

CEMENT.

ADVANCES IN CEMENT TECHNOLOGY, 1906.

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INTRODUCTION.

The year 1906 was a prosperous and satisfactory year for the American cement industry, being marked by increases both in production and in profits. The year was notable, moreover, for certain developments of both industrial and technologic importance, which seem calculated to have an important effect on the future of the industry. In a later section of this report the statistics of production and value, arranged by States, are presented in tabular form. In the present section an attempt will be made to use these statistics as a basis for discussion of points which seem of general interest and importance.

GROWTH OF THE PORTLAND-CEMENT INDUSTRY.

Before taking up matters which relate specifically to the Portland-cement industry, it will be of interest to compare its growth with that of a nearly related industry—the manufacture of pig iron. This is done graphically in fig. 2, reproduced in revised form from the Engineering Magazine, which shows what may be called the “growth curves” of the two industries for the period 1890–1906, inclusive. The figures on which this diagram is based are official, except for the present year, where estimated quantities are given.

The diagram is, of course, distorted to the extent that, while the pig-iron production is given in long tons (of 2,240 pounds), the cement output is stated in barrels (of 380 pounds). But this distortion does not affect the value of the diagram when used for its present purpose—a comparison of the form of the two growth curves.

On examination it will be seen that the cement curve rises steadily at an increasing ratio each year, showing no downward flexures or relapses. This is the normal form for the growth curve of a young and rapidly expanding industry. The iron curve, on the other hand, though showing a decided gain for the period covered, also shows at intervals depression flexures, typical of a mature industry, whose annual output must now depend on the general financial and industrial condition of the country.

The cement output, as yet, has not suffered markedly from financial depressions. Prices have fallen off in poor years, it is true, but the annual output has always increased. The rise in yearly output from

1885 to 1906 has not only been continuous, but has even shown a tendency to increase its *rate* of increase. Of course, such a condition of the industry can not be expected to continue indefinitely. Within a few years we must expect to see the rate of increase lowered, and finally, in some period of business depression, some year will show a

lower output than the preceding year. This will mark the end of the youth of the cement industry and the beginning of its period of maturity. Though the present condition of the industry is as prosperous as might be desired, it is entirely possible that the change in rate of growth may be near at hand. The new construction of 1906 and plants to be built in 1907 will provide a great increase in mill capacity. If the succeeding years are generally good this increase will be taken up without difficulty, but a general financial depression in 1908 would probably result in a temporary and, perhaps, a severe check to the cement industry. So far as can be estimated now, the plants which will be in operation before the end of 1907 will turn out cement at the rate of over 55,000,000 barrels per annum, and it is doubtful whether such an output could be absorbed if the business affairs of the United States were not in a generally prosperous condition.

RAW MATERIALS IN USE.

