DEPARTMENT OF MINES AND RESOURCES

BUREAU OF MINES

CANADA.

Ottawa, May 21, 1946.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 2053.

Pembina Bentonite as a Foundry Sand Binder.

(Copy No. ____)

O T T A W A May 21, 1946.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 2053.

Pembina Bentonite as a Foundry Sand Binder.

===========

Introduction:

On February 18, 1946, a sample of bentonite, received by Mr. H. S. Spence of the Industrial Minerals Division from the Pembina Mountain Clays Limited, Winnipeg, Manitoba, was transferred to the Foundry Sand Research Laboratory with a letter requesting that this clay be tested to determine its suitability as a foundry sand binder. This sample had not been ground, and was air-dried.

Method of Testing:

The bentonite was ground in a pebble mill so that 96 per cent or more passed through a 200-mesh screen. As foundry clays may contain up to 15 per cent moisture, all clays used in testing were dried in a laboratory oven at 105° C. to 110° C.

In conducting the tests, the methods and equipment recommended by the American Foundrymen's Association were used (see Foundry Sands Testing Handbook, 1944 Edition, A.F.A.). The Pembina bentonite was compared with three commercial foundry bentonites by mixing test batches in an 18-inch laboratory mixer. The results reported in this investigation are those obtained from the use of a commercial core sand. This sand was used in preference to A.F.A. test sand, as it was found to be more sensitive to the differences in moisture and type of binder.

The sand used in testing had a smooth sub-angular grain, and had the following screen analysis:

U.S. Screen No.		Per Cent Retained.
20	-	0.0
30	-	0.6
40	-	3.8
50	-	22.6
70	-	53.1
100	-	19.3
140	-	0.4
200	-	0.05
Pan	-	0.05
A.F.A. Clay	-	0.0

For each bentonite tested a bentonite-to-sand ratio was chosen to give the test mixture a green compressive strength of 7 pounds per square inch. Foundry sands are usually mixed to a given green compressive strength, although toughness, which is the product of green compression and deformation, is the basis preferred by some foundrymen. If toughness had been used as a basis for determining the

(Method of Testing, cont'd) -

bentonite addition, more of some of the bentonites would have been required.

Moisture to Temper:

The properties of moulding sands vary widely with their moisture content, and the amount of moisture required by different binders also varies. It is therefore important that each moulding sand be used at its optimum "temper" or moisture content. The moisture requirement of each mixture was determined, and this optimum temper was used in all subsequent tests.

In determining the amount of moisture required to temper the sand, the flowability curve was used. Flowability was measured using the method proposed by Dietert and Valtier, which is based on the deformation of the standard A.F.A. specimen between the fourth and fifth blows of the sand rammer (see "Flowability of Moulding Sands," Dietert, H.W., and Valtier, F., Trans. A.F.A., Vol. 42, p. 199, 1934). The formula is:

Flowability = 100-D,

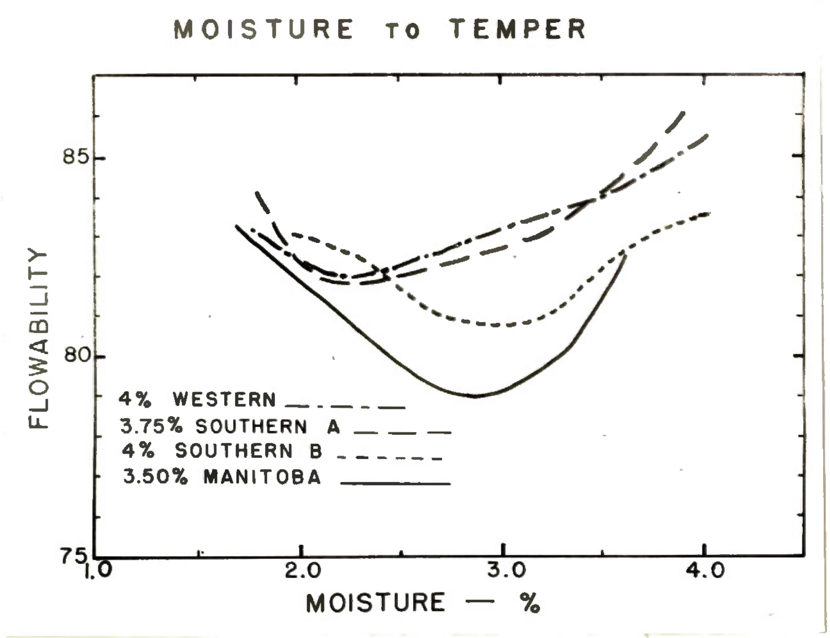
where D is the deformation, in thousandths of an inch, of the standard A.F.A. specimen between the fourth and fifth blows of the sand rammer.

