UNITED STATES DEPARTMENT OF LABOR
L. B. Schwellenbach, *Secretary*
BUREAU OF LABOR STATISTICS
Ewan Clague, *Commissioner*

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LABOR REQUIREMENTS FOR CONSTRUCTION MATERIALS PART III.—CONCRETE PIPE

Bulletin No. 888–3

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Letter of Transmittal

U. S. 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 pipe, a summary of which was published in the Monthly Labor Review for November 1946.

This is the third of a series of reports covering those industries which supply essential building materials. 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.

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

Preface

This study, the third 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 pipe 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 for each of 50 important construction and building materials—both traditional materials such as dimension lumber, cement, and reenforcing 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 III.—Concrete Pipe

Introduction

Concrete is an artificial stone produced by mixing together and hardening definite proportions of cement, aggregates, and water. The initial plasticity of the proportioned mixture permits it to be formed into any desired shape and size. Its hardening qualities allow it to be manufactured in units which may be stored for use as needed. Units so manufactured are known as concrete products. Among the concrete products manufactured are pipes and conduits, building blocks and shapes, and similar products such as poles, piling, vaults, etc.

Concrete pipe comprises an important 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.

Pipes made of concrete have been in use since the time of the Romans. A system of concrete water pipes still in good condition was discovered in 1928 near Cologne, Germany, which had been installed by the Romans about the year 80 A. D. Modern use of the product, following the introduction of portland cement in the nineteenth century, has been expanded to include irrigation and drainage, highway and railway culverts, sewers, airport drainage, and many related uses. The development of irrigation in the Far West went hand in hand with the development of the concrete pipe industry, and the development of our extensive highway and airport systems were largely dependent on concrete pipe culvert and drainage systems.

Today there are approximately 300 concrete pipe manufacturers in the country, 150 of which manufacture pipe exclusively. The remaining producers manufacture concrete products such as blocks, brick, etc., in addition to pipe. Most of these manufacturers are small and employ an average of 6 to 10 workers. A few large pro-

ducers in the United States employ up to 200 men. These are principally multiplant organizations which started temporary plants on job sites. Because of the extreme weight and bulk of the product, transportation is a major item of expense; and to move a plant to the construction site proved to be more economical than transporting finished pipe from distant established plants. When construction on the job was completed the plants continued operations to serve local needs.

The following approximate production figures were obtained from industry representatives:

	Tons
1942	4, 000, 000
1943	2, 000, 000
1944	741, 000
1945 (estimated)	721, 000
1946 (estimated)	705, 000

The above figures indicate that the industry is currently in a depression. When normal business activity is low, concrete pipe consumption increases with the development of public construction programs. The low production for 1946, as compared with previous years, is partially explained by the fact that residential construction was receiving preference in the construction industry and the uses of concrete pipe, except for small diameter drain tiles, are negligible in this field. However, because of extreme shortages in clay tile, and soil pipe for house sewer lines, some substitutions with concrete pipe have been made for these products. As a result the number of units of pipe produced may increase, but because of their small size this increase will not have a marked effect upon tonnage.

Manufacturing Processes

Concrete pipe is made of cement, sand, gravel or crushed stone, and water—materials which are local in nature throughout the United States. Made in sizes from 4 inches in diameter to 138 inches in diameter, in both plain and reinforced concrete, it can be designed to serve a variety of internal pressures and external loading conditions. These sizes and designs are made by a variety of means.

Small nonreinforced concrete pipe is often made by the "packerhead" method, where a revolving vane throws the concrete against the outside form. Molding machines are in common use for the manufacture of pipe sizes up to 60 inches in diameter. Machines using mechanical tampers produce both reinforced and nonreinforced pipe by tamping the dry mixture into forms. Centrifugal concrete pipe is made by several patented methods. Poured pipe can be made in almost any size by using plain poured concrete and concrete poured

and vibrated. Thus, in general, concrete pipe is made by one of the following methods: Packerhead, tamped, poured, poured and vibrated, and several varieties of the centrifugal method.

In the production of larger sizes, stationary forms are constructed of wood and placed in a line, over which is placed a long platform or runway with lead-off chutes at the end of each designated length of pipe. The concrete mixer is placed at the head of the line and charged with proportioned materials. The mix is hauled along the platform by wheelbarrow or other vehicle. As the production process continues, this haul increases in length up to 400 feet. The concrete is emptied into the chutes, flows into the forms, and is firmly tamped or vibrated about the form circumference. A lip and bell or tongue and groove are formed on each length of pipe. The pipe remains in the forms 4 to 6 hours until set sufficiently to be moved. Then the forms are removed, and the pipe is wrapped with burlap, sprinkled, and pushed by tractor or hand to storage space in the yard. The pipe cures in the yard for several days and is then ready for shipment.

If reinforcing is used, a steel cage is built into the forms before the concrete is poured; this requires the additional operation of welding the reinforcing material into the desired diameter. As the size of the pipe increases, the thickness of the reinforcing steel becomes greater. Except for unusual specifications, reinforcing steel is not used in pipe sizes less than 30 inches in diameter. Almost universally, it is used in sizes over 36 inches. Reinforcing adds strength to the wall of the pipe and thereby makes an important reduction in the wall thicknesses necessary for the larger sizes.