For a number of years past the writer has published annually, at first in

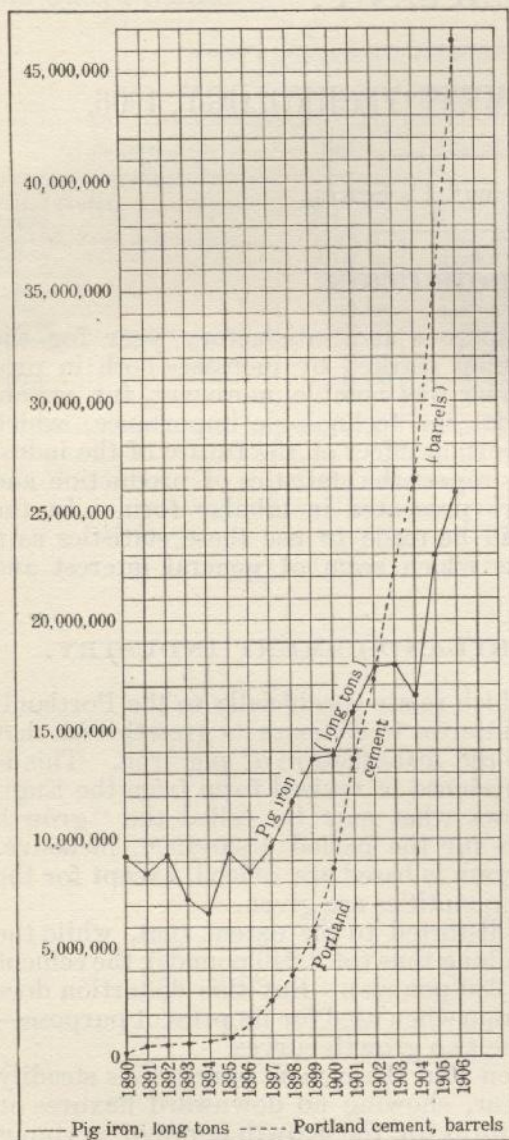


FIG. 2.—Comparison of Portland cement and pig-iron production, 1890-1906.

the columns of Engineering News and later in Mineral Resources of the United States, tables showing the quantities and the percentages of the total Portland-cement output produced from different raw materials. The table following is a continuation of this series, though it has been rearranged so as to be more suited to the apparent trend of trade conditions. The production from chalk and clay has been com-

bined with that from ordinary limestone and clay, as the former showed no tendency to increase. On the other hand, the Portland cement produced from slag and limestone is this year given separately. Practically all of this last class is and has been produced by the United States Steel Corporation, and the fact that it is possible to present these figures without violation of confidence is due entirely to the peculiarly frank and open manner in which the affairs of that corporation are conducted. The figures given are quoted from recently published official statements, and can be accepted as approximating closely to the total production of Portland cement from slag and limestone.

The production is grouped as follows:

Type 1 includes cement produced from a mixture of argillaceous limestone ("cement rock") and pure limestone. This is the combination of materials used in all the cement plants of the Lehigh district of Pennsylvania and New Jersey, and also at several western plants.

Type 2 includes cement made from a mixture of comparatively pure limestone with clay or shale. This mixture is employed at many plants all over the United States.

Type 3 includes cement manufactured from a mixture of marl and clay. This type of mixture is used only in the States of Michigan, Ohio, Indiana, and New York.

Type 4 includes Portland cement manufactured from a mixture of limestone and blast-furnace slag.

Production, in barrels, and percentage of total output of Portland cement in the United States according to type of material used, 1898-1906.

Year.	Type 1. Argillaceous lime- stone (cement rock) and pure limestone.		Type 2. Limestone and clay or shale.		Type 3. Marl and clay.		Type 4. Slag and limestone.	
	Quantity.	Per- centage.	Quantity.	Per- centage.	Quantity.	Per- centage.	Quantity.	Per- centage.
1898	2,764,694	74.9	365,408	9.9	562,092	15.2		
1899	4,010,132	70.9	546,200	9.7	1,095,934	19.4		
1900	5,960,739	70.3	1,034,041	12.2	1,454,797	17.1	32,443	0.4
1901	8,503,500	65.9	2,042,209	16.1	2,001,200	15.7	164,316	1.3
1902	10,953,178	63.6	3,738,303	21.7	2,220,453	12.9	318,710	1.8
1903	12,493,694	55.9	6,333,403	28.3	3,052,946	13.7	462,930	2.1
1904	15,173,391	57.2	7,526,323	28.4	3,332,873	12.6	473,294	1.8
1905	18,454,902	52.4	11,172,389	31.7	3,884,178	11.0	1,735,343	4.9
1906	23,896,951	51.4	16,532,212	35.6	3,958,201	8.5	2,076,000	4.5

The figures for 1906, given in this table, show a continuation of movements which have been in existence for some time. The production from "cement rock" is very slowly falling off in relative importance, that from marl is falling off rather rapidly in percentage, while the production from limestone-clay and limestone-slag mixtures is rapidly increasing. From what is known of the present condition of the marl and slag plants, and of plans for future changes and new construction, it is probably safe to say that within four years more Portland cement will be made from slag than from marl. It must be recognized that marl plants operate under serious natural disadvantages, that these disadvantages are masked by general high prices during such prosperous seasons as we have recently experienced, but that they become painfully apparent during years of general depression. When cement sells at 85 cents or less per barrel at mills in the

Middle West, as it may very well do in 1908 or 1909, it will be an even more serious matter to have water in the raw mixture than to have it in the stock.

KILNS AND KILN PRACTICE.

