UNITED STATES DEPARTMENT OF LABOR
L. B. Schwellenbach, *Secretary*

BUREAU OF LABOR STATISTICS
Ewan Clague, *Commissioner*

Labor Requirements for Construction Materials

PART II.—CONCRETE MASONRY UNITS

Bulletin No. 888–2

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Letter of Transmittal

United States Department of Labor,
Bureau of Labor Statistics,
Washington, D. C., April 8, 1947.

The Secretary of Labor:

I have the honor to transmit herewith a report on the labor requirements in the production and distribution of concrete masonry units, a summary of which was published in the Monthly Labor Review for November 1946.

This is the second of a series of reports covering those industries which supply essential building materials for residential construction. These surveys were made in order to measure the amount of "behind-the-line" employment which would result from any given level of construction activity.

The labor requirements series, under the direction of Brunswick A. Bagdon, is based upon plant data collected by the field personnel assigned to this project in the Bureau's Regional Offices; the report was written by Alfred W. Collier and Clyde Stone in the Bureau's Division of Construction and Public Employment.

Ewan Clague, *Commissioner.*

Hon. L. B. Schwellenbach,
Secretary of Labor.

Contents

Bulletin No. 888–2 of the

United States Bureau of Labor Statistics

[Reprinted from the MONTHLY LABOR REVIEW, November 1946, with additional data.]

Preface

This study, the second of a series covering those industries which supply essential building materials, has been made in order to measure the amount of "behind-the-line" employment which would result in the concrete masonry industry from any given level of construction activity.

Previous studies of man-hour requirements made by the Bureau from 1933 to 1939, as a part of the program of the Federal Emergency Administration of Public Works, included steel, cement, lumber, plumbing and heating supplies, clay products, and electrical goods. For these products, information was collected from the primary sources for raw materials, transportation, manufacturing, and delivery to the construction site. Today these studies, while of historical significance, have several serious limitations; namely, (*a*) new products have been developed which were not included in the previous report, (*b*) manufacturing methods have, in several instances, changed considerably, and (*c*) variations in volume of output as between the period of the thirties and the current time would result in marked variations in man-hour requirements.

Building construction was greatly hindered during the period following VJ-day, and by the middle of 1946 building activity still had not shown marked headway. However, the forecasts, both public and private, indicate peak activity in the months ahead. Housing programs are under way. Federal subsidies have been appropriated to speed up and increase the volume of the production of essential building materials. Thus, everything points to a high level of activity in the building construction industry for some time to come.

This series of reports will provide accurate data on the man-hours required per unit of output and per unit of dollar value, for each of 50 important construction and building materials—both traditional materials such as dimension lumber, cement, and reinforcing steel, and newer materials such as plywood (included only incidentally in the previous reports), insulating material, and the commoner fabricated steel products for residential buildings. For each of the products included, comprehensive field data will be collected on the direct and overhead man-hours in production during a recent period, the output during this period, the quantities or value of materials, supplies, and fuel consumed, and wherever possible, sales both directly to contractors and through distributors and dealers. From these data, total man-hour requirements, from extraction of raw materials to delivery of completed materials at the construction site, will be obtained for an extensive series of materials representative of the requirements for most types of construction; in addition, the data will permit reasonable estimates of man-hour requirements for a large number of other materials generally similar to those studied, but not sufficiently important for individual study (primarily highly specialized materials, and custom-order variants of common materials).

Labor Requirements for Construction Materials

Part II.—Concrete Masonry Units

Introduction

Construction activity, especially in residential and GI housing, continues at a high rate in spite of material and manpower shortages. Employment at the construction site has increased markedly in the past 12 months. At the same time there has been increased employment in most of the industries producing the building materials used. The present study is the second in the series of labor-requirements studies of the more important building materials, undertaken by the Bureau of Labor Statistics, to determine the indirect labor involved in any construction activity.

One of the more important uses of portland cement is as a raw material in the manufacture of concrete units, particularly concrete block. This industry has had remarkable growth in the last 25 years. It has progressed a long way since those days of unsightly, ill-made and nonuniform products which were made in small plants, most of which were in the so-called "back yard" category.

Today, concrete block plants equipped with modern machinery are manufacturing very attractive units that are of uniformly high strength, and which are highly fire resistant. They are being used on a large scale as "back up" for many types of facing materials such as stone, brick, etc., as well as for both load-bearing and non-load-bearing walls. Other uses are for partitions, for fireproofing as floor fillers, and where masonry can be used to advantage in almost any type of building construction.

Concrete masonry has some uses other than as a structural material. Chief among these is its adaptability to any style of architecture. It is widely used as a surface finish for both exterior and interior walls. Units made with lightweight aggregates have excellent sound absorption qualities and as a result are especially desirable for exposed walls in auditoriums, gymnasiums, classrooms, and corridors.

Concrete units made by modern methods easily meet the requirements of the national standard specifications of the American Society for Testing Materials, Federal Master Specifications, and Underwriters' Laboratories. These specifications for hollow units require face shells of 1¼ inches and strength of 1,000 pounds per square inch for use in exterior walls below grade and for unprotected exterior walls above grade. Specifications for protected work above grade require 700 pounds per square inch. Absorption should not exceed 15 pounds of moisture per cubic foot of concrete. The products of better plants exceed these requirements two or three times.

