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GRANTS—HOME OF MUCH OF NEW MEXICO'S PRESSED-EARTH BLOCK INDUSTRY

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Abstract—Traditional adobes (sun-dried mud bricks) are being challenged by pressed-earth blocks, made from similar raw materials, but manufactured by hand-operated or hydraulically operated, gasoline- or diesel-powered machines. The portable pressed-earth block machines produce blocks which are uniform at least in two directions, at the construction site using local soils, and at almost any time of the year. Finished blocks can be stockpiled for later use or conveyed from the machine directly to the wall under construction.

Grants, New Mexico, is the home of two of the five manufacturers of pressed-earth block machines in the state and was where all but one of the 24 machines sold to commercial or non-commercial producers until the summer of 1988 were manufactured. These machines, together with those of other manufacturers, appear to be viable alternatives to the traditional method of adobe-brick manufacture and should be considered by commercial builders and those who wish to construct their own homes of earth materials.

INTRODUCTION

Even today, soil materials remain the primary building material for over 50% of the world's population of about five billion, and adobe structures are quite common in the American Southwest. New Mexico, both historically and up to the present day, is the largest producer and user of adobes and pressed-earth blocks. Within its borders the state contains a third of all of the adobe and similar dwellings constructed of earth materials in the United States.

Pressed-earth block machines were developed in recent years, particularly in the last five years. Of the five manufacturers located in New Mexico in the summer of 1988, two were located in the Grants, New Mexico area, and all but one of the 24 pressed-earth block machines sold to commercial or non-commercial pressed-earth block producers were built by the manufacturers located near Grants (Smith and Austin, 1989).

TERMINOLOGY AND CHARACTERISTICS

Some of the common terms in the adobe trade are:

1. Adobe brick: A sun-dried mud brick made of adobe soil that has a long history of widespread use by the Indians, Spanish and Anglo-Americans in the southwestern United States.
2. Adobe soil: A term applied to clay, silt and sand deposits usually occurring in the basin areas of the state.
3. Pressed-earth blocks: Pressed-earth blocks are manufactured from soils that are placed in a steel mold and pressed into a dense block using a machine- or hand-powered press to produce a dense block of various sizes.
4. Rammed-earth: Rammed-earth walls are built by thoroughly tamping layers of moist soil between wooden, steel or aluminum concrete-type forms. When a section of the wall is completed, the forms are moved upwards or sideways, and the process is repeated until the walls are completed.
5. Stabilizers: A material, such as asphalt emulsion, portland cement, lime or one of many other chemicals, added to soil material to increase the water resistance of the adobe brick or pressed-earth block.
6. Traditional (untreated) adobe bricks: Often referred to as an untreated, unstabilized or standard sun-dried adobe brick, the traditional adobe is made with soil composed of a mixture of clay, sand and silt. Usually straw is added to the adobe brick to prevent the brick from excessive cracking while being cured.
7. Semistabilized-adobe brick: The semistabilized adobe is classified as a water-resistant brick because of the addition of a small amount of a stabilizer, such as asphalt emulsion (3–5%). The adobe contains a sufficient amount of stabilizer to protect stockpiled adobes from local rains.
8. Stabilized-adobe bricks: The fully stabilized adobe, referred to by the New Mexico Building Code as a treated adobe, is defined by the addition of a sufficient amount of stabilizer to limit the brick's 7-day water absorption to less than 2½% by weight. The fully stabilized

adobe is usually manufactured with a 6–12% (by weight) asphalt emulsion mixture which produces a waterproof building material that resists water penetration without a protective coating.

EARTH BLOCKS

During a 1987–88 field investigation, the authors were able to locate and identify 33 commercial adobe brick producers, 28 pressed-earth block machines and their manufacturers and two rammed-earth contractors (Smith and Austin, 1989). According to one manufacturer of pressed-earth block machines (Adobe International), an ideal soil that contains about 50% sand and larger particles and 50% clay and silt produces the best pressed-earth block. A sample taken from soil material at that plant, which the manufacturer said produced a very acceptable brick, contained 9% clay-, 22% silt- and 69% sand-and-larger-(sand +)-size particles. Seven samples in a study of adobe soils by Smith and Austin (1989) from six pressed-earth block producers averaged 7% clay-, 30% silt- and 63% sand+ -size material.