The statistical inquiry card for 1906 contained a number of questions relating to technologic matters which have heretofore been neglected. The questions relative to number and length of kilns were answered by practically all the cement producers of the country, and the results so obtained are summarized below.

Total number of kilns.—Tables showing the number and types of kilns in use at various dates have been published in preceding volumes of Mineral Resources. Omitting vertical or stationary kilns, these figures, with the data collected this year, may be summarized as follows:

Rotary kilns, 1902, 1905, 1906.

	1902.	1905.	1906.
Operated	456	722	793
Idle	9	23	2
Building	46	42	104
Total number of rotary kilns	511	787	899

In this table the kilns listed as "operated" were those actually in operation during part or all of 1906; the "idle" kilns were those at mills which were not in operation at any time during the year, but which are still in good condition; the "building" kilns include only those which are in plants actually under construction and sufficiently far advanced to be able to enter the 1907 production.

Average output per year.—As noted in last year's report, there is not only a marked increase annually in the number of kilns in existence, but a very decided increase in the length of these kilns. Data on this point are presented in the next section, reference being made to it here merely to explain the increase in average output per kiln. In 1902 each active rotary kiln averaged 36,909 barrels during the year; in 1905 this average was increased to 48,118 barrels; in 1906 the average output per active rotary rose to 58,901 barrels. It is probable that the annual average per kiln for 1907 will exceed 60,000 barrels, and with the increased number of kilns then in operation the Portland-cement output of 1907 may reach 55,000,000 barrels.

Length of kilns in use and under construction.—The data obtained as to the length of kiln in both operating and new plants are summarized in the following table. As will be seen by comparison of the totals in this table with those of the preceding table, the statistics as to length are almost complete:

Length of kilns.

Length of kiln.	Number of kilns operated in 1906.	Number of kilns under construction.	Length of kiln.	Number of kilns operated in 1906.	Number of kilns under construction.
60 feet and less	398	.....	105 to 110 feet	80	24
70 to 78 feet	40	.....	120 feet	17	46
80 feet	69	.....	125 feet and longer	57	30
85 to 90 feet	66	.....		
95 to 100 feet	52	22	Total	779	92

This table brings out very sharply the rapidity with which kilns are lengthening, and also the diversity of opinion which still exists as to the relative merits of the various lengths above 100 feet.

Variation in output with length of kiln, etc.—The statistical data received from each plant this year included information as to total output, number and length of kilns, and duration of total shut downs. By means of these data, which cover a very wide range of material, practice, and operating conditions, it seems probable that average results of fair accuracy can be deduced as to the effect of raw material and length of kiln on the output. This has, at any rate, been attempted, and the results are presented in the following table. In explanation of this table it may be said that the average annual output of a 60-foot kiln, fired with powdered coal and working on a dry mixture of limestone and clay, is taken at 100 per cent. The average outputs of similar and longer kilns working on various raw materials is then referred to this standard, the results being expressed in percentage.

Percentage of variation in output with length of kiln, raw materials, etc.

Raw materials.	Length of kiln.			
	60 feet.	80 feet.	90 feet.	110 feet.
Cement rock and limestone	126	164	182	216
Limestone and clay	100	150	166	190
Marl and clay	54	76	.....	.....

These averages plot into a fairly smooth curve, and seem worthy of attention. Unfortunately the results obtained from kilns fired with oil, natural gas, and producer gas were too few and too uneven to be considered in this connection, so that the table refers only to coal-fired kilns. The results in running on a slag-limestone mixture are omitted for obvious reasons, but they fully justify everything that has been said regarding the remarkable kiln efficiency which can be attained in a plant using this mixture.

LOCALIZATION OF THE INDUSTRY.

The Portland-cement industry exhibits the same tendency toward geographic centralization, though to a less degree, that has given Pittsburg its preeminence as an iron producer. In the case of the Portland-cement industry the concentration of plants is in the so-called Lehigh district of Pennsylvania, with its New Jersey continuation. Here, 18 plants made almost 23,000,000 barrels, or almost exactly half of all the cement produced in the United States in 1906. The Lehigh district was the point where American Portland-cement manufacture

was first undertaken, and it owes its continued preeminence to the possession of good raw materials, good labor, good and fairly cheap fuel, and excellent transportation facilities to large eastern markets.