The products enjoy wide acceptance from architects, builders, and prospective home owners. According to estimates by the Civilian Production Administration and reports of the Bureau of the Census, 60 percent of all masonry construction today uses concrete units.[1]

Various reports indicate spotty shortages in concrete block in some areas and a fair to good supply in others. Current delivery dates vary from 2 to 6 weeks on most orders. Demand for block is increasing because it can be used as an alternate for brick and structural clay tile, both of which are in extremely short supply. The backlog of orders is increasing.[2]

Estimates on production and requirements for concrete block for 1946 prepared by Civilian Production Administration are as follows:

	Millions of blocks (8 x 8 x 16-inch equivalent) 1946			
	First quarter	*Second quarter*	*Third quarter*	*Fourth quarter*
Estimated production	153	194	255	300
Requirements	187	205	240	222

From the above statement, it appears that the peak of requirements was reached in the third quarter of 1946, and that by the fourth quarter production met all requirements. According to the Civilian Production Administration, several thousand new plants began operations in 1946 and block-making machines were currently being delivered at the rate of 100 to 200 per month. Production of concrete block was generally meeting all requirements.[3]

With the construction industry expecting to operate at continued high levels for some time to come, the production of block is keeping pace with this trend. The capacity of established plants is sufficient to meet estimated peak requirements but production has been limited by shortages of labor, materials, repair parts, and transportation.

[1] Brick and Clay Record, October 1946 (p. 16).

[2] U. S. Department of Commerce, Construction Division, Construction and Construction Materials, July 1946 (p. 65).

[3] U. S. Department of Commerce, Construction Division, Construction and Construction Materials, November 1946 (p. 53).

Definition of Concrete Masonry

Concrete can be described as an artificial stone produced by mixing together and hardening definite proportions of cement, aggregates, and water. The type of cement generally used is portland cement or some modified product thereof.

The initial plasticity of concrete permits it to be formed into any desired shape and size. Its hardening qualities allow it to be manufactured in structural units which may be stored for use as needed. Units so manufactured are known as concrete products. Among the concrete products manufactured are building blocks and shapes, pipes and conduits, and similar products such as poles, piling, vaults, etc.

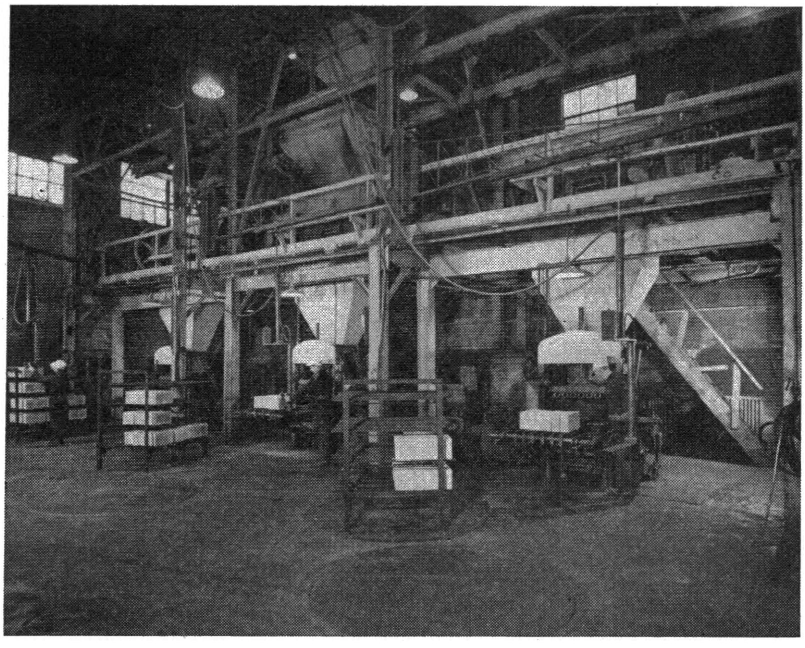

Figure 1.—Vibration equipment operating in modern high-production concrete masonry plant. Three block machines with total capacity of 12,000 to 15,000 8 x 8 x 16-inch blocks per day (8 hours). Note overhead bins, traveling weigh-batcher, and power block handling equipment.

The term "concrete masonry" is applied to block, brick, and tile building units molded from concrete and laid by masons in a wall. Masonry units are durable, fire-resistive, and able to carry heavy loads.

Concrete masonry may be classified into two general types—lightweight and heavyweight—according to the materials used as the aggregates in the mixing process. Among the lightweight aggregates are cinders, expanded slag, expanded clay and shale, volcanic cinders, crushed pumice rock, and certain other materials which are sold under various trade names (Haydite, Waylite, Superock, etc.). The cinders

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are the waste product of industrial firing of either anthracite or bituminous coal; desirable qualities are hard clinkers and low combustible content. Waylite and Superock are made from molten blast furnace slag, expanded by controlled quantities of water and violent agitation set up in an especially designed processing machine. Haydite is clay or shale expanded by a rapid rise of temperature of the prepared material feeding through a rotary kiln. Natural aggregates (sand, gravel, crushed stone, etc.) and air-cooled blast furnace slag (unprocessed) are the principal heavyweight aggregates.

