped by hand, a little friable.	550
1300	6.0	6.668	White in colour, compact texture, smooth surface, no friability, good strength, metallic sound when tapped.	850
1300	7.0	6.672	—Same as above—	1000
1350	4.0	6.674	White in colour, possessed good strength, smooth surface, no friability; compact texture, clear metallic sound when struck.	1000
1350	6.0	6.678	—Same as above—	800
1350	7.0	6.800	—Same as above—	1240

and 5 to 8 percent binder would prove very successful for (a) light grey iron and medium sized non-ferrous castings and (b) medium to fairly large grey iron castings. In view of the above study, it implies that the higher addition of binder is essential if the moulds for heavy jobs are required.

TABLE 4.—HIGH TEMPERATURE TESTS ON THE SAND BONDED WITH 7% BENTONITE. (A.F.S. STANDARD PIECES RAMMED WITH 3 BLOWS WERE USED; SOAKING TIME 2 HOURS: VOLUME OF EACH TEST PIECE BEFORE FIRING). (6.284 CU. IN).

Temperature of firing °C.	Tempering water used %	Volume of test piece after firing cu. in.	Surface characteristics of the test piece after firing.	Crushing strength of fired piece lb./sq. in.
1200	3.0	—	Brick red in colour, highly friable, poor texture	—
,,	5.2	—	Same as above.	—
,,	7.0	—	Light brown in colour, corners more friable as compared to the surface, possessed very little strength, rough texture.	50
1300	3.0	6.628	Light brown in colour, corners more friable than the surface, possessed a fairly smooth texture.	200
,,	5.2	6.682	Surface friable, rough texture, very little strength, dull sound when struck.	40
,,	7.0	6.88	Same as above.	50
1350	3.0	6.688	White in colour smooth surface, friable	350
,,	5.2	6.721	White in colour, negligible crushing strength, poor texture.	50
,,	7.0	6.782	White in colour, smooth surface, a little friable, dull sound when struck.	350

TABLE 5.—HIGH TEMPERATURE TESTS ON THE SAND BONDED WITH 8% BENTONITE. (A.F.S. STANDARD PIECES RAMMED WITH 3 BLOWS WERE USED; SOAKING TIME 2 HOURS: VOLUME OF EACH TEST PIECE BEFORE FIRING) (6.284 CU. IN).

Temperature of firing °C.	Tempering water used %	Volume of test piece after firing cu. in.	Surface characteristics of the test piece after firing	Crushing strength of fired piece lb./sq. in.
1200	4.0	—	Brick red in colour, partly crumbled at room temperature	—
,,	6.0	—	Brick red in colour, completely crumbled at room temp.	—
,,	7.4	—	Same as above	—
1300	4.0	6.612	Compact texture, dull brick sound when tapped by hand.	750
,,	6.0	6.662	Same as above	1250
,,	7.4	6.664	Same as above	1000
1350	4.0	6.880	Compact texture, metallic sound produced when struck possessed good strength, smooth surface, no friability at any part of the surface.	1250
,,	6.0	6.782	Same as above.	1650
,,	7.4	6.788	Same as above.	1000

Acknowledgement.—The authors wish to thank Mr. M.M. Farookhi, T. Pk., General Manager, PITAC, Lahore, and Mr. K.A. Kazmi, Senior Engineer Foundry, for their keen interest in this project. They are greatly indebted to Mr. Aftab Yousuf, Senior Engineer Foundry, PITAC, Lahore, for his valuable assistance during this study.

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