

Pumice pit near Cochiti, Valle Mountains district.

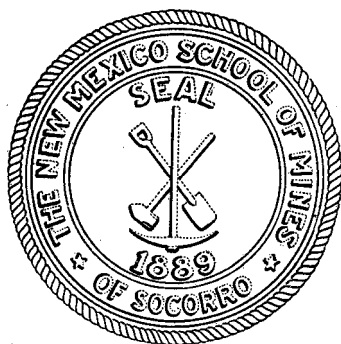
NEW MEXICO  
BUREAU OF MINES AND MINERAL RESOURCES  
A DEPARTMENT OF THE SCHOOL OF MINES

E. C. ANDERSON  
Director

BULLETIN 24

Building Blocks from Natural Lightweight  
Materials of New Mexico

By  
DONN M. CLIPPINGER



SOCORRO, NEW MEXICO

1946

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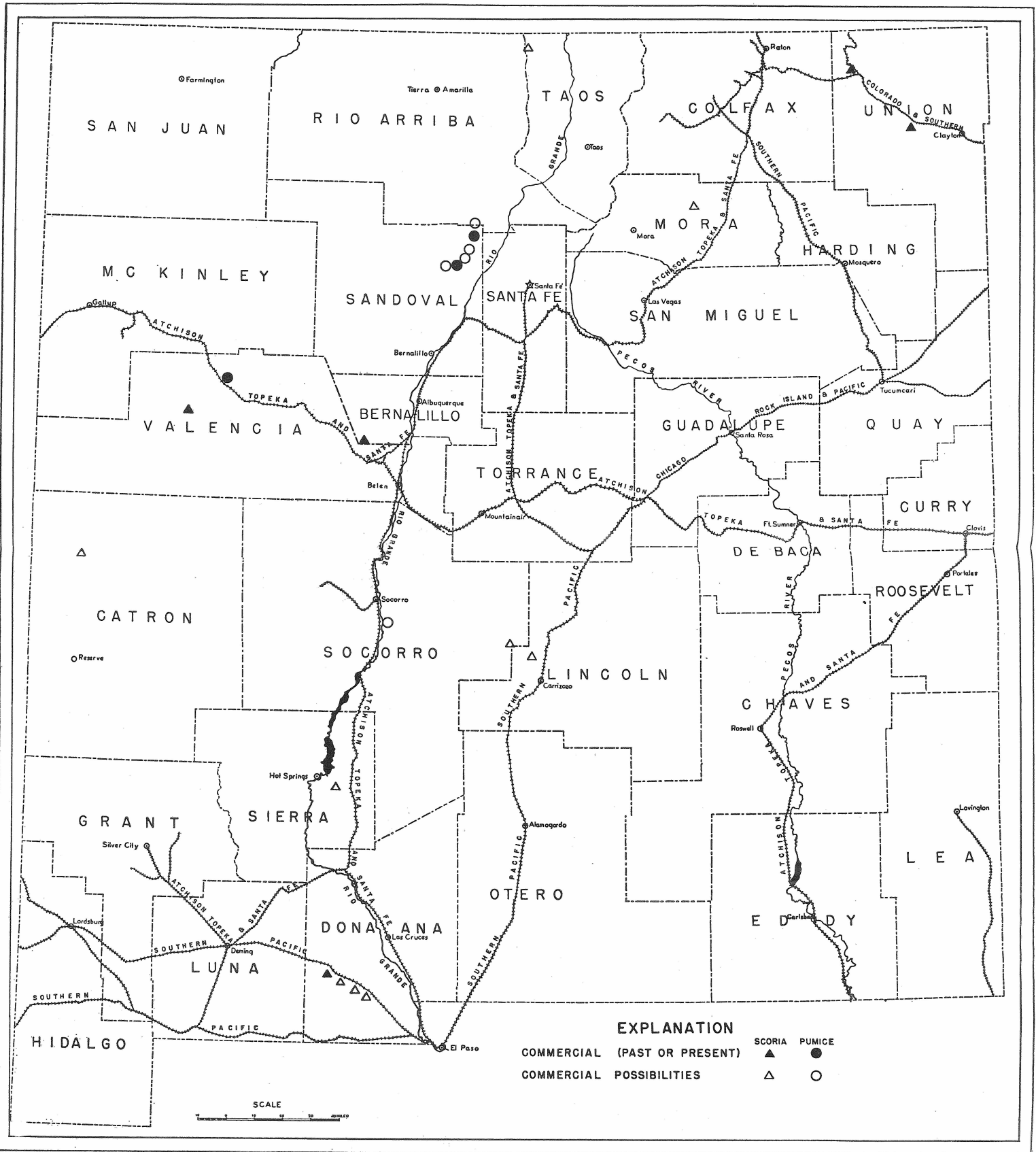
THE NEW MEXICO BUREAU OF MINES AND  
MINERAL RESOURCES

The New Mexico Bureau of Mines and Mineral Resources, designated as "a department of the New Mexico School of Mines and under the direction of its Board of Regents," was established by the New Mexico Legislature of 1927. Its chief functions are to compile and distribute information regarding mineral industries in the State, through field studies and collections, laboratory and library research, and the publication of the results of such investigations. A full list of the publications of the New Mexico Bureau of Mines and Mineral Resources is given on the last pages of this Bulletin.

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Map of New Mexico showing locations of pumice and scoria deposits.

# Building Blocks from Natural Lightweight Materials of New Mexico

By

DONN M. CLIPPINGER

## INTRODUCTION

### PURPOSE AND SCOPE OF THE REPORT

The increasing use in New Mexico of concrete building blocks employing lightweight volcanic aggregates has presented many problems. Questions have arisen regarding locations of suitable lightweight aggregates, properties of the various materials, proper sizing of aggregates, properties of blocks with certain proportions of cement, and methods of manufacture. In the interest of promoting the use of the natural lightweight materials throughout the State, the New Mexico Bureau of Mines and Mineral Resources has conducted research work on available scoria and pumice. This report embodies the results of this work.

Samples were obtained from seventeen deposits of scoria and pumice within the State (see map, Plate 1). Large enough samples of eight of these materials were procured so that they could be made into 8" x 8" x 16" hollow concrete building blocks for testing. Samples were prepared and blocks were tested in the laboratories at the New Mexico School of Mines. Test blocks were made on one of the commercial vibrator block-machines at the plant of Edgar D. Otto & Son, Albuquerque.

The factors causing variations in the properties of concrete building units are so numerous that it was not possible with the available time and facilities to delve into all phases of the subject.

This bulletin supersedes a previous circular on the same subjects.<sup>1</sup>

<sup>1</sup> Benjovsky, T. D., and Clippinger, D. M., Natural light-weight building-block materials of New Mexico: N. Mex. School of Mines, State Bur. Mines and Min. Res. Circ. 10, 4 pp., 1945 (mimeographed).

### ACKNOWLEDGMENTS

The author wishes to acknowledge the cooperation in obtaining samples for this work of J. A. Freeman, general manager of the Pumice Corporation of America; Messrs. Germer and Balreich of Grants Cement Products Company; Southwestern Portland Cement Company of El Paso, Texas; and Joseph Montag, Col. E. G. Cullum, Douglas Cornwall, Carl Oliver, and James Wolf.

The author also wishes to make special mention of the excellent cooperation and assistance accorded this Bureau during the manufacture of the units for the test program by Edgar D. Otto, Richard Otto, and Hugo Hesse of Edgar D. Otto & Son Concrete Products, of Albuquerque.

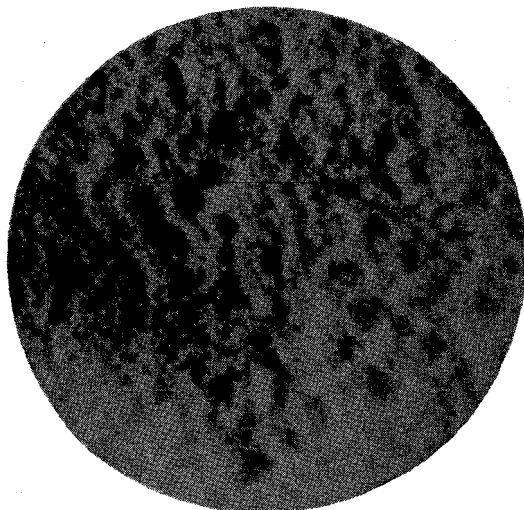
Thanks are due also to T. D. Benjovsky, chief of the Mining Division, and E. L. Murusky, office engineer, New Mexico Bureau of Mines and Mineral Resources, for valuable assistance in field and laboratory work pertaining to this bulletin.

### PUMICE AND SCORIA

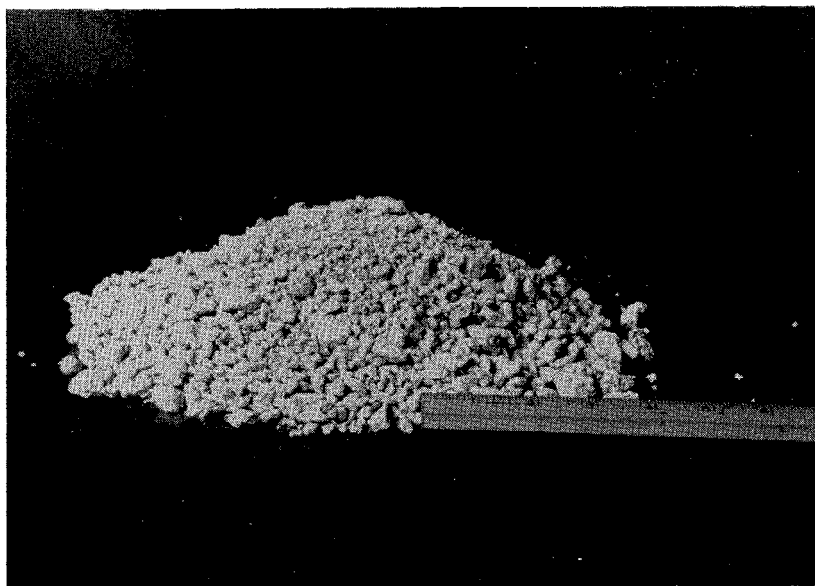
The lightweight volcanic aggregates used for concrete include pumice and scoria. Pumice is a natural silicic glass that was produced by volcanism in the form of a molten froth. This froth, upon cooling rapidly, trapped tiny gas bubbles that caused it to remain extremely porous and minutely vesicular in structure (Plate 2A). Pumice is white to light gray or light tan in color. Its porous texture and glassy composition make it desirable as a building aggregate. Because of its porosity, pumice is light in weight; one cubic yard in pebble form weighs between 825 and 900 pounds, as compared to ordinary sand and gravel which weighs about 2,600 pounds per cubic yard. The dead-air cells in the pumice give it excellent insulating properties against heat, cold, and sound. The glassy composition makes it practically fire-proof; its fusing point is 2,450° F.