The Dietert flowability of bentonite-bonded sands is at a minimum when the sand is at temper. The flowability curves are shown in Figure 1.

(Figure 1 follows,)
(on Page 4.)

(Moisture to Temper, cont'd) -

Figure 1.



MOISTURE REQUIREMENTS.

Hot Strength:

The hot strength of sand is an important factor in foundry work. If the hot strength is too low the metal will cut and wash the sand. Excessive hot strength results in hot tears and casting cracks in the metal.

The specimens used in the hot strength test were cylinders 1-1/8 inches in diameter by 2 inches long. They were soaked in a dilatometer furnace at the given temperatures for twelve minutes before they were broken. The results are tabulated below in Table I, and shown graphically in Figure 2.

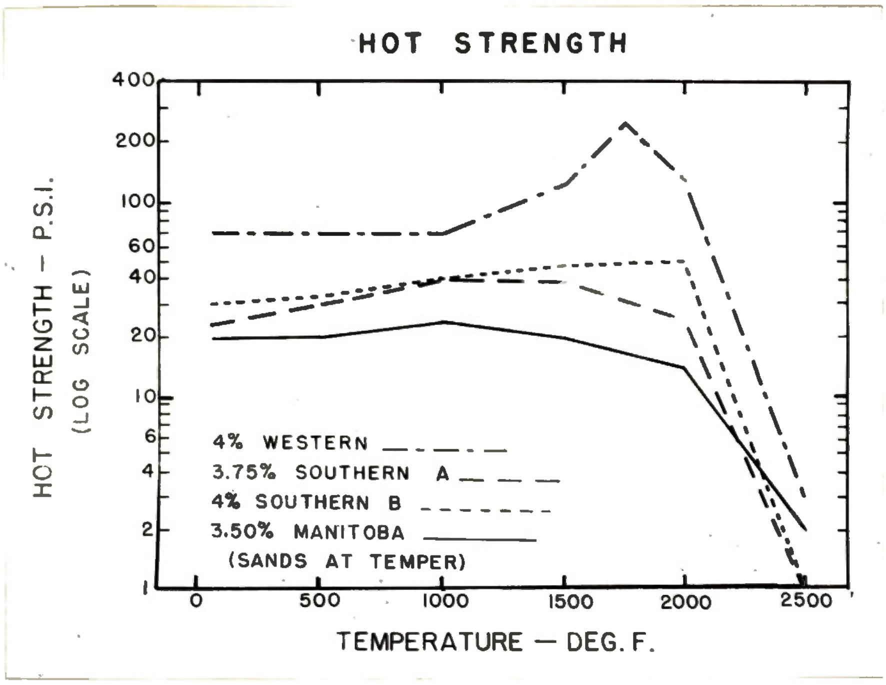
TABLE I. - Hot Compressive Strength of Bentonites.

Temperature, ° F.	Western	Southern A	Southern B	Pembina
Room	70	24	30	20
500	70	30	33	20
1000	70	40	40	23
1500	120	38	46	20
1700	250	-	-	-
2000	125	25	49	14
2500	3	1	1	2

2053

(Hot Strength, cont'd) -

Figure 2.



HOT STRENGTH.

-

Durability:

When moulding sand is used it is heated by the metal. This heating causes deterioration of the bond. One criterion of moulding sand is its durability, or the resistance of the bond to deterioration under heat.

The durability was tested by baking test batches at temperatures of 400, 600, 800, 1000 and 1200° F. The properties of the bentonite-bonded sands were tested after baking at each of these temperatures. The durability was measured on the basis of green bond,[*] toughness (green bond multiplied by deformation, in thousandths of an inch), and dry bond.[*] These results are tabulated below in Tables II, III and IV, and are also shown graphically in Figures 3, 4 and 5.

(Continued on next page)

[*] Green sand contains tempering moisture, and dry sand has had the moisture driven off after moulding.

(Durability, cont'd) -

TABLE II. - Durability of Green Bond.