The clay-size fraction (<2 µm) of the Adobe International's test soil consisted of five parts in 10 kaolinite, three parts in 10 calcium smectite, two parts in 10 illite and a trace of mixed-layer illite-smectite (I/S), plus minor amounts of calcite and quartz. The <2-µm fraction of samples from other pressed-earth block producers ranged from five to one part in 10 kaolinite, three parts in 10 to a trace calcium smectite, four to one part in 10 illite and four to one part in 10 mixed-layer I/S, plus minor calcite in all samples, quartz in all but one and feldspar in one. In general, expandable clay minerals (smectite and mixed-layer I/S) make up about 50% of the clay-size fraction in soils used by pressed-earth block manufacturers, as is true of adobe producers (Smith, 1982; Smith and Austin, 1989). The amount present of specific clay minerals themselves, however, does not seem to be highly significant.

ADOBE-BRICK PRODUCTION TECHNIQUES

The adobe-brick industry is a labor-intensive operation with the production usually limited by the number of frost-free days for that particular adobe yard. In general, the production season varies from seven to nine months. Adobe bricks are made in various sizes; the principal standard-size adobe brick used in New Mexico measures 4 × 10 × 14 inches and weighs approximately 30 lbs. A total of 29 adobe-brick manufacturers produced in 1987 a total of 3,124,000 bricks which included 879,000 traditional (untreated) bricks, 2,080,000 semistabilized bricks and 165,000 stabilized bricks.

Adobe bricks can be made in the traditional way by hand methods at the construction site, but today even on smaller building jobs the trend has been to purchase the bricks ready-made. These bricks are manufactured commercially on a large scale at various adobe yards where automatic adobe-laying machines are becoming increasingly more common. These machines, however, speed up the adobe-making process and lower labor costs.

PRESSED-EARTH BLOCK PRODUCTION TECHNIQUES

Pressed-earth block machines produce blocks that look like traditional adobe bricks in color and size in far less time than older methods. The resulting block is called a pressed-soil block in Australia (Middleton, 1987), or a pressed-earth block in New Mexico. The development of greatly improved, portable (trailer-mounted), pressed-earth block machines and accessory equipment occurred during the early 1980's. Today, five New Mexico manufacturers are producing and selling in the U.S. and on foreign markets a variety of machine models that, with a crew of two or three employees, are capable of producing several thousand blocks per day. In 1987, of 642,000 pressed-earth blocks produced in New Mexico, most were the standard $4 \times 10 \times 14$ -inch blocks that sold for prices ranging from 25 to 40 cents each and were produced at the builders homesite using local soils or soil hauled to the lot site.

A major advantage of pressed-earth block machines is their ability to produce the blocks at the construction site, where finished blocks go from the machine directly to the block layer for immediate placement. The blocks are usually placed into the wall without further drying, sometimes using only a thin mud slurry or wetting of the block surfaces for bonding.

PHYSICAL PROPERTIES OF ADOBES AND PRESSED-EARTH BLOCKS

In New Mexico, the building of structures composed of earth materials is regulated by specifications adopted from the Uniform Building Code and the New Mexico State Code. The sections of the code on unburned clay masonry state basic requirements concerning adobe brick, pressed-earth block and rammed-earth, including standards of water absorption, compressive strength and modulus of rupture, as well as construction specifications. The New Mexico code requires that an adobe brick have a compressive strength averaging 300 psi. This standard assures that all units from the tested-brick batch will resist a compressive force equal to 300 lbs for each square inch of surface area. The importance of this test for a relatively heavy material such as adobe brick is apparent when considering the great amount of weight a typical wall unit must resist.

The other major test on all types of adobe bricks, pressed-earth blocks and rammed-earth is the rupture test which requires a modulus of rupture of at least 50 psi. This test helps indicate the relative cohesion of the materials that make up the various earth blocks and the ability of the material to resist the tension and shear forces that might result from settling of foundations or wind action. Other tests are used on semi-stabilized and stabilized adobes to determine the water resistance quality of the bricks. The New Mexico State Code requires that for a treated (stabilized) adobe brick the moisture content will not exceed 4% and the water absorption will not exceed 2.5% by weight.