Scoria is a highly vesicular cindery material occurring on the surface of volcanic flows of any composition. The samples studied ranged in composition from that of basalt to that of basic volcanic glass. In general scoria has larger cells and thicker cell walls than pumice (Plate 3A), and therefore is slightly heavier; a cubic yard of the crushed material weighs 1,000 to 1,500 pounds. Scoria ranges in color from red or brown to black. Its insulating and fire-resisting properties are similar to those of pumice. Scoria is generally stronger than pumice.





A



B

A. Microphotograph of pumice from Valle Mountains. X 12.  
B. Photograph of pumice from Valle Mountains.

## MANUFACTURE OF BLOCKS

Many different types of hollow masonry units are being made from the lightweight aggregates in the State. Sizes of blocks range from 4" x 6" x 12" to 8" x 8" x 16". Aggregates used in the blocks are diversified: scoria; scoria and sand; pumice; pumice and sand; pumice, coal cinders and sand. Block-making machines include small single-block hand-tamp machines turning out 175 units a day, and fully automatic vibrator press machines capable of making 600 8" x 8" x 16" units per hour. The types most commonly used are small vibrator machines which produce from 500 to 1,500 units per day.

The general procedure for the manufacture of these building units is as follows. The aggregate is first measured into the mixer, about two-thirds of the mixing water is added, and these materials are allowed to become thoroughly mixed. The necessary cement and the remainder of the water is added and the concrete is allowed to become completely mixed. The concrete is removed from the mixer and is introduced into a hopper above the mold, from which it is measured into the mold. There it is vibrated a few seconds to produce compaction. The wet blocks are ejected from the mold onto wooden or steel pallets and are placed on racks or stacked and allowed to stand for 24 to 36 hours. They may then be stripped from the pallets and stockpiled to cure until they have attained adequate strength to be shipped or used for building.

## TESTING PROCEDURE

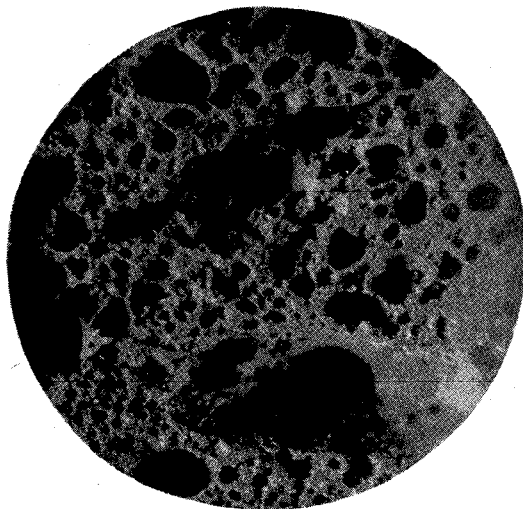
Each sample to be made into blocks consisted of at least 4 cubic feet of material. It was necessary to crush and roll or in some instances merely to roll all of the material (with the exception of Valle Mountains pumice) to obtain a sized aggregate suitable for hollow masonry units. The material was first put through a Blake-type jaw crusher that crushed it to minus 1-inch mesh. From the crusher it went through a set of Allis-Chalmers rolls that reduced the material to minus 3/8 inch. This procedure gave enough fines from some samples to make a suitable aggregate, but from others a part of the material had to be re-rolled to produce the necessary fines. Samples were taken from each batch for sieve analysis and determination of weight and moisture content.

Mixing of the concrete was done in a drum-type mixer. The test blocks were made on a Kirkham Vibrator Block Machine, which made one 8" x 8" x 16" block at a time. Each block was vibrated approximately 10 seconds. The blocks were dry-cured for the first 24 hours they were stored in one of the regular curing rooms of the plant. They were then placed outside. After four

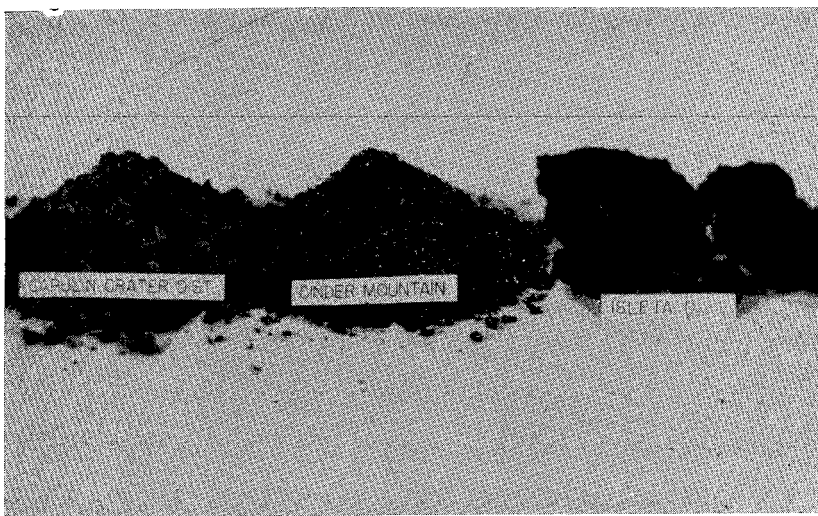
days they were trucked from Albuquerque to Socorro and stacked out-of-doors.

The drum-type concrete mixer was used as a matter of necessity rather than preference, as a trough-type mixer of small enough proportions was not available. The superiority of a trough-type mixer over the drum-type in the preparation of light-weight "dry-mix" concrete for masonry units is unquestionable. The difference between the density of the cement and that of the lightweight aggregate is so great that the cement has a tendency to leave the mixture and to pack on the blades and sides of the revolving drum, robbing the batch of much of its cement. As the mix is drier than ordinary concrete, it does not have the scouring action that accompanies a wet mix of heavy sand and gravel and keeps the mixer clean. If the lightweight material is left in the mixer longer in an attempt to get a more thorough mixture, the cement forms in small balls which do not mix further. In the trough-type mixer the cement does not concentrate on the sides of the mixer; as it is agitated by the revolving blades, there is no chance for packing or for the formation of balls. A more thoroughly and satisfactorily mixed concrete is the result.

The compression tests and percentage-absorption determinations were made, as far as practicable, in accordance with A.S.T.M. specifications (methods of sampling and testing concrete masonry units C140-39). Because the compressive testing machine used was equipped only with 8½" x 8½" face plates, blocks were sawed in two with an aluminum-oxide cut-off saw and tested as 8" x 8" x 8" units.



A



B

A. Microphotograph of scoria from Isleta deposit. X 12.  
B. Photograph of scoria from several deposits.

# MATERIALS INVESTIGATED

## PUMICE

### GRANTS DEPOSIT, VALENCIA COUNTY

The material sampled was a jig-tailing, a by-product from the mill of the Pumice Corporation of America at Grants. It runs from 1-inch mesh to fines in size. Over 60 percent is pumice; the remainder is mainly obsidian and scoria. Crushed to minus 3/4-inch mesh, loose and dry, the material weighs 1,400 pounds per cubic yard. The pumice is white and fine-grained and is of excellent quality.

A sample which had been screened to minus 1/2-inch mesh was divided into two parts. One of these was run through rolls set at 1/4 inch. The two sizes were combined to make up a concrete aggregate. The sieve analysis of this aggregate follows.

#### *Sieve Analysis of Prepared Grants Pumice*

| Sieve number     | No. 3   | No. 4     | No. 8     | No. 28    | No. 48    | No. 100    |
|------------------|---------|-----------|-----------|-----------|-----------|------------|
| Size designation | 3/8 in. | 0.263 in. | 0.185 in. | 0.093 in. | 0.023 in. | 0.0116 in. |
| Percent passing  | 94      | 80        | 67        | 48        | 22.5      | 17         |
| sieves           | 80      | 67        | 48        | 22.5      | 17        | 14         |

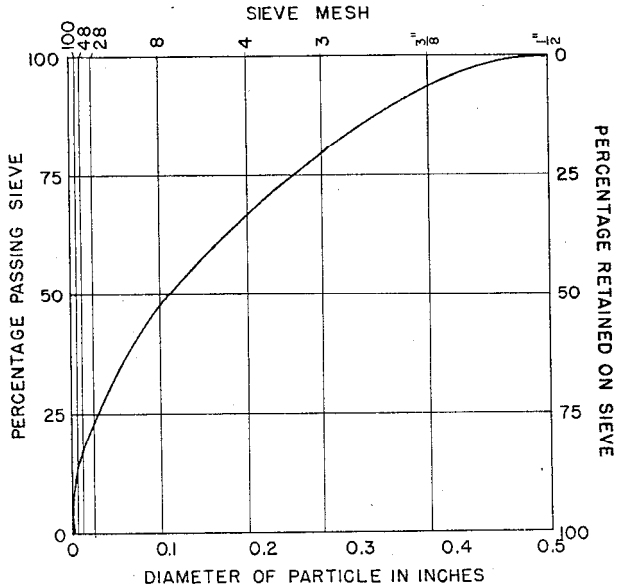


FIGURE 1. Sieve analysis of prepared Grants pumice.

