Mr. V.A. Haw, MSD

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EFFECT OF KILN TEMPERATURE ON THE UNIT WEIGHT OF A LIGHTWEIGHT AGGREGATE PRODUCED IN EDMONTON, ALBERTA

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Mineral Processing Division

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SUMMARY OF RESULTS

The clay bloated through a temperature range of 90 Centigrade degrees between 1030° and 1120°C (1890° and 2050°F). The resulting coarse lightweight aggregates had unit weights between 50 and 29 lb/cu ft. The unit weight of the lightweight aggregate being produced by the company could possibly be reduced by: (a) firing the material to a higher temperature, (b) reducing the retention time of the material in the kiln, or (c) heating the material more uniformly.

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INTRODUCTION

Edmonton Concrete Block Co. Ltd., Edmonton, Alta., requested the assistance of the Mineral Processing Division in solving a problem in the company's production of lightweight aggregate. Normally, the lightweight aggregate discharged from the company's rotary kiln has a unit weight 42 to 44 lb/cu ft. Recently, the product has had a unit weight of 56 lb/cu ft at a kiln temperature of 1125°C (2060°F). The company requested an investigation to determine at what firing temperature the product from the kiln would have the desired unit weight of 42 to 44 lb/cu ft. To carry out this investigation, the company submitted 75 lb of pelletized clay in a moist condition. The pellets, which had been formed by extruding plastic clay through a screen having square openings, were primarily between 1½ and ½ in. in size, and contained 25.6 per cent water.

STATIONARY-KILN TESTS

To obtain preliminary information on the bloating-temperature range of this clay, some of the pellets were fired in a stationary kiln. This kiln, a Remmey, Model 2150, has a hearth of 4 by 8 in., and is fired with natural gas. The gas and air supplies are arranged so that there is a constant gas-air ratio at all temperatures. The atmosphere in the kiln is oxidizing, there being about 30 per cent excess air, all supplied as primary air.

A portion of the material was dried prior to making these tests. Charges of five pellets each in a preheated refractory sagger, were inserted into the kiln at each of four temperatures, 1040°, 1070°, 1100° and 1125°C (1910°, 1960°, 2010° and 2060°F) and removed after 8 min. While the material was in the kiln, the temperature was controlled with ±5 Farenheit degrees of the selected temperature.

The product of each firing was examined for degree of bloating and agglomeration or sticking, and the bulk specific gravity was determined. The weights of the products were measured on a direct-reading single-pan balance and the volumes were measured by the mercury-displacement method. The bulk specific gravity of the dried, raw pellets was also determined. The observations and specific gravities are shown in Table 1 and the specific gravities are presented graphically in Figure 1.

TABLE 1

Stationary-Kiln Tests

Firing Temperature (°C)	Observations	Bulk Specific Gravity
	raw pellets	2.1
1040	moderately bloated	1.3
1070	well bloated	1.0
1100	very well bloated, very slight agglomeration	0.7
1125	overbloated, moderate agglomeration	0.5