Taking a general view of the matter, the present geographic distribution of the cement industry is well shown in the following table. The term "East" as here used, includes plants in Pennsylvania, New York, and New Jersey, none being located in New England. The "Central" plants are those in Ohio, Indiana, Illinois, Michigan, and Missouri. Under "West" are included Kansas, Colorado, South Dakota, Arizona, and Utah. On the Pacific coast are the three active California plants and one recently started in Washington. The "South" includes Virginia, West Virginia, Georgia, Alabama, Arkansas, Texas, and Kentucky.

Geographic distribution of Portland-cement industry in 1905 and 1906.

	Number of plants operating.		Output, in barrels.		Percentage of total output.	
	1905.	1906.	1905.	1906.	1905.	1906.
East	30	31	19,589,675	25,483,025	55.6	54.9
Central	32	34	10,723,802	14,030,665	30.4	30.2
West	7	8	2,470,349	3,834,656	7.0	8.2
Pacific coast	3	4	1,225,429	1,310,435	3.5	2.8
South	7	7	1,237,557	1,804,643	3.5	3.9
Total.....	79	84	35,246,812	46,463,424	100.0	100.0

The year shows a slight relative increase in the Western and Southern States as compared with conditions in 1905. Western areas will be supplied much better than they are at present. A powerful impetus in this direction was given by the destruction of San Francisco, which called to the attention of investors in the Eastern States and in England the fact that the Pacific Coast States could normally absorb much more cement than was made on the coast. In the face of the San Francisco disaster the few western plants in operation were not capable of making much impression on the immense and instant demand.

In the South, too, there is an excess of demand over supply, and the few plants now actually under construction in the Southern States will hardly reduce this excess. It is probable that the States south of the Potomac and the Ohio and east of the Mississippi could use, at profitable prices, about five times as much cement as is now made in that district; and for a long time this field will be one of the most profitable ones for the cement manufacturer. Fuel is cheap, raw materials are abundant and good, and the demand is steadily increasing.

THE DIFFICULTY OF MONOPOLY.

Perhaps the most marked feature of American economic history during the last decade has been the manner in which industry after industry has become consolidated in control, so as to approach more or less closely to monopoly. This has been particularly well marked in the iron and steel industries, and it is worth considering how far a similar evolution is likely to affect the cement industry. At present the cement industry is the most individualistic of the larger branches of manufacture. No "trust," nor even any approach to a monopoly,

is now in existence, newspaper statements to the contrary notwithstanding; and in the writer's opinion the nature of the cement industry renders it impossible that any such large degree of consolidation of interest can take place as to result in permanently or unfairly high prices for the product.

When the history of both successful and unsuccessful "trusts" is examined it will be seen that the only way in which a permanent monopoly can be secured and retained by any consolidation is by the control of the supply of raw material, by the absolute control of basic patents, or by the control of transportation. Any trust which disregards this history, and is content with simply consolidating all or most of the existing manufacturing plants, is in line for disaster; for, supplies of raw materials being still available for outsiders, the first advance in prices will be the signal for the erection of competitive plants. If, on the other hand, the raw materials can be cornered, or processes can be monopolized, or transportation can be controlled, there is no possibility of competition. This experience, though unobserved or disregarded a decade ago, is now generally borne in mind.

The bearing of these facts upon the future of the cement industry is obvious enough. If there is any possibility that one large cement corporation can acquire control of most of the available deposits of cement material in the United States, it will be possible to form a real American "cement trust," to defy competition, and to raise prices to an unwarranted level. If, on the other hand, it is impossible to form such a corner in cement rock or in cement-making processes, or permanently to control transportation, it will be impossible for any consolidation to raise prices permanently above the normal.

On careful consideration of the matter it will be seen that only one answer is possible. It is safe to say that more than 20 per cent of the entire area of the United States is underlain by raw materials out of which cement could be made if prices were forced high enough. The Standard Oil Company, the United States Steel Corporation, and the United States Government could not, by combining their financial resources, hope to acquire control of any large fraction of this immense reserve of raw material.