Test blocks (Plate 4A) were made by using 1 part port-land cement to 6 parts aggregate by volume. Properties of the resulting blocks are given below.

|  |            |
|--|------------|
| Compressive strength at 14 days -----        | 730 p.s.i. |
| Compressive strength at 28 days              | 755 p.s.i. |
| Average weight of 8" x 8" x 16" hollow block | 24 lbs.    |
| Percentage absorption by weight -----        | 12.9%      |

Blocks with these properties are satisfactory for building purposes. Blocks made with a cement-to-aggregate ratio of 1 to 8 tested only 540 p.s.i. at 28 days.

#### SAN ANTONIO DEPOSIT, SOCORRO COUNTY

Talmage and Wootton<sup>2</sup> have described this deposit as follows.

This deposit lies about three-quarters of a mile east of the side road that branches north from U. S. Highway 380 at the San Pedro school house, directly across the Rio Grande from San Antonio. From a point on this side road about 1½ miles north of the highway, the pumicite can be seen about a quarter of a mile to the east in a bold westward-facing bluff about 50 feet high. The lower slopes of this bluff are of reddish unconsolidated clay, and the pumicite forms a white cliff near the top of the bluff. Above the pumicite is a layer of volcanic agglomerate containing large rounded pebbles of leached pumice stone.

The outcrop of pumicite extends for about 1,200 feet north and south, and can be followed eastward in two ravines for about 300 feet, where it is apparently cut off by a fault. North of the ravine that cuts through this deposit, the pumicite has an average thickness of about 2 feet, with a maximum thickness of 4 feet at the southeast corner of the northern block. The block south of this ravine is roughly 100 yards square, and the pumicite is exposed on two sides with a thickness of 3 to 5 feet. Probably something less than half of this southern block is of workable thickness.

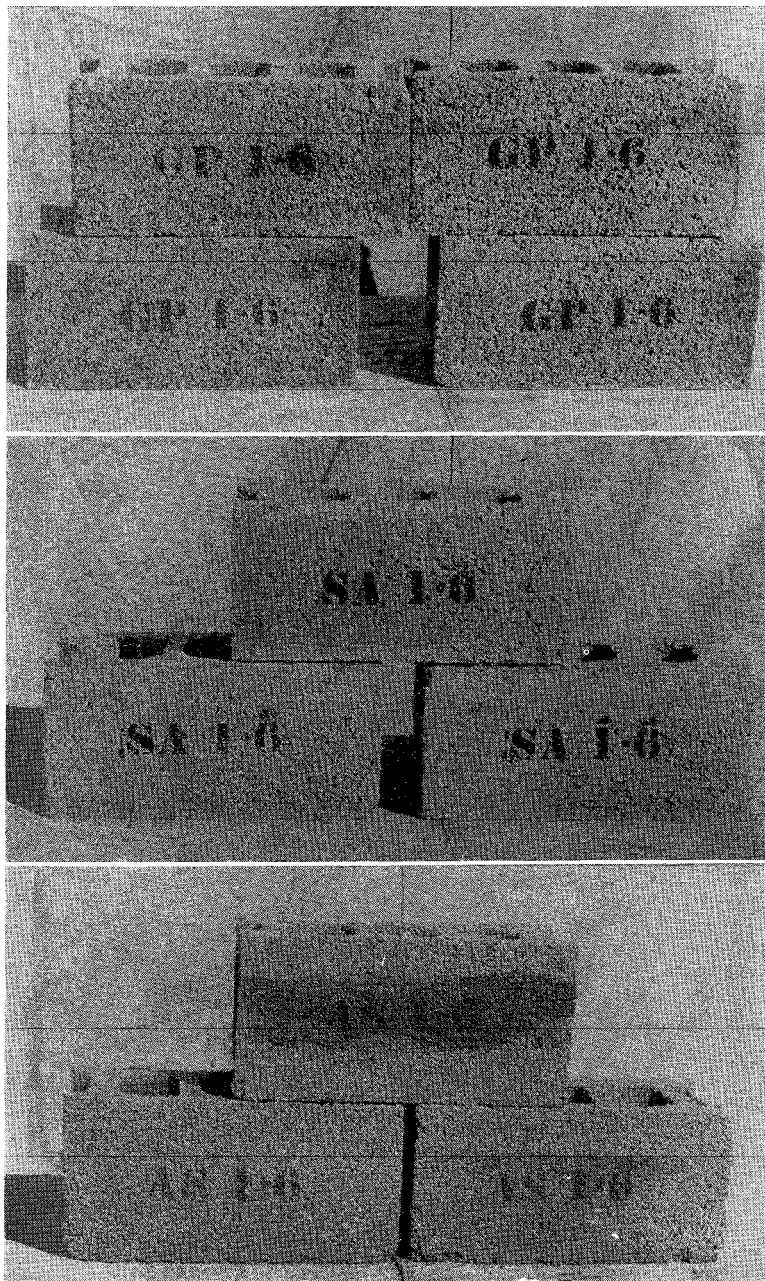
The volcanic agglomerate covers the pumicite bed to a thickness of 2 to 6 feet. The cemented fragments of pumice in the agglomerate range from 8 inches in diameter to fine sand. The pumice is a light tan soft coarse-grained material. It is necessary to crush and roll it to produce an aggregate for concrete masonry units. Such material weighs, dry and loose, 910 pounds per cubic yard.

The sample was prepared by breaking up the large pieces of the agglomerate with a hammer and passing them through a jaw crusher and rolls set at ¼ inch. This procedure gave an aggregate sized as follows.

##### *Sieve Analysis of Prepared San Antonio Pumice*

| Sieve number           |         | No. 3 | No. 4 | No. 8 | No. 28 | No. 48 | No. 100 |
|------------------------|---------|-------|-------|-------|--------|--------|---------|
| Size designation       | 3/8 in. | 0.263 | 0.185 | 0.093 | 0.023  | 0.0116 | 0.0058  |
|                        |         | in.   | in.   | in.   | in.    | in.    | in.     |
| Percent passing sieves | 96      | 91    | 75    | 47    | 22     | 16     | 12      |

<sup>2</sup> Talmage, S.B., and Wootton, T. P., The non-metallic mineral resources of New Mexico and their economic features : N. Mex. School of Mines, State Bur. Mines and Min. Res. Bull. 12, p. 136, 1937.



Top (A). Blocks made from Grants pumice.  
Middle (B). Blocks made from San Antonio pumice.  
Bottom (C). Blocks made from Isleta scoria.

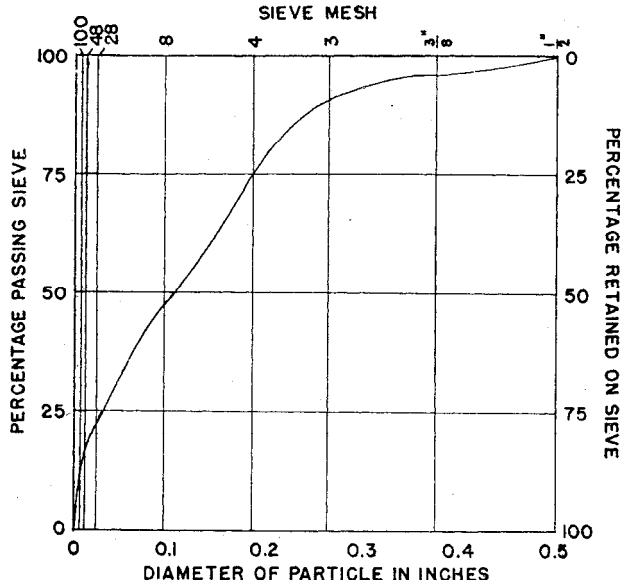


FIGURE 2. Sieve analysis of prepared San Antonio pumice.

Blocks were made of this material using portland cement and aggregate with the ratios of 1 to 6, 1 to 8, and 1 to 10. None of these mixtures produced a block of required strength. The best of these, was the 1-to-6 mixture (Plate 4B), which had the following properties.

- Compressive strength at 14 days -----459 p.s.i.
- Compressive strength at 28 days -----514 p.s.i.
- Average weight of block -----23 lbs.
- Percentage absorption by weight -----17.2%

It is doubtful that a block of required strength could be made from this aggregate alone. A mixture of 1 part portland cement, 2 parts hard sharp sand, and 4 parts pumice aggregate would probably make a satisfactory hollow masonry unit.

VALLE MOUNTAINS DEPOSITS, SANDOVAL AND RIO ARRIBA COUNTIES

This vast area of pumice beds includes deposits that extend from north of Jemez east to Cochiti and northward along the slopes of the Valle Mountains to within a few miles west of Espanola. In this large district there are thousands of acres of beds of excellent pumice aggregate, some of which are as much as 50 feet in thickness. This material is being shipped by truck and by rail to all parts of the State, as well as to Texas and Colorado. The pumice occurs as uncemented, unconsolidated beds of



small rounded fragments ranging in size from 1 inch in diameter to sand. There is generally very little overburden above the pumice and practically no foreign matter mixed with it. The pumice is white to light tan in color and has a very fine cellular structure (Plate 2, A and B).

Samples from several localities of the district averaged in weight, damp and loose as they came from the pits, 1,140 pounds per cubic yard. Dry and loose these samples had an average weight of 850 pounds per cubic yard.

The pebble pumice is being used extensively just as it comes from the pits or in some instances by screening out the small percentage of oversize. Usually ordinary sand is added to the pumice at a ratio of about 1 to 2. This, although making a denser and stronger block with a minimum amount of cement, undoubtedly detracts appreciably from the insulating properties of the pumice and adds to the weight of the block.