CURRENT PRESSED-EARTH MACHINES

Although older hydraulic machines to press soil materials were known (notably the hand-powered CINVA-Ram used by the Peace Corps and the gasoline-powered Porta Press manufactured in New Mexico) in the 1960's and 1970's in New Mexico (Smith, 1982), the 1980's were the first decade in which extensive use of engine-powered pressed-earth block machines occurred. In 1987-88, five manufacturers in New Mexico made and sold various size machines capable of producing several thousand blocks per day, usually of standard $4 \times 10 \times 14$ -inch size and averaging 38 to 40 lbs weight.

The five major active manufacturers of pressed-earth block equipment and their machines are: (1) Adobe International's Earth Press II, III and IV; (2) Worldwide Adobe's Goldbrick "5000"; (3) Rustech's Rustech; (4) Overview Consulting and Manufacturing's Impact 1000; and (5) Terra Manufacturing Company's Terra Rammed Block Machine. In the spring and summer of 1988, the prices for the machines varied from \$9000 for the Impact 1000 to \$72,000 for the Goldbrick "5000" FOB.

Adobe International and Worldwide Adobe, the principal manufacturers, are located in Milan, New Mexico, just west of Grants. Of the 24 commercial and noncommercial pressed-block producers located in

New Mexico in 1988 by the authors, 17 had Adobe International's Earth Press II or III and six had Worldwide Adobe's Goldbrick "5000." Adobe International both manufactured machines and produced blocks for some customers.

ADOBE INTERNATIONAL

In 1969, Henry Elkins, the owner of Adobe International, began to manufacture pressed-earth block equipment for use on building projects at his ranch property in Grants, New Mexico. After ten years of research, Elkins developed his first commercial machine, which cost \$40,000 and attracted few buyers.

Machine production today is largely limited to three models identified as Earth Press II, III and IV. Prices for the equipment vary from \$13,500 to \$35,000 FOB Grants, New Mexico. The most popular model is the Earth Press III machine developed in 1986 (Fig. 1). The new model Earth Press IV was developed in 1988 and produces a 16-inch block, targeted largely for the Arizona and California market.

In the summer of 1988, six Earth Press II (Fig. 2) and ten Earth Press III machines were located in New Mexico. Most machines were used by individual owners on their own construction projects (Fig. 3). However, several of the machine owners had formed small companies and were producing blocks, under a contract arrangement, at the customer's building site. One machine owner also rented his Earth Press equipment on a monthly basis.



FIGURE 1. Earth Press III pressed-earth block machine on a wall-construction site near Velarde, New Mexico.



FIGURE 2. Earth Press III pressed-earth block machine at factory near Grants, New Mexico.



FIGURE 3. Hal Fouts of Gallup, New Mexico, with four untrained helpers produced the walls of his solar adobe home during five months beginning in November 1985 with an Earth Press III machine.

In general, the three Earth Press machines (II, III and IV) produce blocks at the rate of 4 to 14 per minute. Several block sizes are available, varying from the Mexico block measuring 4 × 8 × 8 inches in size, the New Mexico standard 4 × 10 × 14 inches, to the 4 × 8 × 12-inch block. Other sizes are also available on special order or as optional equipment. Weight of the machines also varied from 2720 lbs to 6700 lbs on the earlier Earth Press II machine (Table 1).

WORLDWIDE ADOBE, INC.

John Wright's Worldwide Adobe, Inc., developer of the Goldbrick "5000" pressed-earth block machine, is the second manufacturer of portable hydraulic-press equipment in Grants, New Mexico. The first machine was produced in 1981 at the present sales and service center at 2000 North Highway 53, Milan, New Mexico.

The Goldbrick "5000" machine (Fig. 4) has a gravity feed hopper with a capacity of 2 yard³ and is usually loaded by a front-end loader removing soil from a nearby stockpile. The soil is then funneled into a 4 × 10 × 14-soil mold welded into a revolving wheel where it is pressed



FIGURE 4. Worldwide Adobe, Inc., Goldbrick "5000" pressed-earth block machine at the factory located near Grants, New Mexico.

into a block. The diesel-power unit also has a 5000-watt belt-driven 120/240 volt generator, which supplies power to the machine's programmable controller; the excess wattage is used for operating power tools and a block conveyer system. The machine presses a standard 4 × 10 × 14-inch block, with a 4 × 7 × 14-inch block available as an option, and has a production capacity of 750–850 blocks per hour. The basic Goldbrick "5000" machine was priced at \$72,000, FOB, Grants, New Mexico, in the spring of 1988.