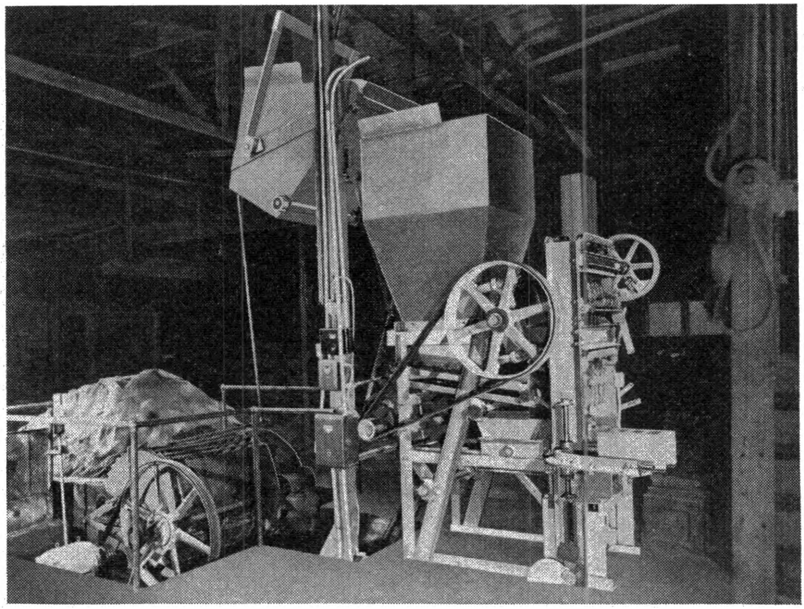

Figure 2.—Tamping equipment operating in small, modern concrete masonry plant. Block machine has capacity of 2,000 8 x 8 x 16-inch blocks per 8-hour day. Note mixer located on machine floor level, skip-hoist for elevating concrete to block machine, and plant lay-out designed for future installation of overhead bins and additional block machines as business expands.

Solid units are defined as having an average core area of not more than 25 percent of gross area, whereas hollow units usually have core areas of approximately 45 percent of gross area.

Concrete masonry is usually identified by the 8 x 8 x 16-inch or equivalent size. It is commonly manufactured in widths of 4, 6, 8, 10, or 12 inches, and it is made in half heights, half lengths, and quarter lengths to work out ashlar patterns in walls. Slight variations are characteristic of localities and of individual producers. There are special units which do not have standard sizes, such as corner units, joist units, jamb units, half units, and fractional units.

The dimensions used by the construction industry for concrete masonry units are in general nominal rather than in stated sizes. Actual heights, widths, and lengths are usually $\frac{1}{4}$ inch to $\frac{3}{8}$ inch scant to allow for the thickness of mortar joints. The industry was one of the first to adopt the recommendation of the American Standards Association on modular sizes to provide the 4-inch increment to both vertical and horizontal dimensions. This permits the nominal lay-out of buildings in plan and elevation in multiples of 4 inches. Thus, the modular unit $7\frac{5}{8}$ inches by $7\frac{5}{8}$ inches by $15\frac{5}{8}$ inches used with a $\frac{3}{8}$-inch mortar joint occupies a space in the wall exactly 8 by 16 inches. This gives perfect conformity with all other building materials that can be used in multiples of 4 inches (such as clay or glass brick window and door jambs, lintels, etc.).

Concrete block comprises a major segment of the concrete products industry, but there are other important products in this field. Recently, because of shortages in lumber, concrete joists have been substituted for wood in many structures. Likewise, the field of precast slabs for roofs, partitions, and floors is relatively undeveloped and great possibilities unquestionably lie ahead for these products.

Other specialty products are burial vaults, outdoor garbage receptacles, laundry trays, and a variety of miscellaneous products, such as lighting standards, fence posts, signal standards, battery boxes, manhole and silo staves, and concrete ornamental products.

Development of the Industry

The growth and development of concrete products manufacture is coincidental with the development of modern producing machinery. Concrete blocks were produced by hand in the early part of the century. Typical of the early machines was one introduced about 1904. It was wholly hand-operated and consisted of a mold with collapsible sides and cores which were withdrawn through the bottom of the mold. Compacting the material was accomplished by shoveling into the mold box and tamping by hand. Under favorable conditions, two workers could produce about 200 blocks per day, or 100 blocks per man per day.

Until 1914 the industry was primarily a "back yard" industry and producers were mainly small contractors and building material firms which manufactured blocks as a subsidiary part of other business. Rock-faced blocks were produced, which were nonuniform and unsightly. They were used primarily for sheds, outbuildings, cellars, garages, etc.