Baking Temperature, ° F.	Western	Southern A	Southern B	Pembina
225	6.8	7.1	6.8	6.9
400	7.1	6.0	6.0	8.4
600	7.9	4.5	4.3	5.8
800	6.1	3.2	3.0	2.9
1000	4.3	1.3	1.0	1.1
1200	0.9	0.8	0.7	1.0

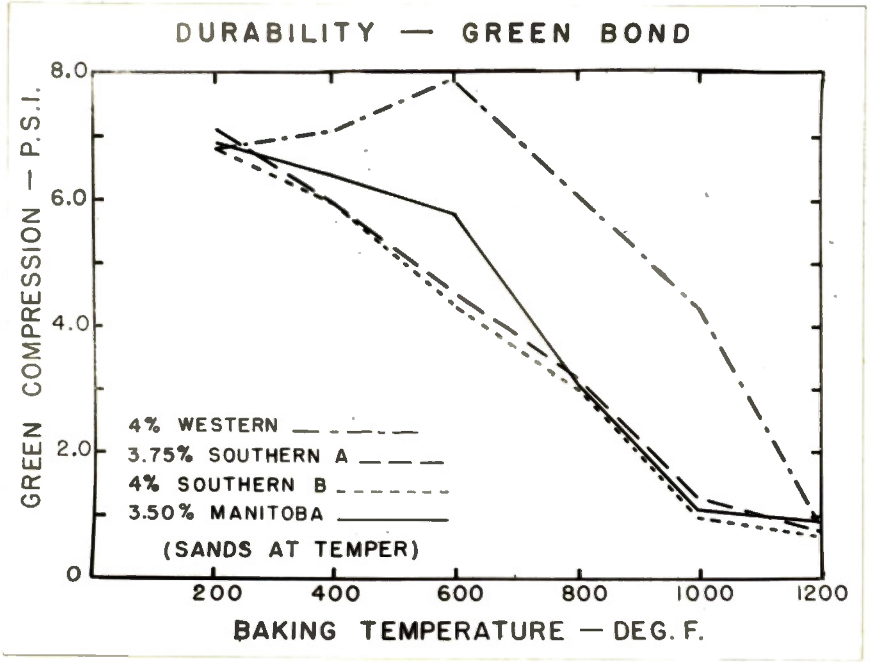
TABLE III. - Durability of Toughness.

Baking Temperature, ° F.	Western	Southern A	Southern B	Pembina
225	102	78	75	73
400	96	54	51	55
600	91	36	25	46
800	58	12.8	11.5	9
1000	19.4	4	3	3
1200	0	0	0	0

TABLE IV. - Durability of Dry Bond.

Baking Temperature, ° F.	Western	Southern A	Southern B	Pembina
225	78	30	34	24
400	69	35	47	24.5
600	47	20	30	21
800	47	20	24	21
1000	9.5	12	10	8
1200	1.0	1.0	1.7	1.3

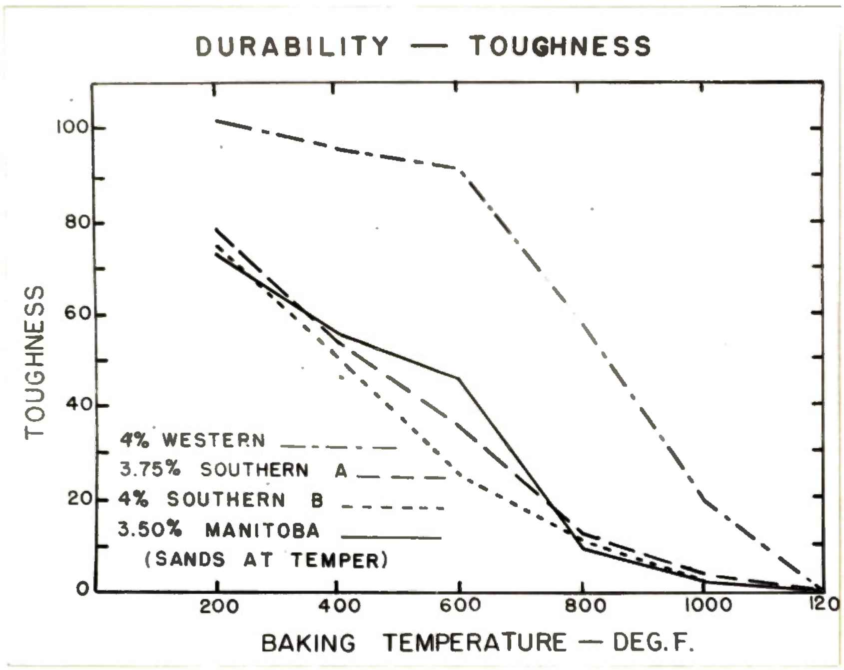
Figure 3.