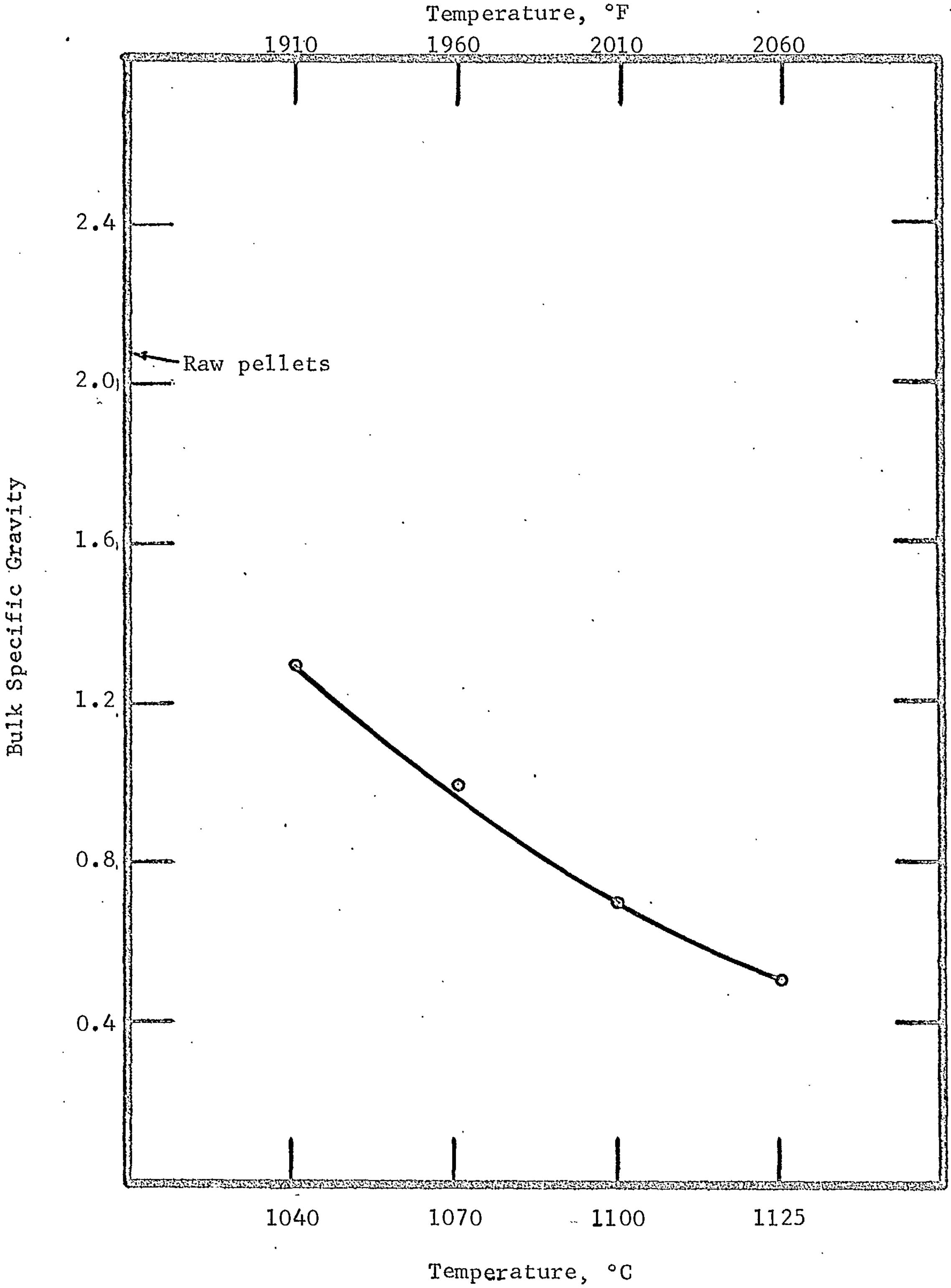

Figure 1: Stationary-Kiln Tests

ROTARY-KILN TESTS

These tests were made in a rotary kiln, of 5-in. internal diameter by 8 ft. in length, fired with propane. The gas-air ratio is constant at all temperatures. There is between 30 and 50 per cent excess air in the kiln, the majority of which is primary air; the secondary air is kept at a minimum. The burner is aimed at the kiln lining opposite to the area where the bed of material travels, to keep the hot zone close to the discharge end of the kiln, and to prevent flame impingement on the bed, which would result in localized over-heating. The kiln was set at an inclination of 1.3 in./ft and a rotational speed of 2.5 rpm.

Most of the pellets were too large to be fed into the kiln. A portion of the material was dried, crushed in a jaw crusher, and the ½-in. to 4-mesh fraction was selected by hand screening for testing. One-fifteenth of a cu ft, about 5 lb of the sized material, was used for each test run. It was fed into the kiln by a vibratory feeder at a rate of about 17 lb/hr. The retention time of the material in the kiln was 10 to 15 min. The longer retention time was near the end of the test run when the bed of material thinned out.

