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G M I SHORT PAPER

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NOTES ON
BUILDING-BLOCK MATERIALS OF EASTERN OREGON

by
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CONTENTS

	<u>Page</u>
Introduction	1
Occurrences	1
Tests	2
Fabrication of test blocks	2
Nature of tests	3
Observations and test results	3
Discussion of test results	4
Discussion of the market area	5
Equipment required	5
Conclusions	6
Acknowledgements	6

TABLES

Table 1. Mixes used in test blocks	2
Table 2. Weights of test blocks	3
Table 3. Increase in weight of blocks after immersion in water	4
Table 4. Crushing strength values of test blocks	4

INTRODUCTION

Construction blocks fabricated from various light-weight aggregates are becoming popular in regions where they are available. This popularity is due to many factors, both tangible and intangible. Of the tangible factors, the light weight of the blocks as compared with that of straight concrete blocks is important in that the light-weight blocks are easier for the workmen to handle and less expensive to ship. Such basic costs are extremely important in construction. In instances where lightness in weight is due to porosity of the aggregate, the insulating property looms large, as the dead air space within the body of the aggregate is present in addition to that afforded by the hollow construction of the block itself. The fire-resistant qualities of these fabricated blocks is another specific attribute. It is perhaps needless to point out that the scarcity and high price of lumber cause builders to seek other construction materials. Of the intangible factors, permanence and soundness of construction, cost of maintenance, and low depreciation are perhaps the most important.

Whatever the reasons for the popularity of these blocks, the fact remains that where suitable raw materials exist, flourishing building-block enterprises have been built up with a resultant benefit both to the community and to the consumer.

Excellent deposits of suitable raw materials occur in Baker and Union Counties. In addition, and just as important as the deposits themselves, no such blocks or even suitable competitive substitutes are being made in the appreciable potential market in these counties. The cost of delivery from the nearest producer makes the cost to the ultimate consumer practically prohibitive. Since much interest has been shown in connection with the feasibility of starting such an industry in Baker County, a search for suitable local materials has been conducted by the Department. Following is a discussion of the occurrences studied, of tests on sample blocks made from the various materials, and a brief description of the possible market.

OCCURRENCES

Three types of materials potentially suitable for aggregates have been found in the Baker area, namely, volcanic tuff which makes a very light gray and light-weight block; volcanic cinders, both red and black; and diatomaceous earth.

Tuff is a rock formed by the accumulation of fine fragments of pre-existing rock, lava, volcanic glass, and occasionally mineral crystals - all representing material blown originally from old volcanic cones. Such material frequently forms thick deposits miles from the crater source. Volcanic cinders, on the other hand, are primarily composed of solidified lava full of small holes which represent cavities formed by gas bubbles trapped as the molten lava cooled. Like tuff, these cinders are commonly blown forcibly from a volcanic vent, but unlike the tuff they accumulate nearer to their source, due to the appreciably greater size and weight of the individual fragments. Cinders may be composed of any of the different lava types normally erupted from a volcano - that is, the acid lavas (pumice and pumiceous cinders) or the basic lavas. There are no known pumice occurrences of any consequence in northeastern Oregon, and the cinders mentioned as one of the three types of possible aggregate materials found in the area are of basaltic or andesitic composition. Diatomaceous earth is an altogether different type of rock formation. It is of sedimentary origin, being composed of siliceous remains of minute unicellular plants which accumulate in both salt and fresh water. The resultant rock formed by these remains is very light in weight. While this material is commonly used as a filter-aid and as an insulation agent, it is seldom used in its natural form as a construction medium except under special conditions, on account of lack of both strength and resistance to weathering. Thus, although diatomaceous earth does occur in both Baker and Union Counties, it is not considered suitable by itself as an aggregate for construction blocks, especially in view of the existence of the superior alternatives available. However, diatomaceous earth may prove advantageous in combination with other aggregates.

The tuff occurs within a few hundred feet of Highway 30 and the Union Pacific Railroad at Pleasant Valley, Baker County, in secs. 19 and 24, T. 10 S., R. 41 E. This rock was quarried extensively in the past and used in the construction of most of the larger public and private buildings in the city of Baker. The rejects alone from this quarrying constitute a large tonnage. The reserves in place are limitless in terms of any contemplated construction block operation.