Aggregate for test blocks was obtained by screening minus 3/8-inch material from the pit-run pebble pumice. Sieve analysis of this material follows.

| Sieve number     | No. 3   | No. 4 | No. 8 | No. 28 | No. 48 | No. 100 |
|------------------|---------|-------|-------|--------|--------|---------|
|                  | 3/8 in. | 0.263 | 0.185 | 0.093  | 0.023  | 0.0116  |
| Size designation | in.     | in.   | in.   | in.    | in.    | in.     |
| Percent passing  | 100     | 96    | 89    | 69     | 16.5   | 8.5     |

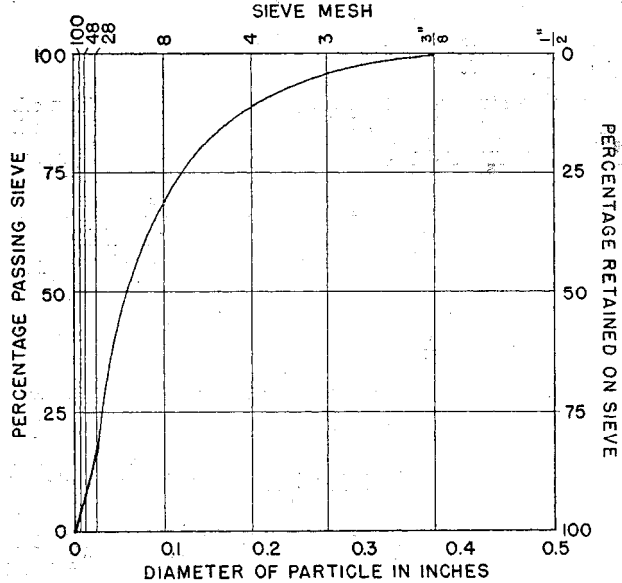


FIGURE 3. Sieve analysis of prepared Valle Mountains pumice.

Test blocks were made, using three different mixtures: 1 part of hydroplastic cement to 6 parts of aggregate; 1 part of ordinary portland cement to 6 parts of aggregate; 1 part of ordinary portland cement to 8 parts of aggregate. All measurements were by volume. The first two of the above mixtures produced blocks having, the following physical properties.

*Hydroplastic cement 1 to 6 ratio*

|   |              |
|---|--------------|
| Compressive strength at 14 days -----           | 1,062 p.s.i. |
| Compressive strength at 28 days -----           | 1,139 p.s.i. |
| Average weight 8" x 8" x 16" hollow block ----- | 24 lbs.      |
| Percentage absorption by weight -----           | 10.8%        |

*Ordinary portland cement 1 to 6 ratio*

|   |            |
|---|------------|
| Compressive strength at 14 days -----           | 596 p.s.i. |
| Compressive strength at 28 days -----           | 801 p.s.i. |
| Average weight 8" x 8" x 16" hollow block ----- | 23¼ lbs    |
| Percentage absorption by weight -----           | 12.4%      |

The first of these was an excellent, smooth, strong block (Plate 5B). The second was a good block (Plate 5A) but it did not have the smooth appearance or the high strength of the preceding block.

The 1-to-8 mix with ordinary portland cement did not have adequate compressive strength, and the absorption was over the permissible maximum of 15 percent.

## SCORIA

### ADEN-AFTON DEPOSITS, DONA ANA COUNTY

These deposits are in a series of volcanic cones that lie south of the Southern Pacific Railroad and extend from a few miles northwest of Aden southeastward beyond Afton. The material sampled was taken from a scoria pit in a cone about 250 feet high and over ¼ mile in diameter, in sec. 9, T. 25 S., R. 3 W., ½ miles southwest of Aden. The pit has been worked for a number of years and the scoria has been used in lightweight concrete at El Paso.<sup>3</sup> The pit is at present being operated by an El Paso company for the manufacture of bricks.

The deposit is made up of scoria fragments ranging in diameter from 6 inches to sand size. Rolled to minus ¾-inch mesh, the material when dry and loose weighs approximately 1,100 pounds per cubic yard. The scoria, which is black to dark brown, is an aphanitic basalt; the cellular structure is fine. Most of the material in the deposit is fine enough in size that preliminary crushing would probably be unnecessary; rolls would be capable of sizing the material satisfactorily for a masonry-unit aggregate.

<sup>3</sup> Talmage, S. B., and Wootton, T. B., op. cit., p. 16.

A sample was passed through rolls set at  $\frac{3}{8}$  inch. A sieve analysis of the product follows.

*Sieve Analysis of Prepared Aden Scoria*

| Sieve number           | No. 3 | No. 4 | No. 8 | No. 28 | No. 48 | No. 100 |
|------------------------|-------|-------|-------|--------|--------|---------|
| Size designation       | 0.263 | 0.185 | 0.093 | 0.023  | 0.0116 | 0.0058  |
|                        | In.   | in.   | in.   | in.    | in.    | in.     |
| Percent passing sieves | 97    | 93    | 83    | 51.5   | 23.5   | 14      |
| Preferable sizing      | 97    | 93    | 83    | 67     | 35     | 14      |

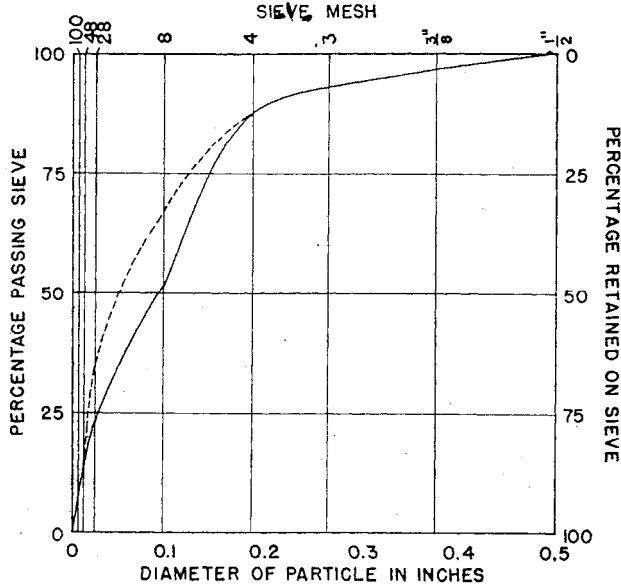
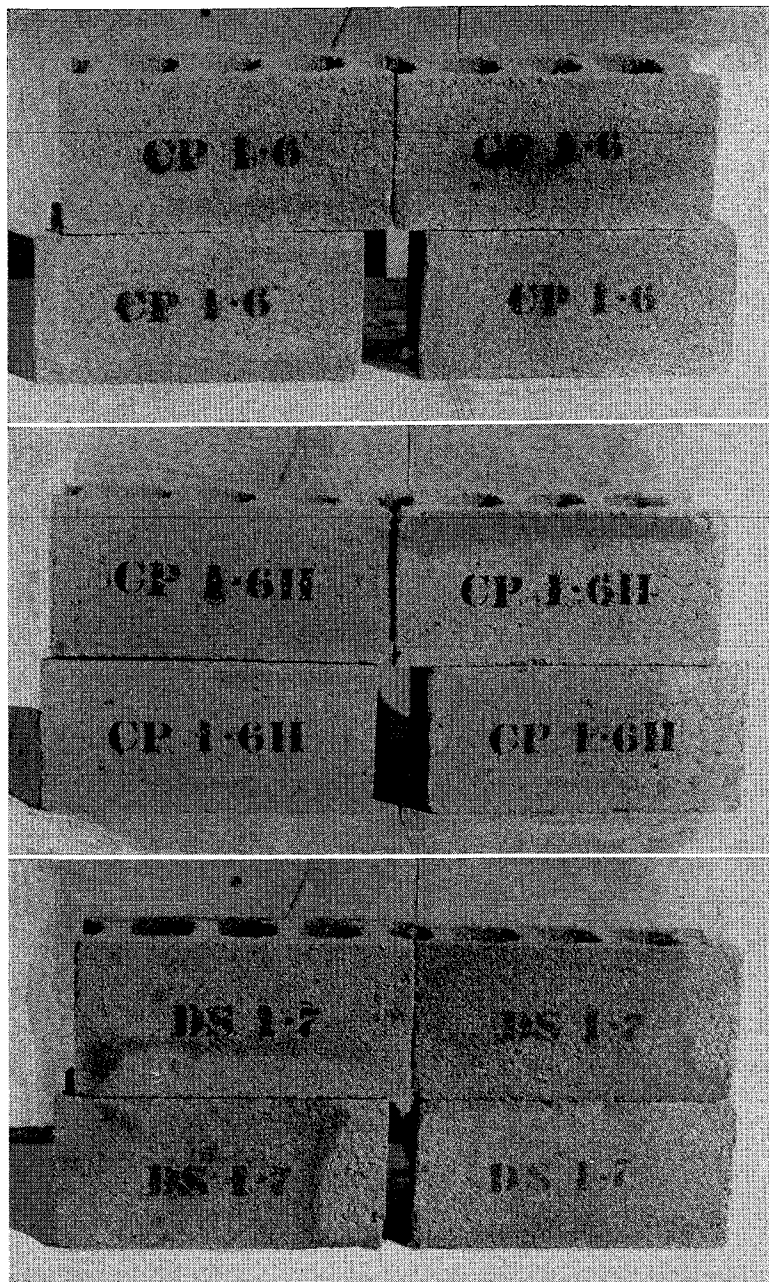


FIGURE 4. Sieve analysis of prepared Aden scoria.

The test blocks (Plate 4C) were made with 1 part portland cement to 6 parts aggregate by volume. They showed the following properties.