The temperature of the kiln was measured with an optical pyrometer. Readings were taken on the lining at the point where the flame impinged, which is in the hottest zone in the kiln. At that point, the flame is invisible and the temperature readings were the temperatures of the kiln lining. The temperature of the bed of material was approximately 5 Farenheit degrees higher than the temperature of the lining.

One preliminary test was made to verify the findings of the stationary-kiln tests as to bloating-temperature range. This test was started with the temperature about the middle of that range (1070°C, 1960°F). When the material was steadily discharging from the kiln, the temperature was rapidly increased to that at which agglomeration of the particles began (1112°C, 2035°F). It was then decreased to the lowest temperature at which appreciable bloating was noticed (1035°C, 1895°F).

Five subsequent test runs were made, at the two extreme temperatures and at three intermediate temperatures: 1035°, 1050°, 1075°, 1095° and 1110°C (1900°, 1930°, 1970°, 2000° and 2035°F). These temperatures could not be held constant but were held as closely as practicable.

The percentage increase in volume of the clay during each firing was determined. The loose dry unit weight of each ungraded product was measured. The products were then screened and recombined in the following proportion:

70 per cent ¾ to 3/8 in.
30 per cent 3/8 in. to 4 mesh

This grading meets the ASTM specification for graded coarse lightweight aggregate, size designation ¾ in. to 4 mesh. The unit weights were measured using standard cylindrical metal containers. The bulk specific gravity of a representative portion of each graded lightweight aggregate was determined. The firing temperatures of the five test runs and the results are shown in Table 2. The bulk specific gravities are shown graphically in Figure 2.

TABLE 2

Rotary-Kiln Tests

Test Run	Firing Temperature		Volume Increase (%)	Unit Weight (lb/cu ft)		Bulk Specific Gravity
	(°C)	(°F)		Ungraded	Graded	
1	1030 - 1035	1890 - 1900	20	49.4	49.0	1.4
2	1050 - 1060	1930 - 1945	25	43.1	42.2	1.3
3	1070 - 1080	1965 - 1980	38	41.2	41.3	1.2
4	1090 - 1095	1995 - 2000	44	37.2	37.1	1.1
5	1110 - 1120	2030 - 2050	95	29.4	29.4	0.8

Very slight agglomeration of the clay particles was evident at about 1112°C (2035°F) but did not intensify up to 1120°C (2050°F) and the particles continued to discharge separately from the kiln.

