PORTLAND CEMENT.

By Spencer B. Newberry.

PRODUCTION.

The product of Portland cement in the United States in 1899 was 5,652,306 barrels, an increase over that of 1888 of 1,352,382 barrels, or 33 per cent. This increase is nearly double that of the preceding year, and shows that the erection of new factories and the extension of those already existing are going on still more extensively than in the past. From present indications, the production in 1900 will show a still greater increase, as a great number of new enterprises are projected. The growth of the industry continues to be most marked in Lehigh County, Pennsylvania, and immediate vicinity.

The following table shows the production of Portland cement in 1898 and 1899, by States:

<table>
<thead>
<tr>
<th>State</th>
<th>1888</th>
<th>1899</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of works</td>
<td>Product</td>
</tr>
<tr>
<td></td>
<td>Barrels.</td>
<td></td>
</tr>
<tr>
<td>Arkansas</td>
<td>1,000</td>
<td>50,000</td>
</tr>
<tr>
<td>California</td>
<td>5,000</td>
<td>50,000</td>
</tr>
<tr>
<td>Illinois</td>
<td>10,000</td>
<td>34,000</td>
</tr>
<tr>
<td>Indiana</td>
<td>20,000</td>
<td>50,000</td>
</tr>
<tr>
<td>Michigan</td>
<td>40,000</td>
<td>100,000</td>
</tr>
<tr>
<td>New Jersey</td>
<td>60,000</td>
<td>1,000,000</td>
</tr>
<tr>
<td>New Mexico</td>
<td>10,000</td>
<td>20,000</td>
</tr>
<tr>
<td>New York</td>
<td>50,000</td>
<td>50,000</td>
</tr>
<tr>
<td>Ohio</td>
<td>200,000</td>
<td>500,000</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>5,000,000</td>
<td>5,142,711</td>
</tr>
<tr>
<td>South Dakota</td>
<td>30,000</td>
<td>60,000</td>
</tr>
<tr>
<td>Texas</td>
<td>8,000</td>
<td>24,000</td>
</tr>
<tr>
<td>Utah</td>
<td>10,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Total</td>
<td>81,000</td>
<td>5,652,306</td>
</tr>
</tbody>
</table>
MINERAL RESOURCES.

In the above table the figures for 1888 include the product of three factories manufacturing slag cement, a mechanical mixture of blast-furnace slag and slaked lime, sold by the manufacturers under the name of Portland cement. All authorities agree, however, that this product is not Portland cement. It has therefore been omitted from the table for 1890, and is described as slag cement in a later paragraph.

It will be seen from the above table that the manufacture of Portland cement has been resumed in Arkansas after a year of no production. Illinois appears in the field for the first time, with two factories, and will undoubtedly play an important part in the future development of the industry. One small factory in Indiana was shut down during the year, and the State shows no production. Two large factories are under construction, however, and there is no doubt that Indiana will soon be a large producer. Pennsylvania and New Jersey show, as usual, a great increase in their large production, and this region still maintains its place as the chief center of Portland-cement manufacture in America.

The relative growth of the industry in the most important producing sections during the last ten years is shown in the following table:

*Development of the Portland-cement industry in the United States since 1880.*

<table>
<thead>
<tr>
<th>Section</th>
<th>1890</th>
<th>1894</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Num. of works</td>
<td>Product</td>
</tr>
<tr>
<td>New York</td>
<td>4</td>
<td>65,000</td>
</tr>
<tr>
<td>Lehigh and Northampton, Pa., and Warren County, N.J.</td>
<td>5</td>
<td>201,000</td>
</tr>
<tr>
<td>Ohio</td>
<td>2</td>
<td>22,000</td>
</tr>
<tr>
<td>Michigan</td>
<td>3</td>
<td>17,500</td>
</tr>
<tr>
<td>All other sections</td>
<td>5</td>
<td>47,500</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td>355,500</td>
</tr>
</tbody>
</table>
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Development of the Portland-cement industry in the United States since 1896—Continued.