Mechanical improvements appeared and their use was generally extended throughout the industry during the First World War. Devices to provide mechanical tamping were quickly seized upon by block producers to eliminate the laborious hand tamping heretofore employed. The tampers were raised by chain or by eccentric crankshaft that lifted and dropped the rods, to which the tampers were attached. Over the years, the efficiency of these mechanical tamping devices was greatly improved, with the result that modern tamping machines are widely used today.

Power feeders, another labor-saving device, developed coincidentally with power tamping. Fresh concrete was carried to the mold box by various methods, including drag elevators, small bucket elevators, feeder belts, and feed drawers. The latter two methods are the most widely used in today's modern equipment.

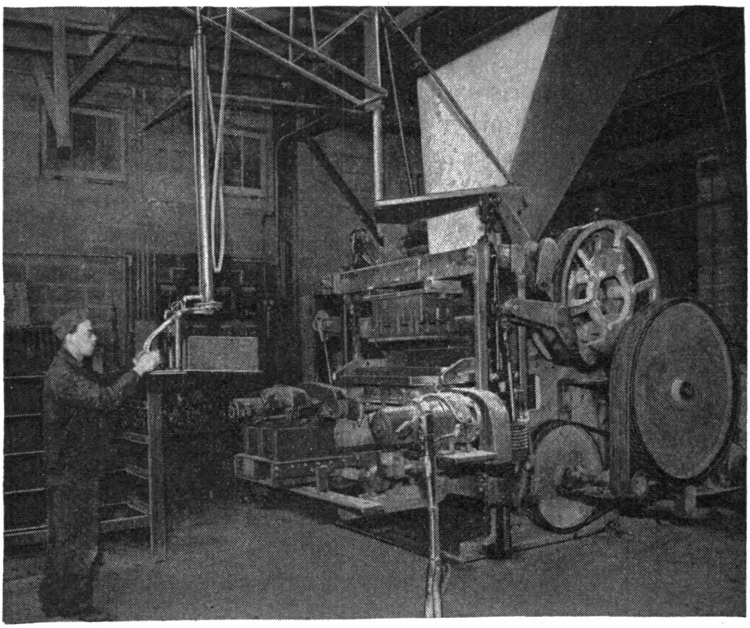

Figure 3.—Modern concrete block machine with power off-bearer in operation.

Constant efforts were exerted by block producers and machinery manufacturers to reduce the amount of hand labor involved in block manufacture. Mechanical means were developed to stop and start the tampers and the feeders automatically. Another development was mechanical troweling of the tops of the units. Still another tedious back breaker was eliminated by the development of automatic strippers for removing the block from the mold box. Machines were developed in which blocks were made face down—a convenient means of molding the then popular rock-faced block; and efforts were made to produce two blocks per operation instead of one. By the early 1920's production had been increased so that the daily output per machine approached 1,400 blocks, with four men as a crew, or 350 blocks per man per day.

During the 1920's, the face-down machines were superseded by vertical stripper type machines, on which the blocks were manufactured with the cores formed in a vertical plane, in the same position as laid in the wall. One type of stripper machine made blocks on plain pallets by suspending the cores from the top of the mold box and ejecting the blocks by means of a stripper head in a stationary position while the mold was stripped up from the blocks.

Another type of stripper machine made blocks on cored pallets. In this machine the cores were stationary and the block itself was stripped upward from the cores and then removed from the machine. Nearly all blocks today are made on improved stripper machines of either the plain or cored pallet type.

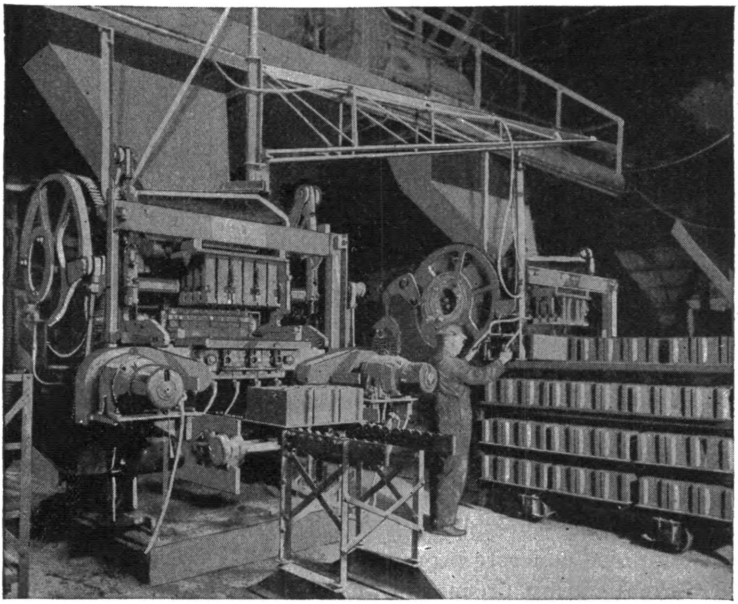

Figure 4.—Concrete block machinery which combines the features of multiple-unit production per operation, automatic operation, and compaction of concrete by vibration.