- Compressive strength at 14 days ----- 407 p.s.i.
- Compressive strength at 28 days ----- 390 p.s.i.
- Average weight of 8" x 8" x 16" hollow block-----28 T.S.
- Percentage absorption by weight ----- 8.2%

The low compressive strength was not the fault of the aggregate, for in every instance the concrete failed around the aggregate. This failure resulted from insufficient fines between 8 and 48 mesh (see Fig. 4); because of this lack of fines the mix had to be made very dry in order for the wet blocks to stand when removed from the mold. Consequently the mixture was too dry to make a high-strength concrete. If mixed wetter, with a higher proportion of fines, this aggregate should yield excellent blocks.



Top (A). Blocks made from Valle Mountains pumice, using ordinary portland cement.  
Middle (B). Blocks made from Valle Mountains pumice, using hydroplastic cement.  
Bottom (C). Blocks made from Capulin scoria.

## DEPOSITS NEAR CAPULIN CRATER, UNION COUNTY

These deposits consist of numerous cinder cones in north-western Union County. The pit sampled is in a cone about 200 feet high and about 0.3 mile in diameter. The site is in sec. 29, T. 30 N., R. 29 E., just west of State Highway 72. The pit is on the Colorado and Southern Railroad, which has been using the cinders for several years as railroad ballast. Several carloads were also used in Amarillo, Texas, for the manufacture of lightweight concrete masonry units. The scoria is scraped from the hillside by a tractor and loaded into railroad cars by means of a diesel shovel.

The deposit consists of scoria fragments ranging in diameter from 4 inches to sand size. Rolled to minus 3/8-inch mesh the material weighs, when dry and loose, approximately 1,000 pounds per cubic yard. The scoria, which is a basic glass, is brick red in color. The cellular structure is medium fine. Most of the material composing the cone is small enough in size to be rolled as it comes from the pit. If sand were used with the concrete mixture, rolling would probably be unnecessary and the only preparation needed would be to screen out the oversize.

The sampled material was passed through rolls set at 3/8 inch. The sieve analysis follows (see also Fig. 5).

*Sieve Analysis of Prepared Capulin Crater Scoria*

| Sieve number     | No. 3   | No. 4 | No. 8 | No. 28 | No. 48 | No. 100 |
|------------------|---------|-------|-------|--------|--------|---------|
| Size designation | 3/8 in. | 0.263 | 0.185 | 0.093  | 0.02   | 0.0116  |
| Percent passing  | in.     | in.   | in.   | 3      | in.    | in.     |
| sieves           | 100     | 97    | 90    | 65     | 37     | 25      |
|                  |         |       |       |        |        | 16      |

The test blocks were mixed with 1 part of portland cement to 7 parts of aggregate by volume. The blocks showed the following properties.

|  |                 |
|--|-----------------|
| Compressive strength at 14 days              | -----274 p.s.i. |
| Compressive strength at 28 days              | -----373 p.s.i. |
| Average weight of 8" x 8" x 16" hollow block | 22½ lbs.        |
| Percentage absorption by weight              | -----16.8%      |

Under compression the blocks (Plate 5 C) crumbled rather than fractured. The concrete failed both around and through the aggregate. It is doubtful that an ordinary small block machine could produce a hollow concrete block of required strength from this scoria as the only aggregate. The scoria itself does not appear to have sufficient strength; furthermore it is so glassy and smooth that ordinary cement does not adhere and mix with it properly. A more adhesive cement used with a ratio of 2 parts of hard sharp sand and 4 parts of this scoria would probably produce a satisfactory lightweight building block.

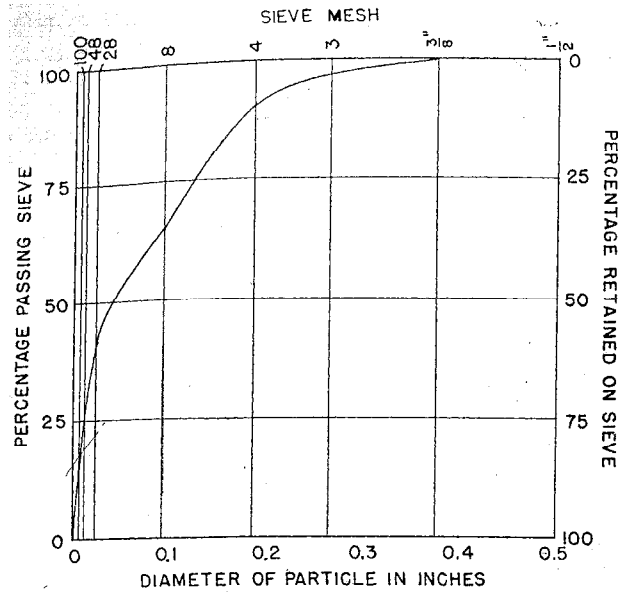


FIGURE 5. Sieve analysis of prepared Capulin Crater scoria.

#### CINDER MOUNTAIN DEPOSIT, VALENCIA COUNTY

The great cinder cone that is known locally as Cinder Mountain is the largest single scoria deposit that was sampled. The cone is over 500 feet in height and about a mile in diameter. It is located in sec. 14, T. 9 N., R. 12 W., 23 miles southwest of Grants on State Highway 53. Scoria from pits along the highway is trucked to Grants where it is used in the manufacture of lightweight hollow building-blocks.

Most of the cone appears to be composed of fragments of scoria averaging about  $\frac{1}{4}$  inch in diameter and ranging from 1 inch to the size of fine sand. The scoria fragments in some parts of the deposit are coarser than in other parts thus coarse material and fines could be selected in such a way that an excellent aggregate could be obtained merely by screening. The aggregate from the pit, damp and loose, weighs about 1,300-pounds per cubic yard; dry and loose it weighs 1,050 pounds per cubic yard. The scoria is a hard tough black basic glass with a fine even cellular structure.

The sample was passed twice through the rolls set at  $\frac{3}{8}$  inch in order to obtain sufficient fines. The product showed the following sieve analysis.

*Sieve Analysis of Prepared Cinder Mountain Scoria*

| Sieve number           | No. 3   | No. 4 | No. 8 | No. 28 | No. 48 | No. 100 |
|------------------------|---------|-------|-------|--------|--------|---------|
|                        | 3/8 in. | 0.263 | 0.185 | 0.093  | 0.023  | 0.0116  |
| Size designation       |         | in.   | in.   | in.    | in.    | in.     |
| Percent passing sieves | 100     | 94    | 80    | 36     | 8      | 4       |
| Preferable sizing      | 100     | 94    | 80    | 50     | 20     | 10      |

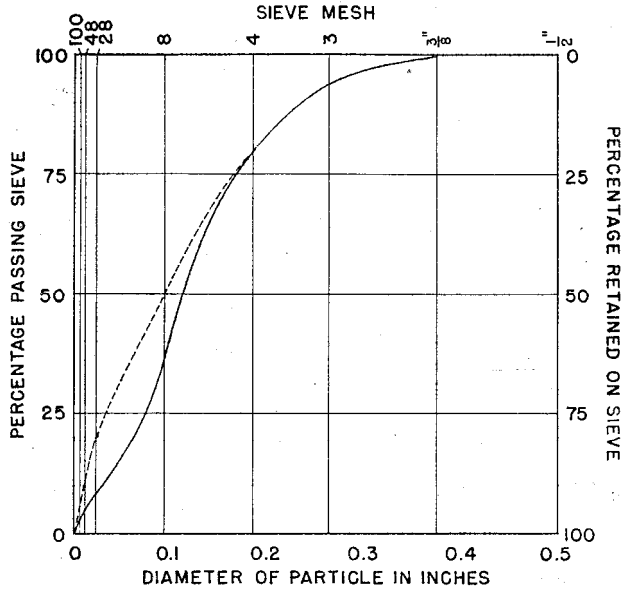


FIGURE 6. Sieve analysis of prepared Cinder Mountain scoria.

Blocks were made of a mixture of 1 part portland cement to 6 parts of aggregate by volume. These blocks (Plate 6A), which are considered of excellent quality, had, the following properties.

- Compressive strength at 14 days ----- 880 p.s.i.
- Compressive strength at 28 days ----- 1,092 p.s.i.
- Average weight of 8" x 8" x 16" hollow block----- 29½ lbs.
- Percentage absorption by weight-----9.3%

DEPOSIT NEAR ELEPHANT BUTTE, SIERRA COUNTY

This volcanic cone is located in secs. 11 and 15, T. 14 S., R. 3 W. It is 2 miles south of State Highway 52 from a point 5 miles east of Elephant Butte. There is no regular road to this deposit but it may easily be reached by automobile as the terrain approaching it is relatively smooth and the vegetation is sparse. The cone is about 200 feet in height and about ½ mile in diameter. It is not composed entirely of scoria. The core of the cone is a dense black basalt that was capped with scoria. The scoria has

been eroded down the sides of the cone and covers the surface on the slopes and at the base to a depth of from 1 to 4 feet. The area covered with scoria is probably about 1 square mile. The material ranges in size from 1 foot to 1 inch in diameter. Crushed and rolled to minus 1/2-inch the aggregate, dry and loose, weighs about 1,400 pounds per cubic yard. This reddish brown scoria is a coarse-grained basalt having a coarse to fine cellular structure. It was the toughest material sampled.

In preparing this material for concrete aggregate, the scoria was passed through the jaw crusher and then through rolls set at 3/8 inch. Two passes through the rolls were necessary to obtain sufficient fines. The sieve analysis of the product ran as follows.