NEW MEXICO'S PRESSED-EARTH BLOCK INDUSTRY

In 1987, over 642,000 traditional (untreated), semistabilized and stabilized (with portland cement or asphalt emulsion) pressed-earth blocks were produced commercially throughout the state. Blocks sold for 25–40 cents each for the traditional (untreated) 4 × 10 × 14-inch size that was produced at the builder's homesite using local or hauled-in soil.

Various New Mexico Building Code tests were performed on sampled pressed-earth blocks by the United Nuclear Rock Mechanics Laboratory, New Mexico Institute of Mining and Technology and other private laboratories. The blocks produced an unusually good modulus of rupture of 46–279 psi and a compressive strength of 512–3702 psi (Smith and Austin, 1989).

The major advantage to using pressed-earth blocks for construction is their convenient method of production. The portable pressed-earth block machine produces blocks which are uniform in at least two directions at the construction site using local soils. The finished blocks can be conveyed directly from the machine to the wall or stockpiled for later use. The blocks are commonly placed into the wall without further drying, and a thin mud slurry or lightly wet block surfaces bind the blocks. Most pressed-earth blocks also have a higher average compressive strength and modulus of rupture than normal sun-dried adobe bricks. However, unless a stabilizer, such as portland cement, polymer, lime or asphalt emulsion, is added to the soil mixture, the blocks must be protected from moisture at all times. Without a stabilizer or other protection, the blocks rapidly disintegrate when wet. In addition, production of the blocks is not limited to the normal warm sunny months. Block production is possible in all but sub-freezing temperatures.

SUMMARY

The pressed-earth block appears to be a viable alternative to the traditional adobe. Competent and uniform blocks can be produced by the pressed-earth machine at competitive prices, many times from the local soil at the construction site. Stabilization with one of a variety of compounds lowers the pressed-earth block's tendency to crumble with heavy rains, and the salability of used machines enhances the possibility of landowners constructing their own building and then selling the equipment to the next builder. The Grants, New Mexico, area appears

TABLE 1. Comparison of the pressed-earth block machines manufactured in Grants area, New Mexico in 1988. After Smith and Austin (1989).

	Earth Press II	Earth Press III	Earth Press IV	Goldbrick "5000"
Weight:	6700 lbs	2720 lbs	4200 lbs	9500 lbs
Dimensions:	6' wide, 6'8" high, 21' long	5' wide, 8' high, 16' long	5' wide, 8' high, 20' long	8' wide, 8' high, 16' 6" long
Power:	4 cyl - 72 Hp John Deere liquid-cooled, diesel engine	2 cyl - 18 Hp Tecumseh, air- cooled, gasoline engine	Two 2 cyl - 20 Hp Koehler, air- cooled, diesel engines	6 cyl - 115 Hp Onan L634, liquid- cooled, diesel engine
Controls:	manual or automatic	manual or automatic	manual or automatic	automatic (Rexroth Worldwide hydraulics with programmable controller)
Press Force:	7" diameter hydraulic cylinders, double RAM producing 2500 psi	2-4" hydraulic cylinders, double RAM, producing 2500 psi	2-5" hydraulic cylinders, double RAM, producing 2500 psi	8" diameter hydraulic cylinder producing 3,000 psi - up to 250,000 on bricks
Production:	14 blocks/minute	4 blocks/minute	6 blocks/minute	16 blocks/minute
Trailer:	tandem axles, electric brakes, and towing signals	tandem axles, electric brakes, and towing signals	tandem axles, electric brakes, and towing signals	tandem axles, electric brakes, and towing signals
Block Sizes:	10 x 4 x 14 inches 10 x 4 x 16 inches 10 x 4 x 12 inches	8 x 4 x 12 inches 8 x 4 x 8 inches	10 x 4 x 16 inches 10 x 4 x 14 inches 10 x 4 x 12 inches	10 x 4 x 14 inches 7 x 4 x 14 inches other sizes available
Price:	\$35,000 FOB, Grants, NM	\$15,500 FOB, Grants, NM	\$25,000 FOB, Grants, NM	\$72,000 FOB, Grants, NM

to be a center of both technical know-how to produce the machines and the market to sell the equipment and produce the blocks.

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