DURABILITY - GREEN BOND.

(Dirability, cont'd) -

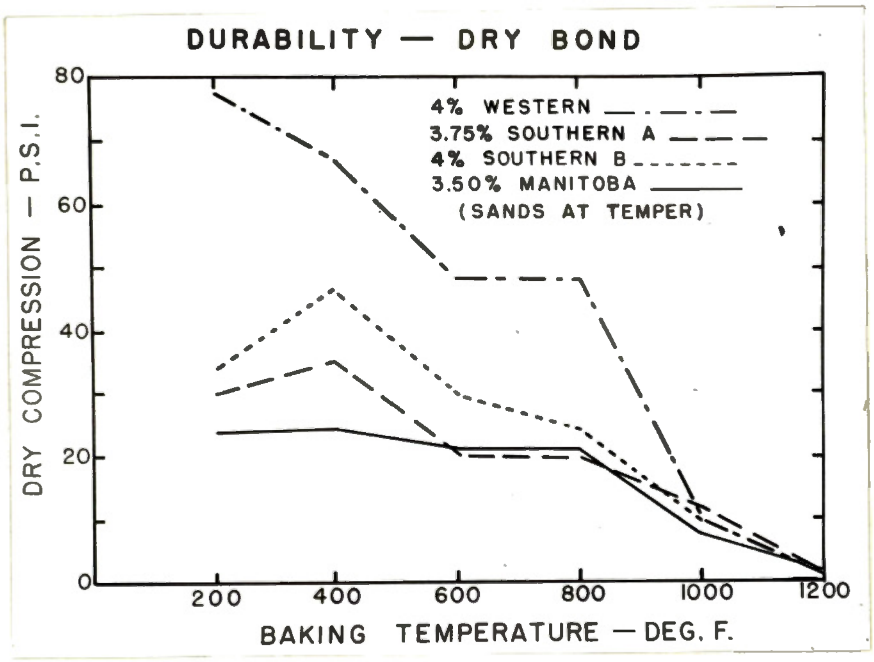
Figure 4.



DURABILITY - TOUGHNESS.

-

Figure 5.



DURABILITY - DRY BOND.

-

DISCUSSION:

Examination of the test results reveals that Pembina bentonite has similar properties to the so-called "southern" bentonites, produced in the southern United States. In comparison with western bentonites, from the Black Hills of South Dakota and Wyoming, these bentonites possess the following properties:

(1) High green bond.
(2) Low toughness.
(3) Low dry bond.
(4) Low hot strength.
(5) Low durability.
(6) Poor suspending properties.

The use of southern bentonite in the foundry industry is a fairly recent development, and the demand for this material is growing. It should be recommended for foundry use only where its peculiar properties give it an advantage over the more commonly used western bentonite. Following are ways in which southern bentonite is proving useful:

(1) Synthetic Sand -

The most important use of foundry bentonite is as a bond for synthetic moulding sands. In North America most steel foundries use synthetic sand. As steel is cast at very high temperatures the better durability of western bentonite makes it the logical binder for steel sands. It is also found that the high dry and hot strengths of western bentonite are helpful in preventing liquid metal from cutting and washing sand into the mould cavity.

Some steel foundries on light work experience trouble from cracked castings, because of the high hot strength of western bentonite. As the metal shrinks on cooling the sand may crack castings if it is too strong. In such cases a blend of western and southern bentonites is used to control the hot strength. ("Southern Bentonite in the Steel Foundry," N. J. Dunbeck - Trans. A.F.A., Vol. 51, June 1944, p. 289.)

Most cast iron and non-ferrous foundries use

(Discussion, cont'd) -

natural moulding sand, but some of the larger production shops use synthetic sand. As these metals are poured at lower temperatures than steel, the lower durability of southern bentonite would not be so objectionable. However, if southern bentonite were used as the only bonding agent for these sands, its low dry and hot strengths would result in washing of the sand by the metal. A judicious blending of western and southern bentonites, to control the hot strength, would produce the most satisfactory bond for malleable iron, cast iron and non-ferrous synthetic sands.