*Sieve Analysis of Prepared Elephant Butte Scoria*

| Sieve number           | No. 3   | No. 4     | No. 8     | No. 28    | No. 48    | No. 100    |
|------------------------|---------|-----------|-----------|-----------|-----------|------------|
| Size designation       | 3/8 in. | 0.263 in. | 0.185 in. | 0.093 in. | 0.023 in. | 0.0116 in. |
| Percent passing sieves | 95      | 78        | 64        | 41        | 16        | 9.5        |

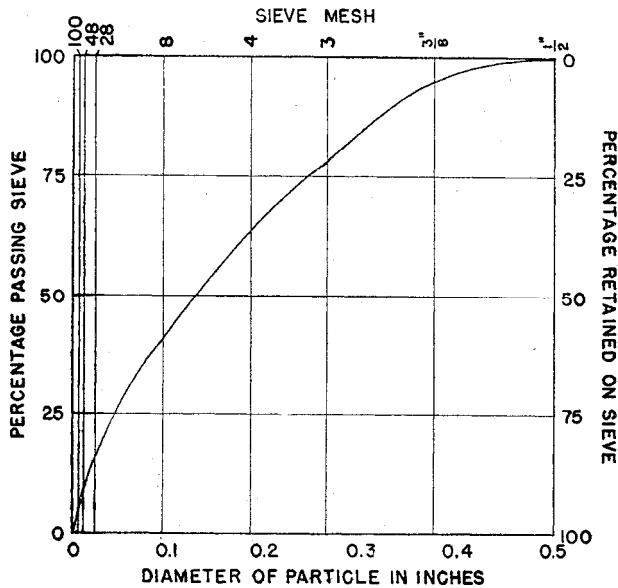


FIGURE 7. Sieve analysis of prepared Elephant Butte scoria.

The test blocks were made of a mixture of 1 part air-entraining portland cement to 6 parts of aggregate by volume.

|  |            |
|--|------------|
| Compressive strength at 14 days              | 672 p.s.i. |
| Compressive strength at 28 days              | 745 p.s.i. |
| Average weight of 8" x 8" x 16" hollow block | 29½ lbs.   |
| Percentage absorption by weight              | 11.1%      |



The concrete failed mostly through the aggregate. This material made a good block (Figure 6B), but a crushing plant would be necessary to prepare the material for use as a concrete aggregate.

#### ISLETA DEPOSITS, BERNALILLO COUNTY

There are several cinder cones in this area, which is in T. 8 N., R. 1 E., on the Isleta Indian Reservation. The cones, 10 to 12 miles west of the village of Isleta, are reached by a road which leads west from U. S. Highway 85 just south of the village. Two cones in the vicinity are producing scoria at present. One is leased and operated by Edgar D. Otto & Son of Albuquerque. This deposit is about 150 feet in height and about 1,000 feet in diameter. The material of the cone is loaded by a tractor with blade into a bin from which it is dumped into trucks and hauled to the block plant in Albuquerque to be crushed, rolled and screened for use as masonry-unit aggregate. The second cone is located about 2 miles southeast of the Otto deposit. The material is rolled at the pit and trucked to Albuquerque as lightweight aggregate.

These deposits are cones of scoria fragments which range in size from 5 inches in diameter to fine sand. The scoria is a hard tough black aphanitic basalt. The cellular structure (Plate 3 A) is medium to fine. Crushed and rolled as an aggregate, the material, dry and loose, weighs about 1,400 pounds per cubic yard.

Aggregate for blocks was obtained from the plant of Edgar D. Otto & Son. The sieve analysis is as follows (see also Fig. 8).

#### *Sieve Analysis of Prepared Isleta Scoria*

| Sieve number     |         | No. 3 | No. 4 | No. 8 | No. 28 | No. 48 | No. 100 |
|------------------|---------|-------|-------|-------|--------|--------|---------|
| Size designation | 3/8 in. | 0.263 | 0.185 | 0.093 | 0.023  | 0.0116 | 0.0058  |
| Percent passing  |         | in.   | in.   | in.   | in.    | in.    | in.     |
| sieves           | 91      | 85    | 75    | 53    | 30     | 22     | 15      |

Three sets of test blocks were made with this material—one set using hydroplastic cement at a ratio of 1 to 6, another using regular portland cement at the same ratio, and a third using regular portland cement at a ratio of 1 to 8. Properties of the first two sets were as follows.

#### *Hydroplastic cement 1 to 6 ratio*

|  |       |              |
|--|-------|--------------|
| Compressive strength at 14 days              | ----- | 1,024 p.s.i. |
| Compressive strength at 28 days              | ----- | 1,024 p.s.i. |
| Average weight of 8" x 8" x 16" hollow block | ----- | 31 lbs.      |
| Percentage absorption by weight              | ----- | 10.4%        |

#### *Ordinary portland cement 1 to 6 ratio*

|  |       |            |
|--|-------|------------|
| Compressive strength at 14 days              | ----- | 707 p.s.i. |
| Compressive strength at 28 days              | ----- | 817 p.s.i. |
| Average weight of 8" x 8" x 16" hollow block | ----- | 29¾ lbs.   |
| Percentage absorption by weight              | ----- | 11.7%      |

## MATERIALS INVESTIGATED

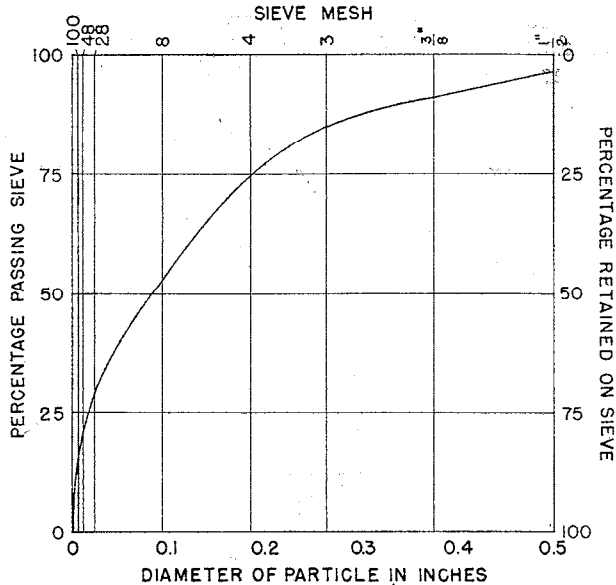


FIGURE 8. Sieve analysis of prepared Isleta scoria.

The first of these was an excellent, smooth, strong block. The test showed it to attain maximum strength at 14 days. The second was also an excellent block (Plate 6C)

Blocks made with a mixture ratio of 1 to 8 did not quite come up to the required strength.

## OTHER SCORIA DEPOSITS

Several deposits were investigated and sampled but no test blocks were made of the materials at these localities.

A deposit of scoria is located in Union County,  $3\frac{1}{2}$  miles southwest of the town of Mt. Dora in sec. 17, T. 26 N., R. 32 E. The pit was once owned by the Santa Fe Railway and the cinder was used for railroad ballast. The deposit is a large mound about 75 feet in height and about 1,000 feet in diameter. The pieces of scoria which form this mound are from 4 inches to  $\frac{1}{2}$  inch in diameter. Crushing and rolling would be necessary to prepare the scoria for use as a concrete block aggregate. The material would weigh approximately 1,500 pounds per cubic yard.

Little Black Peak is a cinder cone that lies in the north central part of the lava flow west of Carrizozo. The peak is on unsurveyed land  $10\frac{1}{2}$  miles north-northwest of Carrizozo. It is about 100 feet in height and about 400 feet in diameter. North of this main cone is a ridge of cinder 250 feet long, about 100 feet wide, and nearly 50 feet high. The material composing these masses seems to be rounded pebbles of scoria that average about



Top (A). Blocks made from Cinder Mountain scoria.  
Middle (B). Blocks made from Elephant Butte scoria.  
Bottom (C) Blocks made from Isleta scoria.

1 inch in diameter. The scoria is black to brown in color and finely cellular in structure. Crushed and rolled as a block aggregate it weighs about 1,150 pounds Per cubic yard. Because of the exceedingly rugged nature of the lava flow surrounding the cone it is doubtful that it would be economically possible to build a road to this deposit.

Two other probable deposits of suitable scoria in the vicinity of Carrizozo are located in sec. 35, T. 5 S., R. 8 E., in Socorro County. One of these cones, mapped as Broken Back Crater, is just south of State Highway 146. This and another crater are described as the "Cerros Prietos" by Meinzer and Hare.<sup>4</sup>

The two volcanic cones of the older lava bed "(the Cerros Prietos...)" stand at the east edge of the Chupadera Plateau, about 6 miles west of the north end of the younger bed [lava flow of Carrizozo] and are less than a mile apart. The rim of the crater of the northwest cone is 250 to 300, feet above the general level of the plateau, nearly 1,000 feet above the plain at the southeast base of the older lava, and nearly 6,500 feet above sea level. The top of the southeast cone is 50 to 100 feet lower. The north-west cone is the larger of the two, but both are much larger than the younger cone [Little Black Peak].

The southeast cone, which stands somewhat more than 100 feet above the surrounding surface, is very symmetrical and exhibits a smooth cinder-covered surface, except in one locality on its southwest flank where it has been cut open by recent erosion. It is crowned by a saucer-shaped crater about 500 feet in diameter and 10 to 15 feet deep.

In referring to the terrain in the vicinity of these cones Meinzer and Hare state (p. 37):

"The surface of the old lava bed is not nearly so rough as that of the younger [Carrizozo lava] bed. In most places it is possible to drive across it with a wagon. . . ."

A deposit is described<sup>5</sup> as being located in Catron County, 18 miles west of Quemado and 3 miles south of U. S. Highway 60. The deposit is said to be a cinder cone 300 to 400 feet in height and nearly a mile in diameter. The fragments of red scoria that make up this deposit are 1 foot in diameter and smaller. Samples from this deposit made up into very good concrete building blocks.

A hill of solid scoria is located on the Mora Land Grant in Mora County, 8½ miles northwest of Wagon Mound and ½ mile north of State Highway 120. This is a finely cellular scoria having a pleasing red color. Two houses have been built in Wagon Mound of fragments of the material and it is also used in that district for building rockeries and fireplaces. To be used for concrete masonry units, the scoria would have to be blasted, crushed, and rolled. As an aggregate of minus ¾-inch mesh this

<sup>4</sup> Meinzer, O. E., and Hare, R. F., Geology and water resources of Tularosa Basin, New Mexico ; U. S. Geol. Survey Water-Supply Paper 343, p. 39, 1915.