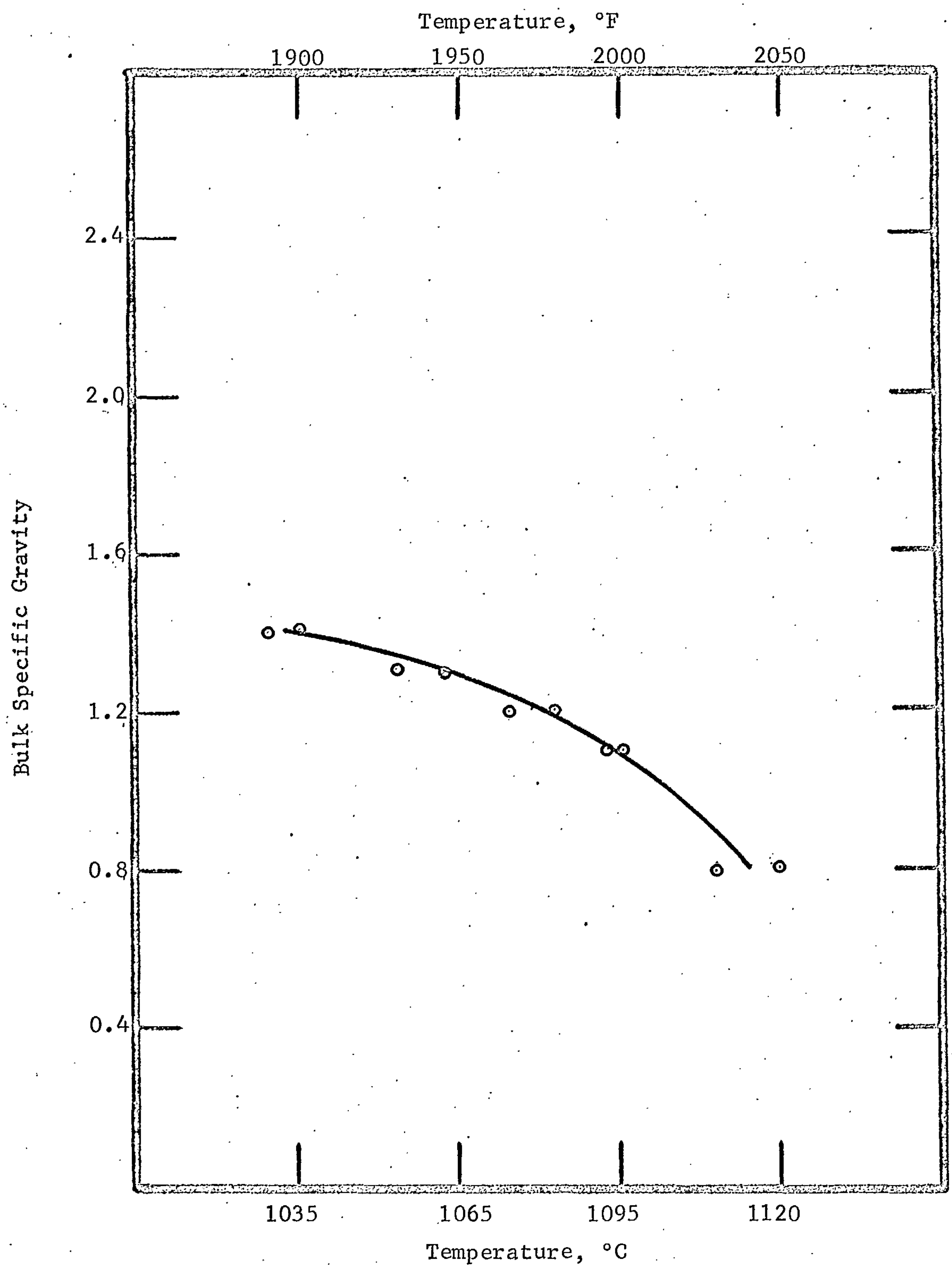

Figure 2: Rotary-Kiln Tests

DISCUSSION OF RESULTS

Both the stationary-kiln and rotary-kiln tests indicate that this is a good-bloating clay. In the rotary kiln, the bloating-temperature range, below the agglomerating temperature, was at least 90 Centigrade (160 Farenheit) degrees between 1030° and 1120°C (1890° and 2050°F). At the maximum temperature, agglomeration had not become a problem, but a slight increase in temperature would probably have resulted in more serious agglomeration. The degree of bloating is almost directly proportional to the temperature. This is illustrated by the two bulk specific gravity curves, which approach straight lines. The clay bloated to a greater degree in the stationary kiln than in the rotary kiln, at all temperatures. In the stationary kiln the clay was exposed to a particular temperature for 8 min, whereas in the rotary kiln, although the clay was in the kiln for up to 15 min, it was exposed to the comparable temperature for only a fraction of that time.

CONCLUSIONS

This work indicates that it should be possible to produce a lightweight aggregate of a unit weight well below the 56 lb/cu ft presently being obtained at an indicated temperature of 1125°C (2060°F).

There are three possible reasons why the unit weight is too high:

1. The temperature recorded in the company's kiln may not be the true temperature of the material. If the temperature is determined by optical means, the reading may be influenced by the flame from the burner and the recorded temperature will be considerably higher than the actual temperature of the bed of material.
2. The retention time of the material in the kiln may be too long. If the material takes too long to reach the vitrification temperature, some of the bloating gases will escape and bloating will be decreased.
3. The bed of material may be too deep for uniform heating. Improved bloating, at the same production rate, might be achieved if a thinner bed were passed more rapidly through the kiln.

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