Magnesium, which is usually poured in synthetic sand, has a low pouring temperature. This metal is so light that it should not wash in a sand with a southern bentonite bond. The low hot strength of magnesium makes it desirable to pour it into a sand with a low dry and hot strength, to prevent cracked castings. The use of at least some southern bentonite in magnesium sands is standard practice. However, the volume of magnesium at present cast in Canada is quite low, and offers a limited market for bentonite.

(2) Bentonite in Natural Moulding Sand -

Most small foundries using natural-bonded moulding sands for non-ferrous and cast iron work do not possess a sand muller but depend upon mixing their sand manually. The natural bond burns out as the sand is repeatedly used, and the sand must be rebonded. This may be done by adding a natural sand with a high bond, or by adding clay. Western bentonite is not suitable as a rebonding material under these conditions, as it must be mulled to develop its bond. Southern bentonite is more easily wet than western bentonite, and satisfactory results can be obtained by mixing it with the sand manually. The high bond imparted by southern bentonite with little mixing makes it one of the most satisfactory rebonding clays.

(Discussion, cont'd) -

(3) Bentonite in Foundry Cores -

Foundry cores are usually bonded with oxidizing oils, such as linseed, which develop their strength on baking. When metal is cast around these cores the oil bond burns out, allowing the sand to collapse, and the metal contracts without cracking. In addition to oil, core sand requires some material, such as cereal flour or clay, to make it workable in the green state, and to enable it to hold its shape until it is baked. For small cores, cereal alone may be used, but in large cores, which require a fairly high green bond, bentonite may be used in conjunction with the cereal flour. Cereal flour alone is not used to give a high green bond, as its use in excess gives the sand too high a plasticity.

In oil sands, the use of bentonite is uneconomical, as it absorbs the oil binder and destroys its efficiency. If bentonite is used, however, southern bentonite has an advantage over western bentonite because of its lower hot strength. The high hot strength of western bentonite is usually a disadvantage in cores, as it prevents the sand from collapsing and results in cracked castings. Sometimes, for heavy metal sections, a high hot strength is desirable, to prevent the sand from collapsing too soon and the sand from washing into the mould cavity. Silica flour and iron oxide are usually preferred to western bentonite as high temperature binders, because the excessive strength of western bentonite around 1700° F. is a source of trouble, and its excessive consumption of oil is uneconomical.

Resin is sometimes used instead of oil to impart baked strength to foundry cores. Resin is not absorbed by clay, and therefore works well with bentonite. Combinations of resin and southern bentonite can be made to produce results comparable with those given by the usual oil and cereal flour core sand

(Discussion, cont'd) -

mixtures. In recommending southern bentonite as a substitute for cereal flour it would be wise, therefore, to stress its use with resin-bonded rather than oil-bonded sands.

Although cereal flour is usually preferred to bentonite as a core binder, it is at present unavailable to the foundry industry. Substitutes such as bentonite and sulphite liquors must therefore be used. Southern bentonite is a better substitute than western bentonite for cereal flour, because of its low hot strength. The use of this material by the foundry industry will therefore be increased while the cereal shortage lasts.

(4) Bentonite in Cores and Mould Washes -

Bentonite is used as a suspending and bonding agent with silica flour as a mould and core wash. Western bentonite is better than southern bentonite as a suspending agent, and is therefore the better material to use in mould and core washes.

CONCLUSIONS:

1. Pembina bentonite is similar to the type of foundry bentonites classed as "southern" bentonites.

2. Low drying temperatures should be used when preparing Pembina bentonite for shipping, as it deteriorates on heating.

3. This material may be used in foundry work in the following ways:

(a) With western bentonite in synthetic sand mixtures, to control the hot strength. Synthetic sand mixtures containing southern bentonite are used for light steel castings, and in cast iron and non-ferrous work.

(Continued on next page)

(Conclusion, cont'd) -

(b) As a rebonding clay for natural-bonded moulding sands, in cast iron and non-ferrous work.

(c) To develop green bond in core sands without impairing collapsibility. It should be used with resin-bonded rather than oil-bonded sands wherever possible, as it destroys the efficiency of core oil as a sand binder.

oooooooooooo
oooooooo
oo

AEM:LB.