The rock is light in weight and porous, but the porosity is due to intrafragmental voids rather than gas-bubble holes as in the case of the lavas and cinders of comparable glassy material. Consequently there may be a tendency for the cavities to be interconnected instead of being separate and distinct individuals. Even so no troubles have been experienced from moisture in the buildings made from sawed blocks. The rock is soft and easily sawed or cut, but it hardens on exposure and from the standpoint of structural strength, it is quite satisfactory.

The cinders, both the red and the black varieties, occur in a low, rounded hill a few hundred feet off the Ladd Canyon Road in Clover Creek Valley, Union County, in secs. 17 and 20, T. 5 S., R. 39 E., seven miles from Highway 30 and the Union Pacific Railroad at North Powder. These cinders have been utilized locally to a small extent as road metal and there is a small quarry on one flank of the hill. The cinders are unconsolidated, and although blocks as much as two feet in diameter may be seen, the usual size of the individual fragments ranges from one-half inch to 5 or 6 inches. The black cinders constitute approximately one-quarter of the quarry face and the red constitute the remainder. Although each is relatively uniform in quality and distinct from the other, yet the occurrence of two colors of cinders introduces a mining problem which any prospective operator should reckon with if a uniformly colored product is to be produced over a period of time. A certain amount of prospect testing will need to be done before a definite estimate of the yardage of the cinders may be made. Such prospecting is especially pertinent as far as the depth is concerned, as the existing quarry is not at the base of the deposit and there is no way of estimating how much of the flanks of the hill are slide material. However, even from a cursory examination, it is clear that there is sufficient material present to justify the installation of a plant of moderate capacity.

Other cinder deposits have recently been reported to the Department as occurring in this same general region.

TESTS

Fabrication of test blocks

All materials used were crushed and screened through $\frac{1}{2}$ -inch mesh and then re-crushed in order to develop an adequate percentage of fines. All aggregates were mixed in the proportions (by volume) as shown in Table 1.

Table 1.

	<u>Mix 1</u>	<u>Mix 2</u>	<u>Mix 3</u>
Tuff	1 - 6 cement* and tuff	1 - 1 - 5 cement, sand, and tuff	1 - 1 - 5 cement, diatomite, and tuff
Red cinders	1 - 6 cement and cinders	1 - 1 - 5 cement, sand, and cinders	
Black cinders	1 - 6 cement and cinders	1 - 1 - 5 cement,** sand, and cinders	

* Portland cement.

** As will be pointed out later in the article, certain difficulty was experienced in the casting of some of the cinder blocks due to an insufficient percentage of fines, and in this case additional sand was added to an estimated $2\frac{1}{2}$ parts sand to $3\frac{1}{2}$ parts cinders.

These mixes were all prepared and sacked in Baker and taken to Bend, Oregon, where they were cast into blocks on a Syntrol electric vibrator at the plant of the Bend Concrete Products Company where comparable blocks are made utilizing local pumice sands and cinders. The blocks cast measured 11 3/4" x 5 3/4" x 5 1/2" and had two center holes 2" x 3". All blocks were sun-dried under wet burlap for three days and then subsequently cured for 42 days before further testing.

Nature of tests

The only tests given these blocks were for absorption and crushing strength. No facilities were available for determining the rate of heat conductivity, but the foregoing tests were considered sufficient to demonstrate adequately the potential qualities of the respective materials for the purpose required. For the absorption test the blocks were weighed dry, then immersed in water and reweighed at intervals thereafter as shown in Table 3. For the crushing strength test, the blocks (different ones than used in the absorption tests) were sent to the laboratory of the State Highway Materials Department, Salem, Oregon, where they were given full compression tests.

Observations and test results

From the standpoint of workability, all the tuff mixes were easy to handle and cast exceptionally well. Although satisfactory cinder blocks were made, it was necessary to cast them several times. In the opinion of Mr. Syverson of the Bend Concrete Products Company, this was due to an insufficient amount of fines and this conclusion is supported by the fact that cinder blocks with a sand content were easier to handle. A factor further contributing to the difficulty of casting was a lack of previous knowledge concerning the proper proportion of water for the best results. In the end it was found expedient to wet these cinder mixes far more than was at first thought necessary. In practice no difficulty should be experienced in the handling of these cinders as comparable material is commonly handled successfully elsewhere. Complete success in this respect is just a matter of working out the optimum fineness of the aggregate and wetness of the mix. As has already been mentioned, the test blocks appeared satisfactory in all respects in spite of the difficulties experienced in casting them.