The next important development in the industry was compaction of the concrete by vibration rather than by tamping. An extended series of experiments and research tests, culminating the work of Kurt F. Wendt and Paul M. Woodworth at the Materials Testing Laboratory of the University of Wisconsin,[4] demonstrated the efficiency of vibration, with the result that equipment was made available by machinery manufacturers to combine multiple-unit production, automatic operation, and vibration. Today's high production machines are the outgrowth of this development.

Machines are available today which produce from 9 to 15 blocks per minute of the 8 x 8 x 16-inch equivalent size on either cored or

[4] Tests on Concrete Masonry Units, *in* Journal of the American Concrete Institute, Vol. 36 (p. 121).

plain pallets, with operating crews of four men. As these machines are entirely automatic, the operations of placing the pallet, feeding concrete into the mold, vibrating and stripping and ejecting the block from the machine are accomplished mechanically. Thus the use of hand labor in the manufacturing operation in a block plant has largely been eliminated. The direct production labor output has been increased to 1,500 blocks per man per day, and even better in the more efficiently operated plants. It should be noted, however, that with these high production records additional labor is required to handle raw materials as well as the finished blocks in the curing room and storage yard.

Along with the development of the molding machine, the use of auxiliary mechanical equipment has increased. The various kinds of such equipment which have resulted in the reduction of hand labor, and a high degree of mechanical efficiency, include power offbearers for removing the block from the machine, power lift trucks for handling the fresh block from the machine to the curing room and from the curing room to the storage yard, and power yard handling equipment to remove the cured block from the racks and load them into the stock pile, or from the stock pile to the delivery trucks. Various block manufacturers are developing ingenious devices for mechanical handling of their product from the delivery trucks to the building site, so that the time is rapidly approaching when blocks will be "untouched by human hands" until the mason actually lays them in the wall.

Along with the block machinery improvement, the curing process has made tremendous progress. Better methods of moisture and heat application have greatly speeded up production and have resulted in highly uniform concrete products.

The original curing process is known as the dry cure or natural process. Many plants still use this process and it consists of sprinkling the units with water and protecting them from temperatures of 50° F. or less for about 3 days. The limitations of the process are that manufacturing of block can be done only in the warmer months or in areas where the temperature is moderate the year round, and that the length of time required for the cure is 28 days.

The next development was the addition of moisture in the form of steam and heat, which is applied in curing rooms or kilns for a minimum of 24 hours This necessitated the building of closed rooms or kilns where temperature and humidity could be controlled, and into which racks of units could be pushed or drawn by tractor. This process is in wide use today in most modern plants.

To speed up the curing process, experimental work is currently under way by the National Concrete Masonry Association on high-temperature curing, which reduces the 24-hour curing time to less than 10 hours. Simultaneously, a number of plants employ autoclave curing, in which the blocks are subjected to temperatures of 350° F. at steam pressure of 125 pounds per square inch. A limiting factor in high temperature and high pressure steam curing is, of course, the added cost of these processes, and it is toward the reduction of these costs that the research is aimed.

Improvements in the quality of general-use cement have resulted in better products, and the development of special cements which have quick-setting properties has reduced the time required in production. Air-entrained concrete, obtained by the addition of air-entraining agents to the concrete mix or to the cement when manufactured, has expanded the field of uses for concrete products where durability and resistance to disintegration are important. More exacting specifications in natural aggregates, as well as prepared aggregates which serve to improve the insulation and sound absorption properties of the product, have also been important factors in the development of the industry.

Scope of Survey

Data for man-hour requirements in plant operations were obtained by direct reporting in the field. The sample consisted of 50 concrete block plants which produced 8,674,284 concrete blocks during one month in 1946. In selecting the sample, consideration was given to size of plant, geographical location, type of aggregates used, and diversity of products manufactured. The majority of plants surveyed supplied data for a period during the second quarter of 1946. In some cases it was necessary to collect data for periods during the first quarter of the year in order to have a representative period of plant operations.

Certain precast concrete products are not included in this survey because of varying specifications and nonuniformity of production methods. The study analyzed only units cast in plant operations before delivery to the construction site, and is confined to concrete blocks of varying sizes, brick, corner units, jamb units, chimney block, etc. All block sizes are converted into 8 x 8 x 16-inch equivalent units which are the standard measurements of the industry.

From previously published Bureau reports and secondary sources, the Bureau estimated the man-hour requirements for the production and transportation of raw materials, cement, aggregates, and electric power. It was found practicable to omit estimates for materials used in small quantities, such as lubricants, fuel, repair parts, curing agents, etc. It is believed that the omission of man-hour estimates for these items would not materially affect the total man-hour requirements.

Manufacturing Processes for Concrete Masonry

After the raw materials have been delivered to the plant they are placed in storage bins from which they are fed by gravity, or by the use of mechanical conveyors, into the processes of manufacture. The first step in the manufacture of concrete masonry units is the proportioning and mixing of cement and aggregates with water. Proper proportioning of raw materials in preparation for mixing is accomplished by use of measuring devices. In most plants, batch mixers are used into which a batch of materials is placed, mixed, and discharged before another lot is added. Continuous mixers are also used in which the ingredients are added continuously and mixed during passage through the machine.