Since the supply of limestone and clay can not be cornered, since no essential parts of the processes of manufacture are covered by exclusive patents, and since transportation companies will seek freight, it is reasonable to believe that no cement combination can succeed in permanently raising prices to unfair rates. As already stated, there is nothing in existence at present even remotely approaching a cement trust. The trouble is rather in the other direction. The prosperity of the last few years, with reports of enormous profits earned by existing companies, has led to the building of many new cement plants. A fair proportion of these are either too small, badly located, faulty in design, or badly managed; and with the first general business depression and the commencement of falling prices such plants will necessarily become a danger to the entire industry. The condition at present is therefore marked by excess rather than lack of competition.

At present, indeed, the only limitation on unprofitable increase in the number of cement plants arises from the fact that even the smallest units are expensive to construct and operate. In any district where

competition could be expected, for example, it would usually be inadvisable to build a smaller than a 4-kiln plant. This plant would have an output of 1,500 barrels or more per day; but its construction would cost \$350,000 to \$450,000, and it would require a working capital of \$125,000 to \$175,000 in addition. Evidently, therefore, the cement industry is not one in which individuals or small firms can find much of an opening.

NORMAL GROWTH AND CONCENTRATION.

Although, as already stated, it is impossible that the cement industry should ever become a monopoly based on control of deposits of raw materials, another phase of the subject requires consideration. The cement industry is essentially one in which brains and money are far more important than raw materials, and consequently cement plants with intelligently directed capital will rapidly increase in size, while poorer or ill-managed plants either remain stationary or expand very slowly. This of itself operates to cause a gradual concentration of interest; the stronger plants grow at the expense of the weaker.

Most of the larger companies which now produce the bulk of the American cement output were originally concerns of only average size. Their growth has taken place in a natural manner, not by the absorption of competitive plants, but by using part of the profits of the business to increase the size of the original plant. In a strongly held and well-managed company this course of action is possible. In a company less strongly owned or less intelligently directed the tendency is always to sacrifice the prospects of ultimate success to the certainty of immediate returns. A company owned by a number of small stockholders can rarely withstand the pressure to pay out all the profits of an unusually prosperous year as dividends.

The larger company, growing by accretion, has also a certain advantage in the matter of advertising its products. When a new plant is established by an old company there is no difficulty in introducing the cement from the new plant, for it sells under an already well-known brand name, and has behind it the accumulated prestige of all the older plants.

During the year 1906 progress toward concentration of interests has been marked. The formation of the North American Cement Company in the East and the Iola consolidation in the West have attracted general attention to this phase of the cement industry.

CAPITALIZATION AND PROMOTION.

From two evils more serious than monopoly—over-capitalization and fraudulent promoting—the American cement industry has been fairly free, though there are signs that this happy immunity is not destined to continue. So far as the first is concerned, figures obtained unofficially from various sources indicate that the total authorized capitalization of all the American Portland-cement plants operating in 1906 falls within the limits of \$110,000,000 and \$125,000,000. This estimate takes no account of outstanding bond issues, but, on the other hand, gives no credit for stock authorized but not issued. On the whole, therefore, it can be accepted as representing very fairly the total capitalization of the entire industry, and can not be considered excessive.

Considering the matter broadly, it can be said that in the East, including the plants from New York to Illinois, there has been little attempt at over-capitalization or fraud. Most of these older companies were organized by persons familiar with the business, and the necessary capital was secured more or less privately, with little attempt to raise money by selling stock to the public. Michigan, apparently, was the first State in which the promoter found an opportunity to display his peculiar talents, and for a number of years that State was dotted with prospective cement plants. Most of these flotations were capitalized excessively, owing to the fact that for the first time in the history of the industry the stock was being sold to the public by promoters. Advertisements of stock for sale at 10 cents or \$1 per share, with promises of 20 to 60 per cent dividends and with wonderful miscalculations as to operating costs, filled the papers of the Middle West during this period.

After the Michigan boom had collapsed, leaving behind it a few good plants, a few poor ones, and a much larger number which had never come into existence other than in the prospectus, the promoter was for a few years scarcely seen or heard of. His reappearance took place when the Iola plant proved the profits in making cement in the natural-gas belt in Kansas, and for the last few years there have been exaggerated statements of the profits awaiting the erection of cement plants in the States west of the Mississippi, notably in Kansas and Iowa.