The weights of the various dry blocks are as follows:

Table 2.

Straight tuff aggregate	13 3/4 lbs.
Tuff with sand bond	14 1/2
Tuff with diatomite bond	13 1/2
Straight red cinders	16 1/2
Red cinders with sand bond	16 7/8
Straight black cinders	17 1/2
Black cinders with sand bond	18 1/4
Pumice block of the Bend Concrete Products Company	13 1/4

An equivalent concrete block would weigh approximately 27 pounds.

Table 3 shows the increase in weight in pounds for each of the different blocks after specified intervals of soaking.

Table 3.

Type of Block	Time in Minutes						
	0 (dry)	10	20	30	40	60	360
Straight tuff	13 4/8	16 5/8	16 7/8	16 7/8	17	17	17 1/8
Tuff with sand	14	16 5/8	16 7/8	16 7/8	16 7/8	16 7/8	17
Tuff with diatomite	13	15 5/8	16 3/8	16 3/8	16 4/8	16 4/8	16 4/8
Red cinders	16 2/8	18 1/8	18 1/8	18 1/8	18 1/8	18 1/8	18 1/8
Red cinders with sand	16 5/8	18 2/8	18 3/8	18 3/8	18 3/8	18 3/8	18 3/8
Black cinders	17	18 1/8	18 4/8	18 5/8	18 5/8	18 5/8	18 5/8
Black cinders with sand	18	19 3/8	19 5/8	19 6/8	19 7/8	19 7/8	19 7/8
Commercial pumice	12 5/8	13 6/8	14	14 2/8	14 2/8	14 3/8	14 4/8

Crushing strength values in Table 4 include also figures for three types of commercial blocks for comparative purposes.

Table 4.

Description	Surface Dimensions	Crushing Strength
		in lbs. per sq. in. of Gross Area*
Straight tuff	5 3/4 x 12	225
Tuff with sand bond	"	370
Tuff with diatomite bond	"	590
Red cinders	"	775
Red cinders with sand bond	"	910
Black cinders	"	1630
Black cinders with sand bond	"	960
Commercial pumice block	"	787
Commercial cinder block	8 x 16	535
Commercial diatomite-tuff block	"	425

DISCUSSION OF TEST RESULTS

Comparison of the figures show that local materials produce blocks which compare favorably with competitive products from other places. Furthermore, it is altogether probable that blocks from the local materials can be made which will have a higher crushing strength than those tested. The proper wetness of a cement mix has great bearing on the ultimate strength of the final product, and in this respect a certain amount of trial and error experimentation will be necessary to determine the best proportions in practice. Curing with live steam may also prove beneficial.

Of the materials used in the experiments, the tuff produced the lightest blocks. These were also the weakest. Although it might seem that the tuff should be ruled out as unsatisfactory because of the strength test, certain considerations indicate that the tuff might prove suitable. This material yielded a considerable amount of fines of a "flour" nature on crushing, and these fines probably do not react favorably with the cement, and account for the low test results. It is altogether probable that if this "flour" were screened out to give a clean tuff product of plus 1/8-inch mesh, and commercial sand were used for the fines, then a far stronger block could be made, and at the same time a large measure of the lightness of weight and good workability characteristics could be preserved. As building stone in its natural state this tuff has shown adequate strength in some moderately large buildings and it seems likely that a cast block made of a clean aggregate of such tuff fragments should possess like, or similar characteristics.

*No allowance made for center holes, which if done would raise the values given some 18.3 per cent. The small blocks had two holes totalling approximately 12 square inches. The large commercial blocks had three holes.

The test cinder blocks show excellent crushing strength, and with a proper and balanced-sized aggregate and controlled conditions of manufacture and curing, it would seem that an average crushing strength in excess of 1000 pounds per square inch, gross surface area, could be realized and maintained in practice. The cinders do not produce such an abundance of fines on crushing, nor do the fines tend to "flour" as much as in the case of the tuff. Crushing to 1/4-in. mesh should produce a good sized aggregate with about the right percentage of fines.

Manifestly, these blocks are prone to take on water at a rather excessive rate, but in usage little difficulty has been experienced with commercial products of identical composition with the local materials. While in practice residential buildings are frequently stuccoed, it is by no means uncommon to dispense with such a cover, reportedly with no seemingly unfavorable results. Evidently the blocks have the capacity for drying out rapidly.