<sup>5</sup> Oliver, Carl, oral communication.

material would weigh, dry and loose, around 1,100 pounds per cubic yard.

A fine red lightweight scoria is reported<sup>6</sup> to have been obtained from a large deposit below Antonita, 6 miles south of the Colorado border and east of U. S. Highway 285. This scoria would require crushing and rolling to obtain proper sizing.

### CONCLUSIONS

In general a mixture of 1 part of portland cement to 6 parts of aggregate by volume gave a block of required strength. A great deal of the variation in the strength of the blocks is dependent upon the thoroughness of mixing, the sizing of the aggregate, and the amount of water used. As stated previously, the trough-type mixer gives the most thorough mixing with lightweight aggregates,. In making most of the blocks in this testing program, it was found that the aggregate did not contain sufficient fines between 4 and 48 mesh. Around 75 percent by weight of minus 4-mesh material would probably be advisable. In mixing ordinary concrete, it has been proved that a "dry mix" produces a stronger concrete than a "wet mix". However, in casting vibrated blocks of lightweight concrete, a mix of ordinary concrete considered "dry" would be found to be a "wet" mix for block-making. For that reason it seems that a mixture as wet as possible that will produce a true block without slump would take advantage of the maximum strength of the cement added. By experimenting with sizing of aggregate and amount of water, and with thorough mixing, blocks of standard quality could probably be produced from most of the materials mentioned in this bulletin by using a 1 to 7 ratio concrete.

New Mexico is fortunate in having distributed over the greater part of the State large quantities of lightweight aggregates suitable for concrete building units. There are many opportunities for persons in the growing building industry, not only in the manufacture of blocks but also in their production and distribution. Individual block-plant operators hesitate to go into mining, crushing, screening, and hauling aggregate, and therefore either use whatever material is immediately at hand or have suitable material shipped from some distant locality at high cost. Several well-located crushing and screening plants distributed throughout the State would be of advantage to everyone concerned in the building industry.

<sup>6</sup>Pratt, Wm. K., oral communication.

## APPENDIX

### SECURING LEASES ON STATE LAND

#### RULES OF GENERAL APPLICATION TO ALL MINERAL LEASES OTHER THAN OIL AND GAS

1. Applications for leases for any form of deposit or minerals on State Lands other than oil and gas must be made under oath of the applicant or his authorized agent or attorney or an officer of the corporation, if the applicant be a corporation, on forms prescribed by the Commissioner of Public Lands. An application fee of Five Dollars (\$5.00) for each application will be charged in each case.

2. Monthly reports of operations, production, and sales of minerals or materials produced will be required of lessees in all cases, and all leases will provide for inspection by the Commissioner of Public Lands or his authorized agent at all reasonable times, of the records and books of account of lessees, pertaining to the mining, extraction, transportation, production, returns, and sales of all ores or materials taken from the leased lands.

3. A bond in such sum as the Commissioner may in each case prescribe, executed by the lessee with satisfactory surety will be required in all cases before lease is issued.

4. Where mining leases cover lands sold with a reservation in contract or deed of the minerals to the state, the lessee before commencing development or operations thereon will be required to file with the Commissioner a sufficient bond in the sum of not less than \$2,000.00 in favor of the State of New Mexico for the use and benefit of the purchaser holding purchase contract or deed, his successors and assigns in interest to secure the payment for such damage to the livestock, range, water, crops, or tangible improvements on such lands as may be suffered by such purchaser, his successors or assigns in interest, by reason of the mining, development, operation and use of the lands by the mineral lessee. However, if any such purchaser shall file with the Commissioner of Public Lands a duly executed and acknowledged waiver of his right to require such bond, the mining operations may be permitted without the bond above required.

5. All mining leases or prospecting permits will contain such general provisions and requirements in addition to those prescribed by Statute and specified in these regulations as the Commissioner may deem to be right, necessary, and proper in each case. Form of application for lease will be furnished upon request. The Commissioner of Public Lands in his discretion may require applicants to furnish additional information other than that supplied by the application, by way of appraisements,

reports and affidavits in any case where he shall deem it necessary or expedient so to do.

The foregoing regulations are of general application, and additional information and requirements will be found herein-after set out under rules and regulations pertaining to particular minerals and forms of deposit.

#### ASSIGNMENTS OF PROSPECTING PERMITS AND LEASES

Assignments of prospecting permits and leases will be allowed and approved in the discretion of the Commissioner of Public Lands. Assignees will be required to furnish new bond or procure consent of the surety on the bond of the lessee' to remain bound, notwithstanding the assignment. Assignments should be executed in duplicate and filed with the Commissioner of Public Lands, accompanied by a fee of Five Dollars (\$5.00). Assignments must show the marital status of the assignor and if married, both spouses must join in the assignment and the certificate of acknowledgment must show the marital relationship of the parties. After approval, one copy of the assignment will be filed in the State Land Office and the other returned to the assignee.

#### RULES ESPECIALLY APPLICABLE TO SCORIA, PUMICITE, ETC.

1. Leases will be issued for State lands containing one or more of the forms of deposit above mentioned or other bedded deposits of value in legal subdivisions upon proper application therefor by any qualified applicant and the payment of the required fees and rentals.

2. An annual rental charge of Twenty-Five Dollars (\$25.00) will be made for each forty-acre tract included in any such lease.

3. Leases will prescribe a minimum royalty of five percent (5%) of the net proceeds derived from the sale of the materials or minerals produced after treatment and transportation charges are deducted, but the Commissioner may in any case prescribe a higher rate of royalty.

4. Leases will ordinarily be made for a term of five (5) years with preference right of renewal, but the Commissioner of Public Lands may issue such leases for a term of ten (10) years and as long thereafter as the minerals or materials to be mined shall be produced in paying quantities from the leased lands.

#### NEW MEXICO BUILDING CODE SPECIFICATIONS

Specifications for hollow concrete block or tile in accordance with the "Uniform Building Code for the State of New Mexico" are as follows.<sup>7</sup>

<sup>7</sup>Uniform Building Code of the State of N. Mex., Contractor's License Board, Sec. 2402 (d), p. 113, 1945.

Hollow concrete block or tile shall conform to the requirements of A.S.T.M. "Standard Specifications for Hollow Load-Bearing Concrete Masonry Units" (C 90 - 39)

**STANDARD SPECIFICATIONS OF AMERICAN SOCIETY  
FOR TESTING MATERIALS  
HOLLOW LOAD-BEARING CONCRETE MASONRY .UNITS<sup>8</sup>**

**A.S.T.M. Designation: C 90 - 44**

ADOPTED, 1936; REVISED, 1939, 1944.

This Standard of the American Society for Testing Materials is issued under the fixed designation C 90 ; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

**Scope**

1. These specifications cover hollow load-bearing concrete masonry wall units made from portland cement and suitable aggregates such as sand, gravel, crushed stone, bituminous or anthracite cinders, burned clay or shale, and blast-furnace slag.

NOTE.--When a particular surface texture, finish, or uniformity of color is desired, these features should- be specified separately by the purchaser.

**Cinder Aggregate**

2. The combustible content present in cinder aggregate shall not exceed 35 per cent of the weight of the aggregate.

**Physical Requirements**

3. At the time of delivery to the site of the work the units shall conform to the physical requirements prescribed in Table I.

| Minimum Face<br>Shell Thickness,<br>in. | Compressive<br>Strength, min.      psi.<br>(Average Gross Area) |                    | Water<br>Absorption,<br>- max., lb. | Moisture<br>Content,<br>max., |
|---|---|--------------------|-------------------------------------|-------------------------------|
|   | Average<br>of 5<br>Units  | Individual<br>Unit | Average'<br>of 5<br>Units           | Average<br>of 5<br>Units      |
| 1¼ or over:<br>Grade A <sup>a</sup>     | 1000  | 800                | 15                                  | 40                            |
| Grade B <sup>b</sup>                    | 700   | 600                | ---                                 | 40                            |
| Under 1¼ and<br>over ¾                  | 1000  | 800                | 15                                  | 40                            |

<sup>a</sup> For use in exterior walls below grade, and for unprotected exterior walls above grade.

<sup>b</sup> For general use above grade where protected from the weather with two coats of portland cement paint or other satisfactory waterproofing treatment approved by the purchaser.

**Permissible Variations in Dimensions**

4. No over-all dimension shall vary more than 3 per cent over or under the specified dimension for any form of unit.

<sup>8</sup> A.S.T.M. Standards, Am. Soc. for Testing Materials, pp. 202-203, 1944.



**Visual Inspection**

5. (a) All units shall be sound and free from cracks or other defects that would interfere with the proper placing of the unit or impair the strength or permanence of the construction.

(b) Units that are intended to serve as a base for plaster or stucco shall have a sufficiently rough surface to afford good bond.

**Marking**

6. All units shall bear a distinctive mark of the manufacturer or shall be otherwise readily identified as to origin.

**Sampling and Testing**

7. (a) The purchaser or his authorized representative shall be accorded proper facilities to inspect and sample the units at the place of manufacture from the lots ready for delivery. At least ten days should be allowed for completion of the tests.

(b) Units shall be sampled and tested in accordance with the Standard Methods of Sampling and Testing Concrete Masonry Units (A.S.T.M. Designation: C 140) of the American Society for Testing Materials.

**Rejection**

8. In case the shipment fails to conform to the requirements, the manufacturer may sort it, and new specimens shall be selected by the purchaser from the retained lot and tested at the expense of the manufacturer. In case the second set of specimens fails to conform to the test requirements, the entire lot shall be rejected.