The concrete flows from the mixing machine into molding machines which form the units. From the machine, units are discharged on pallets and placed on racks, usually by a mechanical hoist. The units are then ready for curing.

All concrete work requires proper curing. Concrete hardens in the presence of moisture and heat, causing a chemical reaction in the cement. The processes employed are dry curing, moist steam curing, and high temperature curing. The moist steam curing system is the most widely used in modern plants.

After curing, the units are stacked in the storage yard and kept damp until they develop the strength and absorption properties necessary. The units are stacked in such a manner that proper drying of all units is permitted.

Man-Hour Requirements

SUMMARY

From basic plant records it was found that approximately 30.2 man-hours were required at the plant to manufacture 1,000 concrete blocks. In addition to the man-hours necessary for plant manufacture, it was estimated that 38.8 man-hours were needed to extract the raw materials used, to haul these materials to the plant, and to deliver the finished product to the construction site. Similar estimates were made for the production of block in which lightweight and heavyweight aggregates, respectively, were used. Thus, the following statement indicates that a total of approximately 69.0 man-hours of labor are represented in the manufacture and delivery of 1,000 concrete blocks to the construction site. The same operations require 64.8 man-hours for lightweight blocks and 74.0 man-hours for heavyweight blocks.

	Man-hours per 1,000 blocks		
	All blocks (average)	*Lightweight*	*Heavy weight*
Total production and transportation	69.0	64.8	74.0
Raw materials, production, and transportation [1]	29.2	23.2	36.6
Manufacturing	30.2	32.4	27.4
Transportation, finished product	9.6	9.2	10.0

[1] Includes purchased electric power.

Significant variations were noted in man-hour requirements when the data were analyzed according to rate of production, the number of molding machines per plant, and type of aggregates used. Plants producing at a monthly rate of less than 50,000 blocks required 74.5 man-hours per 1,000 blocks, while those producing at a rate of 350,000 blocks or more required only 23.1 man-hours for each 1,000 blocks produced. Labor requirements in plant operations varied from 34.3 man-hours, for plants having one molding machine, to 24.9 man-hours, for plants having 3 or more molding machines. The manufacture of lightweight blocks required 32.4 man-hours per 1,000 blocks as compared with 27.4 man-hours necessary for the production of 1,000 heavyweight blocks.

PRODUCTION AND TRANSPORTATION OF RAW MATERIALS

The principal raw materials used in the production of concrete block are (1) cement and (2) aggregates, which fall into two classifications, lightweight and heavyweight. Cinders, expanded slag, and burned clay and shale are the principal lightweight aggregates, whereas sand and gravel or crushed stone are the most commonly used heavyweight aggregates.

The quantities of raw materials, including electric power, and the man-hour requirements for these materials are shown below, by type of block, for the production of 1,000 blocks.

	Requirements per 1,000 blocks		
Raw materials:	*All blocks (average)*	*Lightweight*	*Heavyweight*
Cement ---- barrels	10. 9	12. 2	9. 2
Sand and gravel ---- tons	13. 3	----	30. 2
Cinders ---- tons	7. 6	13. 6	----
Electric power ---- kw. hr	56. 3	51. 2	62. 7
Man-hours:			
Cement	10. 9	12. 2	9. 2
Sand and gravel	12. 0	----	27. 2
Cinders	6. 1	10. 8	----
Electric power	. 2	. 2	. 2
Total	29. 2	23. 2	36. 6

The quantities of cement and electric power shown above for all types of block are average quantities required for all plants (producing either lightweight or heavyweight blocks) included in the survey. Similarly, the quantities of sand and gravel and cinders are weighted averages of heavyweight and lightweight aggregates required for the production of the two types of block. The quantities shown separately for lightweight and heavyweight blocks are those required when production is confined to each respective product.

In 1945–46 the man-hour requirements for the production and transportation of 100 barrels of cement were 100.49, and 3.12 man-hours were required to produce 1,000 kilowatt-hours of electric power.[5] In the manufacture of 1,000 blocks it was determined from these figures that the labor requirements were 10.9 man-hours for the 10.9 barrels of cement used, and 0.2 man-hour was expended in providing the 56.3 kilowatt-hours of electric power consumed.

The production and distribution of sand and gravel, the principal heavyweight aggregates, required an average of 0.9 man-hour in 1937.[6] In the absence of information for the current period, these data were used as a basis for estimating the labor requirements for sand and gravel. It was therefore estimated that 12.0 man-hours were needed for the production and transportation of the 13.3 tons of sand and gravel used in the production of 1,000 blocks. While other heavyweight aggregates, such as crushed stone, untreated blast-furnace slag, etc., are sometimes used, sand and gravel are predominant in use, and are considered as representative of all heavyweight aggregates in this study.