<table>
<thead>
<tr>
<th>Section</th>
<th>1896</th>
<th>1899</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of works</td>
<td>Product</td>
</tr>
<tr>
<td>New York</td>
<td>7</td>
<td>554,538</td>
</tr>
<tr>
<td>Lehigh and Northampton counties, Pa., and Warren County, N. J.</td>
<td>9</td>
<td>2,674,304</td>
</tr>
<tr>
<td>Ohio</td>
<td>6</td>
<td>265,872</td>
</tr>
<tr>
<td>Michigan</td>
<td>2</td>
<td>33,600</td>
</tr>
<tr>
<td>All other sections</td>
<td>7</td>
<td>120,790</td>
</tr>
<tr>
<td>Total</td>
<td>31</td>
<td>3,092,284</td>
</tr>
</tbody>
</table>

This table shows that the Lehigh Valley region, in eastern Pennsylvania and western New Jersey, still holds its own in relative output. This region, which lies wholly within a circle 15 miles in radius, with Bethlehem as its center, is the seat of the first successful establishment for the manufacture of Portland cement in this country, and has from the first shown a larger production than all the rest of the United States combined. As explained in previous reports, this is due to the occurrence in that neighborhood of an immense deposit of clay-limestone, belonging to the Caledonian formation, which has nearly the composition of a Portland-cement mixture. There are at present 11 factories in this region, 2 of which are larger than any other works in the world. One of these factories is producing over 8,000 barrels a day, and is increasing its capacity still further. No large deposit of similar material has been found elsewhere in the United States. The Central and Western States are, however, abundantly supplied with materials equally suitable for the manufacture of Portland cement, and some localities are more advantageously situated in respect of fuel supply than the Lehigh Valley region. It is probable, therefore, that other sections will show a greater relative increase in the near future, and that the preeminent position of the Lehigh region will not always be maintained.

Referring once more to the table, we see that there has been a considerable reduction in the product of New York. This is perhaps due to the fact that the works in that State use vertical kilns almost exclusively, and that these are less favorably adapted than the rotary kiln to increase of output and economical production. The product of Ohio shows a steady and rapid growth. Michigan, which produced nothing until 1896, is rapidly taking an important place in the list. In
other sections the development of the industry has been comparatively slow; though Indiana, Illinois, and Kansas will soon contribute extensively to the total product of the country.

IMPORTS.

The imports of Portland cement in 1899 were 2,108,388 barrels, an increase of 94,570 barrels over the quantity imported in 1898. This increase may seem surprising in view of the greatly augmented domestic production, but is explained by the extraordinary activity in building operations which prevailed during the year. There is also a certain class of consumers who will have nothing but imported cement. These are chiefly foreign sidewalk masons in the smaller towns. In spite of the high quality and established reputation of the best brands of American cements, there are still a few engineers who specify imported Portland exclusively for all work done under their supervision. The high quality of several domestic brands is so fully established, and the guarantees of the manufacturers are so substantial, that this attitude can now only be characterized as narrow and unprogressive. The best grades of German cement are sold at prices which are from 50 cents to $1 a barrel higher than those of American Portland cements at least equal in quality.

The following table shows the imports, by countries, in 1897, 1898, and 1899:

Imports of cement into the United States in 1897, 1898, and 1899, by countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>1897</th>
<th>1898</th>
<th>1899</th>
</tr>
</thead>
<tbody>
<tr>
<td>United Kingdom</td>
<td>344,338</td>
<td>241,198</td>
<td>199,633</td>
</tr>
<tr>
<td>Belgium</td>
<td>629,088</td>
<td>631,204</td>
<td>624,139</td>
</tr>
<tr>
<td>France</td>
<td>19,319</td>
<td>17,594</td>
<td>15,649</td>
</tr>
<tr>
<td>Germany</td>
<td>1,106,289</td>
<td>1,032,629</td>
<td>1,193,822</td>
</tr>
<tr>
<td>Other European countries</td>
<td>46,066</td>
<td>51,982</td>
<td>68,248</td>
</tr>
<tr>
<td>British North America</td>
<td>4,007</td>
<td>4,635</td>
<td>4,388</td>
</tr>
<tr>
<td>Other countries</td>
<td>36,489</td>
<td>15,476</td>
<td>2,389</td>
</tr>
<tr>
<td>Total</td>
<td>2,009,924</td>
<td>2,033,818</td>
<td>2,108,388</td>
</tr>
</tbody>
</table>