A minor operation in concrete pipe production is the making of fittings and joints such as Y's and T's. This is usually done by one man who fits the joints by hand.

Scope of Survey

Data for man-hour requirements were obtained by direct reporting in the field. The sample consisted of 34 concrete pipe plants which produced 29,402 tons of pipe during 1 month in 1946. The majority of plants surveyed supplied data for periods 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 obtain a representative period of plant operations.

Represented in this study are all sizes of concrete pipe, both plain and reinforced. Separate analysis for the various sizes and the plain and reinforced pipe was not considered feasible. Because of the range in sizes and the special purposes for which pipe may be used, the production equivalent is in net tons of product manufactured.

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

Man-Hour Requirements for Concrete Pipe

The analysis of 34 plants included in this study indicates that a total of 7.50 man-hours was required for the production of 1 ton of concrete pipe. It was estimated that 2.63 man-hours were required to extract, process, and deliver to the plant the necessary materials (including electric power) for the production of 1 ton of concrete pipe. Plant operations accounted for 4.40 man-hours per ton and the transportation of the finished product to the construction site required 0.47 man-hour. Estimated man-hour requirements, by operations, are presented in the following summary:

	Man-hours per ton of concrete pipe
Total, production and transportation	7.50
Raw materials, production and transportation	2.63
Manufacturing	4.40
Transportation, finished product	.47

Man-hour requirements in the production of 1 ton of pipe varied inversely with the monthly rate of production Plants producing 500 tons or less per month required 6.48 man-hours per ton, while the labor requirements per ton in plants producing more than 1,400 tons per month were 3.93 man-hours. Variations were noted among geographic areas with requirements ranging from 4.00 man-hours for plants in the Pacific States to 6.16 man-hours for plants in the Northeast.

PRODUCTION AND TRANSPORTATION OF RAW MATERIALS

The principal materials used in the manufacture of concrete pipe are (1) cement, (2) sand and gravel or crushed stone, and (3) reinforcing steel. Below are shown the materials, including electric power, and the man-hours required to produce the quantities consumed per ton of concrete pipe, for which data were estimated:

		Requirements per ton	
		Amount of materials	Man-hours to produce quantities consumed [1]
Total, per ton		------	2. 63
Cement	barrels	0. 90	0. 90
Sand and gravel	tons	. 85	. 80
Reinforcing steel	tons	. 02	. 91
Electric power	kw.-hr.	6. 03	. 02

[1] Includes man-hour requirements for delivery to the plant.

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.[1] In the manufacture of one ton of concrete pipe it was determined from these figures that the labor requirement was 0.90 man-hour for the 0.90 barrels of cement used, and 0.02 man-hour was expended in providing the 0.2 kilowatt hour of electric power consumed.

The production and distribution of one ton of sand and gravel required an average of 0.945 man-hour in 1937.[2] 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 0.80 man-hour was needed for the production and transportation of the 0.85 ton of sand and gravel used in the production of 1 ton of pipe. While crushed stone is important as an aggregate in the concrete pipe industry, sand and gravel is considered as representative of the aggregates used in the production of pipe.

An analysis, in 1935, of man-hours per unit of output in steel manufacture [3] did not prepare estimates for the manufacture of the type of steel used as reinforcing for pipe. However, in the absence of these data, the man-hour requirements for drawn wire were substituted. Thus, it was estimated that 0.91 man-hour was required to produce and transport the average quantity of reinforcing steel used in the manufacture of 1 ton of concrete pipe. It should be noted that the 0.02 ton of steel represents an average requirement per ton for the production of all plain and reinforced pipe included in this study, and that the labor requirements estimate does not include the fabrication of this material into the steel fabric used for reinforcing.

[1] Labor Requirements in Cement Production, by Alfred W. Collier, in Monthly Labor Review, September 1946 (pp. 355–363).

[2] Labor Requirements in Production of Sand and Gravel, by John A. Ball, in Monthly Labor Review, July 1939 (reprinted, with additional data, as Serial No. R. 944).

[3] See Man-Hours of Labor per Unit of Output in Steel Manufacture, in Monthly Labor Review, May 1935 (pp. 1155–1161).

Because the pipe plants included in the study manufactured a wide variety of sizes during the period surveyed, it was found feasible not to attempt to separate the manufacturing process in terms of man-hours for machine-molded and hand-cast pipe.

The following figures show the man-hours required to manufacture a ton of pipe, by plant operations. A total of 129,370 man-hours of labor was required to produce 29,402 tons of pipe, or 4.40 man-hours per ton.