Since cinders are a waste product resulting from the combustion of coal, no man-hours were estimated for the production of this material. The estimate of man-hour requirements for this material include those necessary to transport the cinders to the plant and its preparation at the plant after delivery. The labor requirements for the transportation of cinders are similar to those for sand and gravel. From a previous Bureau of Labor Statistics study, it was found that 0.6 man-hour was necessary to transport 1 ton of sand and gravel in 1939.[6] This figure was used as the labor requirement for the transportation of 1 ton of cinders. Thus it was estimated that 4.6 man-hours were required to transport 7.6 tons of cinders to the plant. By use of basic plant data it was determined that 1.5 man-hours were needed to prepare the cinders at the plant after delivery, making a total of 6.1 man-hours for transportation and preparation of the 7.6 tons of cinders. Analysis of the data collected in this study shows that cinders were the aggregate used for 67 percent of the total production of lightweight blocks. Since no available data were found for estimating the man-hour requirements for other lightweight aggregates, labor requirements for the transportation and preparation of cinders, based on data collected in this survey, were used as representative of all lightweight aggregates.

The labor requirement estimate for lightweight aggregates appears to be understated in view of the fact that no allowance is made for labor expended in the production of raw cinders. It is not to be imputed that lower man-hour requirements for lightweight aggregates, as compared with total requirements for heavyweight aggregates, are indicative of lower costs for the lightweight block manufacturer.

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[5] See Labor Requirements in Cement Production, in Monthly Labor Review, September 1946.

[6] See Labor Requirements in Production and Distribution of Sand and Gravel, in Monthly Labor Review, July 1939 (reprinted, with additional data, as Serial No. R. 944).

On the contrary, it has been noted in some areas that the cost of raw cinders (due, at least in part, to inadequate local supplies) exceeded the cost of prepared heavyweight aggregates. In addition, the cinder-block manufacturer had to bear the cost of the extra operations in preparing the raw cinders for use.

MANUFACTURING—PLANT OPERATIONS

The 50 plants in this study represent a monthly rate of production of 8,674,284 lightweight and heavyweight concrete blocks of 8 x 8 x 16-inch equivalent size. Total man-hour requirements for this production and the man-hours per thousand blocks are shown below by plant operation:

	Man-hours required in manufacture of concrete block, 1946 [1]	
	Total	*To produce 1,000 blocks*
Total, plant operations	262, 044	30. 2
Proportioning and mixing	20, 876	2. 4
Machine molding	46, 382	5. 3
Hauling	24, 872	2. 9
Yard	85, 958	9. 9
Maintenance	21, 377	2. 5
Superintendents and foremen	17, 704	2. 0
Miscellaneous labor	9, 114	1. 1
Administration	35, 761	4. 1

[1] Does not include man-hours required for preparation of aggregates or transportation of finished product.

The first operation is the proportioning and mixing of the aggregates and cement before the units are molded. In modern plants the materials are batched by measuring devices and placed into the concrete mixer.

Many aggregates, such as sand and gravel used for heavyweight block, and Haydite and Waylite for lightweight block, do not need additional preparation. They are delivered to the plant ready for use. Cinders, however, sometimes need preparation at the plant, such as crushing and removing foreign particles (metal, sulphur, etc.). For this reason, the man-hours for aggregate preparation are not shown separately above but are included in the raw materials section of the summary statement (see p. 11).

The key operation in the plant is the machine molding operation. The machine forms the units, vibrates or tamps the concrete mixture, and discharges the formed units onto pallets which are lifted to racks by air hoists. Modern machines are almost fully automatic, so that usually only one worker is necessary to operate air hoists and to tend the machine as it is in production.

After the blocks have been molded on the machine and placed on racks, they are hauled by tractor or by hand to the curing rooms or kilns.

In any plant the largest single group of employees is the yard gang. This group numbered from 3 to 7 employees per plant. As concrete units are bulky and must be moved many times, considerable labor is expended in this operation. The yard employees remove the blocks from the curing rooms, stack them in the yard for stock piles or additional curing, sometimes assist with the loading of the finished blocks for shipment, and perform other unclassified tasks. The labor is generally unskilled and nearly a third of the entire plant employment is engaged in yard operations. For this operation a total of 85,958 man-hours was required, or an average of 9.9 man-hours per thousand blocks produced.

Maintenance includes the labor necessary to make repairs on machinery and plant equipment. During the period surveyed, plants were operating at a high rate of production and a considerable range in the man-hours required for this function was noted between plants having relatively new machinery and those where the machinery was older. This range was from 0.5 man-hour per thousand blocks produced in the newer, modern plants to 11.3 man-hours in the older plants.

Plant supervision functions are performed by superintendents and foremen. Administration includes the executive, clerical, and sales force. Miscellaneous labor includes watchmen, janitors, boilermen, etc.

TRANSPORTATION OF CONCRETE BLOCKS

High transportation costs limit the area which can be economically served by the concrete products manufacturer and for this reason plants are widely dispersed. Since they serve relatively small local areas, the shipment of the finished product is usually by motortruck. Most plants deliver varying proportions of their production and this function may be considered as a plant operation. In many plants surveyed, deliveries were made by trucking companies on a contract basis for all or part of the finished product. In addition, considerable proportions were transported from the plant by the purchaser. For the purpose of establishing a basis for comparison, the data for the transportation of concrete blocks to the construction site were not included in plant operations. From plant records it was found that the delivery of 3,244,000 blocks required 31,000 man-hours and it was estimated that 9.6 man-hours were required for the transportation of 1,000 blocks. The transportation of lightweight blocks required 9.2 man-hours for 1,000 units, whereas 10.0 man-hours were needed for heavyweight blocks.