It will be noticed that the imports from Great Britain show a still farther decline from those of former years. The imports from Belgium have also slightly declined, while those from Germany have increased. The quantity imported from other countries is relatively small.
RELATION OF DOMESTIC PRODUCTION TO IMPORTATION.

The amount of Portland cement consumed in the United States in 1899 exceeded that in 1898 by 1,081,012 barrels. As in the previous year, the demand in the autumn months was far greater than the supply, and much inconvenience was felt by contractors on account of the shortage. High prices were paid, in many cases, for immediate shipments, and important engineering works suffered considerable delay. The same conditions prevailed, to a less extent, in England and Germany, and, as in this country, led to the speedy establishment of many new cement factories. The following table shows the relation of production to imports in 1891, 1896, 1898, and 1899.

Comparison of the domestic production of Portland cement with the imports.

<table>
<thead>
<tr>
<th>(Barrels)</th>
<th>1891</th>
<th>1896</th>
<th>1898</th>
<th>1899</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production in the United States</td>
<td>434,813</td>
<td>1,543,823</td>
<td>3,692,384</td>
<td>5,062,268</td>
</tr>
<tr>
<td>Imports</td>
<td>2,988,333</td>
<td>2,980,337</td>
<td>2,913,818</td>
<td>2,108,385</td>
</tr>
<tr>
<td>Total</td>
<td>3,443,126</td>
<td>4,532,659</td>
<td>5,706,122</td>
<td>7,170,654</td>
</tr>
<tr>
<td>Exports</td>
<td>85,489</td>
<td>85,489</td>
<td>85,732</td>
<td>116,272</td>
</tr>
<tr>
<td>Total consumption</td>
<td>3,443,126</td>
<td>4,447,170</td>
<td>5,669,370</td>
<td>7,054,382</td>
</tr>
<tr>
<td>Percentage of total consumption produced in the United States</td>
<td>15.2</td>
<td>34.7</td>
<td>66.1</td>
<td>73.9</td>
</tr>
</tbody>
</table>

The exports given in the above table consisted of exports of foreign cements, 29,182 barrels, and of domestic cements, 81,980 barrels; total, 110,172 barrels. It is probable that a part of the domestic cement exported was natural cement and not Portland.

The increase in the proportion of domestic cement consumed to that of foreign manufacture is a striking feature of the above table. It will be noted that only 15.2 per cent. of the cement used in 1891 was of American manufacture, while in 1899 this percentage had risen to 73.9. Although imported cements will constantly play a less important part in this market, it will probably be many years before importation entirely ceases.
The following diagram shows the course of domestic production, importation, and total consumption of Portland cement in the United States in the last ten years:

![Diagram showing the course of domestic production, importation, and total consumption of Portland cement in the United States from 1890 to 1896.]

This diagram shows that the imports of cement, with some variations, have remained substantially constant since 1890. The domestic product, however, which in that year amounted to only 335,500 barrels, or 15 per cent of the total amount consumed, has increased in ten years seventeen times, and now supplies nearly 74 per cent of the demand. It will be noticed that the cement manufactured in the United States in 1896 was almost exactly equal to the amount consumed in 1898, so closely does the production follow upon the heels of the demand. The regularity of the curve of production is most striking, and shows an uninterrupted increase at a constantly accelerated rate. We may well congratulate ourselves upon this rapid development of a great industry, so long as the demand keeps pace with the advance in production. It is to be feared, however, that factories are being established and extended with little consideration of the probable future condition of the market. For ten years each year has witnessed an increased consumption of Portland cement almost...
exactly equal to the increased output of our factories. It is hardly to be expected that this advance in demand can continue as in the past, at constantly increasing speed. The least check in the extension of the applications of cement, or a year in which the amount used is only equal to that of the previous year, will bring about a sudden and immense overproduction, with great disaster to the smaller and less favorably situated manufacturers. Whether this will take place next year or the year following can only be conjectured; it is certain, however, that the day of keen competition among American producers is not far distant. The fall in prices which this competition will produce will stimulate the demand for the product, partly at the expense of natural cements. There is no doubt that Portland cement is at present manufactured in this country at lower cost than anywhere else in the world, and this fact, with the extent and magnitude of our engineering enterprises and public improvements, will undoubtedly develop a demand for cement far exceeding that in the countries of Europe.