As is shown in Table 3, all blocks attained nearly maximum saturation with a few minutes after immersion. Although there is no conspicuous or conclusive difference, the results suggest that blocks containing sand or diatomite tend to absorb water at a slower rate. Should more moisture-resistant blocks be required (which is doubtful considering the climatic conditions prevalent in the probable market area) a corrective solution can doubtless be found by experimentation with some of the standard water-proofing substances available to the trade.

DISCUSSION OF THE MARKET AREA

Baker, Union, and Wallowa counties would constitute the immediate market area for a plant using either the tuff or the cinders, although a plant situated at North Powder and using the latter would be more centrally located.

The combined area of these counties is 8294 square miles. The 1940 population for each is: Baker, 18,297; Union, 17,399; Wallowa, 7,632*; and the number of farms in each is 1,091; 1,208; and 811 respectively.**

The area embraced by these counties, or at least most of the area, is situated too far distant from the nearest producer of these construction blocks for economic importation, and comparable construction media or competitive substitutes are not available from local sources. Production of building stone from the tuff quarry was discontinued years ago, and the brick plants which operated for a short while both in Baker and La Grande have long since ceased to exist. Thus for construction other than wood, local consumers must either use cement or bring in tile, brick, or construction blocks. This is expensive at best and for the average rancher who is faced with a long secondary haul, it is excessive. There seems little reason to doubt that were they available to the local consumers at the prices they retail for elsewhere, the interest and demand for these construction blocks would be as great locally as in regions where the blocks are now made, such as at Boise, Idaho, and Bend, Oregon.

EQUIPMENT REQUIRED

Plants for the construction of these blocks are relatively simple, the main units being a casting room and a curing shed with aggregate and cement storage bins either a part of the casting room or feeding into it. The plant equipment is likewise not complex, consisting chiefly of a mixer and a casting unit. The mixers are invariably built-in, with paddles on a shaft to effect the mixing. Discharged mix goes directly to the hopper bin of the casting unit either by gravity discharge or by an elevator, depending on the set-up of the plant. There are two types of casting machines commonly used.

* Area and population figures from Oregon Blue Book, 1943-1944.

** Bureau of Census, U.S. Department of Commerce - preliminary figures for 1945.

In one the mix is mechanically tamped while it is fed into a mold. In the other the mold is vibrated while the mix is fed. Both methods are satisfactory and both are widely used. Cast blocks are mechanically ejected from the mold onto trays. Molds come in a wide variety of patterns.

Curing under a spray or under steam, preferably the latter, is important and for this a suitable building is needed. In the case of steam curing, this shed should be divided into at least three rooms, each capable of holding the daily output of the plant. In this way, while one room is being loaded with fresh cast blocks, another is steaming, and the last is being emptied of cured blocks. This provides a 24-hour period of steam curing. Four steam rooms, providing a 36-hour steaming, are sometimes used. Much more space is needed for additional curing and storage of blocks, but for this no building is essential.

The kind and amount of accessory equipment required is governed largely by the capacity of the plant. For instance, in very small plants a helper can carry fresh cast blocks into the curing room as they are made, but for large volume production, some form of mechanical conveyance is necessary. Large racks on wheels, designed to carry several tiers of fresh cast blocks are sometimes employed, and since these are not unloaded in the curing room, a sufficient number of racks to hold several days' output of blocks is required. In larger plants, plain racks are loaded and then picked up and moved around by motor carry-alls.

The quarry phase of the equipment includes digging or loading units, a crushing system, and suitable screens, and (if the quarry is removed from the plant site) trucks. Of the foregoing, the kind of digging or loading equipment depends on the nature of the material to be quarried and the mining problems involved. Shovels, draglines, and bulldozers are all used. Rock-breaking equipment is necessary only on deposits where the rock occurs in a massive form. The crushing system is likely to be the most complex phase of quarry equipment. Since an aggregate should be reduced to $3/8$ or $1/4$ minus with an adequate and consistent amount of fines, two or more stages of crushing and screening are generally necessary.

CONCLUSIONS

An abundant supply of excellent raw materials for the fabrication of attractive lightweight, fire-resistant, construction blocks with good insulating properties occur in a large and prosperous area in eastern Oregon where such blocks are not now readily available to the consumer. An opportunity seemingly exists for the establishment of a profitable new enterprise which will fill a definite consumer need.

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