VARIATIONS IN LABOR REQUIREMENTS

By Monthly Rate of Production and Molding Machines in Use

Among the significant factors in determining the number of man-hours required to produce 1,000 blocks, the monthly rate of production and the number of molding machines in the plants are taken into consideration. Table 1 shows that, in terms of total man-hours, plants producing over 350,000 blocks were about 3 times as efficient as those producing less than 50,000 blocks monthly. The greatest variation appeared in the manufacturing process. The 9 plants producing less than 50,000 blocks required 27.8 man-hours per thousand as compared with 7.6 man-hours for the 5 plants which produced in excess of 350,000 blocks during the same period. The next greatest variation (24.1 man-hours compared with 6.7) occurred in the yard operation. Similarly, the man-hours required for the administrative function varied considerably—from 15.2 man-hours for the small to 3.0 man-hours for the large producers. The least variation was in overhead, with the smallest producers requiring 7.4 man-hours, and the largest 5.8 man-hours per thousand concrete blocks.

Table 1.—*Average Number of Man-Hours Required To Produce 1,000 Concrete Blocks, 1946,[1] by Rate of Production*

Monthly rate of production (8 x 8 x 16 inch equivalent units)	Number of plants	Man-hours per 1,000 blocks				
		Total	Manufacturing	Yard	Overhead	Administrative
All plants	50	30.2	10.6	9.9	5.6	4.1
Under 50,000 units	9	74.5	27.8	24.1	7.4	15.2
50,000–149,999 units	17	38.0	13.6	12.8	6.0	5.6
150,000–249,999 units	14	30.9	10.9	10.6	5.5	3.9
250,000–349,999 units	5	26.9	9.8	9.5	4.5	3.1
350,000 units and over	5	23.1	7.6	6.7	5.8	3.0

[1] Does not include man-hours required for preparation of aggregates or transportation of finished product.

Molding machines.—The most important producing unit in any plant is the molding machine, and the capacity of a plant is based on the number of machines in use. In this study important variations in man-hours were found to exist between plants having one, two, and three or more of these machines. Table 2 shows a break-down of man-hours required to produce 1,000 blocks for 45 plants, by number of machines. A significant difference in total man-hours required existed in those plants having one machine as compared with plants having three or more machines. As table 2 indicates, the manufacturing operation showed the least variation because of the automatic

Table 2.—*Variation in Man-Hours Per 1,000 Blocks, 1946,[1] by Number of Molding Machines*

Machines in use	Number of plants	Number of blocks produced	Man-hours per 1,000 blocks				
			Total	Manufacturing	Yard	Overhead	Administrative
All plants	45	7,723,000	28.7	10.7	9.5	4.7	3.8
1 molding machine	20	2,025,000	34.3	11.5	11.9	6.2	4.7
2 molding machines	19	3,836,000	27.5	10.3	8.7	4.4	4.1
3 or more molding machines	6	1,862,000	24.9	10.3	8.6	3.5	2.5

[1] Does not include man-hours required for preparation of aggregates or transportation of finished product.

features of most machines, while the yard and overhead functions showed the greatest variations.

It should be noted that during this period, 6 large plants, each with 3 or more machines, produced almost as many units as 20 plants with 1 machine.

By Lightweight and Heavyweight Aggregates

Concrete blocks are divided by the industry into two major classifications—lightweight and heavyweight. A lightweight block on the average will weigh about 30 pounds, while a heavyweight block will weigh approximately 40 pounds for the same size—8 x 8 x 16 inches. The range is from 27 to 33 pounds per block for the lightweight, and from 38 to 44 pounds for the heavyweight blocks.

Table 3 shows the average number of man-hours required to produce 1,000 blocks by the two types of aggregates used. In general, 5 more man-hours per 1,000 blocks were required to produce lightweight block than heavyweight block. Some manufacturers contend that no appreciable variation should occur when production factors are equal. It is probable that the variation indicated is due to an unbalanced proportion of efficient producers among the manufacturers of the two types of blocks as represented by the sample. A sample sufficiently large in size would tend to eliminate the chance occurrence of improper proportions and provide more conclusive evidence of variations according to type of aggregates used.

TABLE 3.—*Average Number of Man-Hours Required To Produce 1,000 Concrete Blocks, 1946,[1] by Type of Aggregates Used*

Type of aggregates used	Number of plants	Man-hours per 1,000 blocks				
		Total	Manufacturing	Yard	Overhead	Administrative
All types	50	30.2	10.6	9.9	5.6	4.1
Lightweight	31	32.4	11.2	10.1	6.8	4.3
Heavyweight	32	27.4	10.0	9.6	3.9	3.9

[1] Does not include man-hours required for preparation of aggregates or transportation of finished product.