The production and annual percentage of increase in the last ten years have been as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Product</th>
<th>Increase</th>
<th>Percentage of Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1890</td>
<td>385,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1891</td>
<td>464,833</td>
<td>119,833</td>
<td>31.6</td>
</tr>
<tr>
<td>1892</td>
<td>547,449</td>
<td>92,616</td>
<td>20.4</td>
</tr>
<tr>
<td>1893</td>
<td>590,432</td>
<td>43,083</td>
<td>7.9</td>
</tr>
<tr>
<td>1894</td>
<td>788,752</td>
<td>208,310</td>
<td>55.3</td>
</tr>
<tr>
<td>1895</td>
<td>990,324</td>
<td>201,572</td>
<td>24.0</td>
</tr>
<tr>
<td>1896</td>
<td>1,163,925</td>
<td>552,601</td>
<td>55.8</td>
</tr>
<tr>
<td>1897</td>
<td>2,077,775</td>
<td>1,104,752</td>
<td>73.5</td>
</tr>
<tr>
<td>1898</td>
<td>3,092,284</td>
<td>1,014,500</td>
<td>37.9</td>
</tr>
<tr>
<td>1899</td>
<td>5,052,283</td>
<td>1,959,992</td>
<td>33.1</td>
</tr>
</tbody>
</table>

The average rate of increase from year to year has been about 40 per cent. This rate continued for four more years would give an annual production of over 29,000,000 barrels, or more than the amount at present made in Germany. That the domestic product has not been restrained by limited demand is shown by the nearly constant imports since 1890. There is good reason to believe that the past rate of increase will continue for at least another year, and that the product of 1896 will reach nearly 8,000,000 barrels. Many new enterprises are projected, and existing factories are rapidly increasing their output. Most of the substantial new projects are located in the Lehigh Valley region, and that section appears likely to maintain its preeminence for some time to come. A number of companies have, how-
ever, been organized in Michigan, and that State will probably soon become an important producer. The great obstacle to the establishment of large factories in the central portion of the country is the lack of deposits of material of sufficient extent to warrant the investment of large capital. It must be apparent to everyone that the day is rapidly approaching when no factories will be profitable except those producing several thousand barrels per day. The folly of building works upon small deposits of material is therefore becoming constantly more evident.

THE PORTLAND-CEMENT INDUSTRY IN THE VARIOUS STATES.

ILLINOIS.

Two of the three factories located near La Salle were producing during the last year, and the third, that of the German-American Portland Cement Company, will be started early in 1900.

In the report of 1898 the statement was made that the Illinois Steel Company had practically discontinued the manufacture of slag cement. The writer is informed that this is an error, and that the manufacture of this product has been considerably increased. This company proposes, however, to manufacture Portland cement also, by adding to the slag the necessary amount of Bedford limestone and calcining the mixture in rotary kilns.

INDIANA.

The factories of the Sandusky Portland Cement Company at Syracuse, Kosciusko County, and the Wabash Portland Cement Company at Stroh, Lagrange County, are in process of erection, and will be put in operation early in 1900.