	Man-hour total	*Requirements per ton*
Total (34 plants)	129, 370	4. 40
Proportioning and mixing	12, 251	. 42
Cage welders	7, 484	. 25
Molding (machine and cast)	13, 017	. 44
Trucking and stripping	17, 847	. 61
Yard	41, 201	1. 41
Maintenance	9, 783	. 33
Superintendents and foremen	8, 757	. 30
Miscellaneous labor	2, 492	. 08
Administrative	16, 538	. 56

The first operation, proportioning and mixing the cement and aggregates before the pipe is molded, required 0.42 man-hour per ton. The construction of the steel reinforcing cage, around which the concrete is poured for the larger sizes of pipe, comprises the cage welding operation. This required 7,484 man-hours for the 34 plants surveyed, or 0.25 man-hour per ton.

The molding operation, including pouring concrete into forms, and vibrating or tamping, required 13,017 man-hours, or 0.44 man-hour per ton of pipe produced.

After the pipe is formed or molded, the next operation is stripping the unit from the mold. For machine-molded pipe, this is done by mechanical strippers which remove the mold and allow the pipe to stand and harden. Then the unit is placed on carts or dollies and hauled to the curing rooms or kilns. In cast pipe the mold is removed by hand and made ready for wrapping and sprinkling. A total of 17,847 man-hours was required in all plants for this operation, or 0.61 man-hour per ton.

Because pipe is bulky and heavy, considerable yard labor is necessary to move the pipe from the molding forms to curing places about the plant. After being cured, the pipe is prepared for shipment. In cast pipe plants, yard men assist in stripping the mold and wrapping the pipe. This operation accounts for nearly a third of all labor in the plant. The yard operations required 41,201 man-hours, or 1.41 hours per ton of concrete pipe.

Overhead operations—including maintenance, superintendents and foremen, miscellaneous labor, and administrative—required 1.27 man-hours, or about 30 percent of total requirements for plant operations.

TRANSPORTATION OF CONCRETE PIPE

Wide dispersal of concrete pipe plants is made necessary because of high transportation costs for the finished product. Concrete pipe may be delivered to the point of use by the manufacturer or by trucking companies on a contract basis. Since considerable proportions are also transported from the plant by the purchaser, the data for the transportation of pipe to the construction site are not included in plant operations. Data for plants which delivered their product show that the transportation of 17,333 tons of concrete pipe required 8,071 man-hours, an average of 0.47 man-hour per ton.

VARIATIONS IN LABOR REQUIREMENTS

By Monthly Rate of Production

Table 1 indicates the variations in man-hours per ton of pipe production on a monthly tonnage basis for 29 of the 34 plants included in the survey. Considerable variation was noted between those plants which produced 1,400 tons and over per month and those producing less than 500 tons during the same period. The man-hour requirements are shown for the general classifications of manufacturing, yard, overhead, and administrative operations.

The average for all plants was 4.55 man-hours per ton; the largest manufacturers required 3.93 man-hours for each ton of pipe produced, while the small plants required 6.48 man-hours.

TABLE 1.—*Average Number of Man-Hours Required To Produce 1 Ton of Concrete Pipe,[1] 1946, by Rate of Production*

Rate of production	Number of plants	Man-hours per ton				
		Total	Manufacturing	Yard	Overhead	Administrative
All plants	29	4.55	1.73	1.50	0.73	0.59
Under 500 tons	8	6.48	2.18	2.22	.87	1.21
500–799 tons	8	4.77	1.82	1.35	.90	.70
800–1,099 tons	5	4.34	1.93	.95	.85	.61
1,100–1,399 tons	5	4.24	1.57	1.62	.63	.42
1,400 tons and over	3	3.93	1.40	1.72	.47	.34

[1] Does not include transportation of finished product.

By Geographic Areas

Variations in labor requirements per ton of pipe by geographic areas are given in table 2. Total man-hour requirements per ton range from 4.00 for Pacific plants to 6.16 for the Northeast. It is not to be

concluded that these variations assume significance because of the geographic location of the plants. The comparatively high averages shown for the Northeast appear to be largely due to the low percentage of capacity utilization in the plants of that area. This factor is significantly reflected in the man-hour requirements for the overhead and administrative functions. It should be noted that the plants, in the areas showing man-hour requirements below the average for all plants, were producing larger proportions of pipe in the smaller sizes, which permitted the use of pipe molding machines and did not require the extra employment for welding and placing the reinforcing steel necessary in the production of larger sizes. It can be observed that the average requirements for all areas except the Northeast, representing 31 of the 34 plants, are within the relatively narrow range from 4.00 to 4.74 man-hours per ton.

TABLE 2.—*Average Number of Man-Hours Required To Produce 1 Ton of Concrete Pipe,*[1] *1946, by Geographic Division*

Area	Number of plants	Man-hours per ton				
		Total	Manufacturing	Yard	Overhead	Administrative
All plants	34	4.40	1.72	1.41	0.71	0.56
Pacific	6	4.00	2.13	.68	.75	.44
East North Central	10	4.01	1.40	1.44	.61	.56
Middle Atlantic	8	4.20	1.12	1.91	.51	.66
West North Central	3	4.34	1.81	1.35	.79	.39
South	4	4.74	2.30	1.29	.72	.43
Northeast	3	6.16	2.56	1.34	1.39	.87

[1] Does not include transportation of finished product.