**Expense of Tests**

9. Except as specified in Section 8, and unless otherwise agreed, the expense of inspection and testing shall be borne by the purchaser.

**HOLLOW NON-LOAD-BEARING CONCRETE MASONRY UNITS<sup>9</sup>****A.S.T.M. Designation: C 129 - 39**

ADOPTED, 1939.

Reapproved in 1944 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation C 129; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

**Scope**

1. These specifications cover hollow non-load-bearing concrete masonry wall units made from portland cement and suitable aggregates such as sand, gravel, crushed stone, bituminous or

<sup>9</sup> Op. cit., pp. 204-205.

anthracite cinders, burned clay or shale, and blast-furnace slag.

NOTE.--When a particular surface texture, finish, or uniformity of color is desired, these features should be specified separately by the purchaser.

### **Cinder Aggregate**

2. The combustible content present in cinder aggregate shall not exceed 35 per cent of the weight of the aggregate. Physical Requirements
3. At the, time of delivery to the site of the work the units shall conform to the physical requirements prescribed in Table I.

TABLE I.—PHYSICAL REQUIREMENTS

| Compressive Strength, min., psi.<br>(Average Gross Area) |                 | Moisture Content,<br>max., percent<br>of total absorption |
|--|-----------------|---|
| Average of 5 Units                                       | Individual Unit | Average of 5 Units  |
| 350  | 300             | 40  |

### **Dimensions and Permissible Variations**

4. (a) Minimum face shell thickness shall be not less than  $\frac{1}{2}$  in.
- (b) No over-all dimension shall vary more than 3 per cent over or under the specified dimension for any form of unit.

### **Visual Inspection**

5. (a) All units shall be sound and free from cracks or other defects that would interfere with the proper placing of the unit.
- (b) Units that are intended to serve as a base for plaster or stucco shall have a sufficiently rough surface to afford good bond.

### **Marking**

6. All units shall bear a distinctive mark of the manufacturer or shall be otherwise readily identified as to origin.

### **Sampling and Testing**

7. (a) The purchaser or his authorized representative shall be accorded proper facilities to inspect and sample the units at the place of manufacture from the lots ready for delivery. At least ten days should be allowed for completion of the tests.
- (b) Units shall be sampled and tested in accordance with the Standard Methods of Sampling and Testing Concrete Masonry Units (A.S.T.M. Designation: C 140) of the American Society for Testing Materials.

**Rejection**

8. In case the shipment fails to conform to the requirements, the manufacturer may sort it, and new specimens shall be selected by the purchaser from the retained lot and tested at the expense of the manufacturer. In case the second set of specimens fails to conform to the test requirements, the entire lot shall be rejected.

**Expense of Tests**

9. Except as specified in Section 8, and unless otherwise agreed, the expense of inspection and testing shall be borne by the purchaser.

LIGHTWEIGHT AGGREGATES FOR CONCRETE<sup>10</sup>

**A.S.T.M. Designation: C 130 - 42**

ADOPTED, 1939; REVISED, 1942.

This Standard of the American Society for Testing Materials is issued under the fixed designation C 130; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

**Scope**

1. These specifications cover lightweight aggregates suit-able for use in concrete.

NOTE.—The specification limits that are not enclosed in parentheses are recommended for use when it is practicable to secure economically materials conforming to them. When it is not practicable to secure such materials economically the specification limits may be extended, but not beyond the maximum permissible limits shown in parentheses. Generally, such extension in the specification limits can be compensated for by a change in the design of the mix or by the exercise of more than the usual care in the control of the concrete during construction.

**General Characteristics**

2. (a) Lightweight aggregates shall consist of pumice, lava, tufa, slag, burned clay, burned shale, cinders derived from the high-temperature combustion of coal or coke showing a loss on ignition of not more than 25 per cent (40 per cent) and volatile matter of not more than 5 per cent, or, subject to approval by the engineer, other material having strong, durable particles and conforming to the requirements of these specifications.

(b) When approved by the engineer, for the purpose of securing the desired workability, lightweight aggregate meeting the requirements of these specifications may be mixed with a fine aggregate meeting the requirements of the Standard Specifications for Concrete Aggregates (A.S.T.M. Designation: C 33) of the American Society for Testing Materials, provided, how-ever, that the combined aggregate shall conform to all the other requirements of these specifications.

<sup>10</sup>Op. cit., pp. 428-430.

**Deleterious Substances**

3. (a) Lightweight aggregate shall not contain excessive amounts of deleterious substances. .

(b) *Organic Impurities.* —All lightweight aggregate shall be free from injurious amounts of organic impurities. Aggregates subjected to the colorimetric test for organic impurities and producing a color darker than the standard shall be rejected unless they pass the mortar strength test (Section 6), which requirement may be raised by the engineer by not more than 10 per cent.

**Grading**

4. Lightweight aggregate shall be graded from coarse to fine within the limits prescribed in Table I [page 32].

**Unit Weight**

5. Lightweight aggregate meeting the grading requirements of these specifications when tested in a dry condition shall conform to the following weight requirements:

|                        | Unit Weight, max.,<br>lb. per cu. ft. |
|------------------------|---------------------------------------|
| Fine aggregate -----   | 75                                    |
| Coarse aggregate ----- | 55                                    |

**Mortar Strength**

6. (a) Lightweight aggregate shall be of such quality that when made into a mortar and subjected to the mortar strength test (Section 8 (d)) it shall develop a compressive strength at 7 or 28 days of not less than 70 per cent (or, for concrete not exposed to wear or weather, 60 per cent) of that developed by a mortar prepared in the same manner with the same cement and the graded standard sand described in Paragraph (b) Coarse aggregate shall be reduced to the grading specified for fine aggregate before use in the mortar test.

(b) The standard sand (Note) referred to in Paragraph (a) shall be natural silica sand from Ottawa, Ill., graded as follows:

| Sieve <sup>a</sup>         | Percentage<br>Retained |
|----------------------------|------------------------|
| No. 100 (149-micron) ----- | 98 ± 2                 |
| No. 50 ( 297-micron) ----- | 72 ± 5                 |
| No. 30 ( 590-micron) ----- | 2 ± 2                  |
| No. 16 (1190-micron) ----- | none                   |

<sup>a</sup> Detailed requirements for these sieves are given in the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation : E 11).

NOTE.—Sand conforming to the above requirements may be obtained from the Ottawa Silica Co., Ottawa, Ill.

TABLE I.—GRADING REQUIREMENTS FOR LIGHTWEIGHT  
AGGREGATES

| Size Designation  | Percentages Passing Sieves Having Square Openings <sup>a</sup> |           |           |           |                           |                           |                            |                           |                            |
|-------------------|--|-----------|-----------|-----------|---------------------------|---------------------------|----------------------------|---------------------------|----------------------------|
|                   | 1 in.  | ¾ in.     | ½ in.     | ¾ in.     | No. 4<br>(4760<br>micron) | No. 8<br>(2380<br>micron) | No. 16<br>(1190<br>micron) | No. 50<br>(297<br>micron) | No. 100<br>(149<br>micron) |
| Fine Aggregate:   |  |           |           |           |                           |                           |                            |                           |                            |
| ¼ in. to dust     | ---  | -----     | -----     | 100       | 95 to 100                 | -----                     | 45 to 80                   | 10 to 30                  | 5 to 15                    |
| ¾ in. to dust     | ---  | -----     | 100       | 95 to 100 | 55 to 80                  | -----                     | -----                      | 10 to 25                  | 5 to 15                    |
| Coarse Aggregate: |  |           |           |           |                           |                           |                            |                           |                            |
| ½ in. to No. 4    | ---  | 100       | 90 to 100 | 40 to 75  | 0 to 15                   | 0 to 5                    | -----                      | -----                     | -----                      |
| ½ in. to No. 8    | ---  | -----     | 100       | 85 to 100 | 0 to 20                   | 0 to 5                    | -----                      | -----                     | -----                      |
| ¾ in. to No. 4    | 100  | 90 to 100 | -----     | 20 to 55  | 0 to 10                   | 0 to 5                    | -----                      | -----                     | -----                      |

<sup>a</sup> Detailed requirements for these sieves are given in the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation : E 11).

**Soundness**

7. Lightweight aggregate, when subjected to five cycles of the accelerated sulfate soundness test, shall lose not more than 12 per cent (15 per cent) in weight, provided, however, that an aggregate failing in this requirement may be accepted if it passes a satisfactory freezing-and-thawing test. The engineer may waive the soundness test requirement for lightweight aggregate for concrete not to be exposed to moisture.

**Methods of Sampling and Testing**

8. Lightweight aggregate shall be sampled and the properties enumerated in these specifications shall be determined in accordance with the following methods of the American Society for Testing Materials:

(a) *Sampling*—Tentative Methods of Sampling Stone, Slag, Gravel, Sand, and Stone Block for Use as Highway Materials (A.S.T.M. Designation: D 75).

(b) *Grading*.—Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates (A.S.T.M. Designation: C 136).

(c) *Unit Weight*—Standard Method of Test for Unit Weight of Aggregate (A.S.T.M. Designation: C 29), utilizing the jigging procedure described in Section 6 of Methods C 29. Unit weights shall be determined on material dried to constant weights at not less than 100 C. and not more than 120 C.

(d) *Mortar Strength*.—Standard Method of Test for Structural Strength of Fine Aggregate Using Constant Water-Cement-Ratio Mortar (A.S.T.M. Designation: C 87).

(e) *Compressive Strength*.—Standard Method of Test for Compressive Strength of Molded Concrete Cylinders (A.S.T.M. Designation: C 39).

(f) *Soundness*. Tentative Method of Test for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate (A.S.T.M. Designation: C 88).

(g) *Organic Impurities*.—Standard Method of Test for Organic Impurities in Sands for Concrete (A.S.T.M. Designation: C 40).

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