Works are projected at Bristol, in the northern part of the State, by the Mononith Portland Cement Company. The materials found at that point have the following composition:

<table>
<thead>
<tr>
<th>Material</th>
<th>Per cent.</th>
<th>Clay</th>
<th>Per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbonate of lime</td>
<td>92.50</td>
<td>Silica</td>
<td>49.56</td>
</tr>
<tr>
<td>Carbonate of magnesia</td>
<td>2.19</td>
<td>Alumina</td>
<td>8.32</td>
</tr>
<tr>
<td>Silicious matter</td>
<td>1.61</td>
<td>Iron oxide</td>
<td>2.84</td>
</tr>
<tr>
<td>Water and organic</td>
<td>3.58</td>
<td>Carbonate of lime</td>
<td>37.49</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Carbonate of magnesia</td>
<td>2.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alkalies</td>
<td>1.92</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water and organic</td>
<td>3.95</td>
</tr>
<tr>
<td>Total</td>
<td>100.18</td>
<td>Total</td>
<td>100</td>
</tr>
</tbody>
</table>
PORTLAND CEMENT.

KANSAS.

Large works are under construction at Iola and will be in operation early in 1906. Limestone and clay will be used as materials and natural gas as fuel.

MICHIGAN.

The Michigan Alkali Company is regularly manufacturing Portland cement from the waste or precipitated carbonate of lime produced in causticizing soda and clay. The materials are mixed and burned in rotary kilns. The analysis of the materials is as follows:

<table>
<thead>
<tr>
<th>Waste</th>
<th>Per cent.</th>
<th>Clay</th>
<th>Per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lime</td>
<td>50.90</td>
<td>Silica</td>
<td>46.81</td>
</tr>
<tr>
<td>Magnesia</td>
<td>5.35</td>
<td>Alumina and iron oxide</td>
<td>14.21</td>
</tr>
<tr>
<td>Silica</td>
<td>1.75</td>
<td>Lime</td>
<td>14.04</td>
</tr>
<tr>
<td>Alumina and iron oxide</td>
<td>0.61</td>
<td>Magnesia</td>
<td>3.61</td>
</tr>
<tr>
<td>Sulphur</td>
<td>0.10</td>
<td>Sulphur</td>
<td>1.18</td>
</tr>
<tr>
<td>Alkalies</td>
<td>0.94</td>
<td>Alkalies</td>
<td>3.04</td>
</tr>
<tr>
<td>Loss on ignition</td>
<td>41.70</td>
<td>Loss on ignition</td>
<td>10.75</td>
</tr>
<tr>
<td>Total</td>
<td>106.75</td>
<td>Total</td>
<td>98.64</td>
</tr>
</tbody>
</table>

Works are also under construction or projected at Jonesville, Baldwin, Newaygo, Elk Rapids, Alpena, Cementon, Fenton, and Three Rivers.

NEW JERSEY.

The Edison Portland Cement Company, at Stewartsville, Warren County, proposes to burn cement in a gigantic rotary kiln, 110 feet in length and 10 feet in diameter. The kiln has been constructed, but is not yet in operation.

NORTH DAKOTA.

The factory and deposit from which the Pembina Portland cement is made are located on Tongue River, in the Pembina Mountains. The material is a chalky clay, and geologically belongs to the Middle Cretaceous. It is soft enough to be mined by the pick, but may be wedged out in blocks weighing several hundred pounds. The material occurs in layers of varying thickness, which outcrop from a hillside. They have a total thickness of over 50 feet. Only certain of these layers are used for cement. The material is taken out by tunneling.

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MINERAL RESOURCES.

This mark-clay varies much in chemical composition. It is therefore necessary to observe great care in selecting and mixing the proper layers. A great number of chemical analyses are made and the essential composition of the different layers worked lies within about the following range:

Composition of mark-clay from North Dakota, used for cement manufacture.

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica</td>
<td>9 to 15</td>
</tr>
<tr>
<td>Alumina</td>
<td>4 to 8</td>
</tr>
<tr>
<td>Iron oxide</td>
<td>2 to 3</td>
</tr>
<tr>
<td>Carbonate of lime</td>
<td>63 to 73</td>
</tr>
<tr>
<td>Carbonate of magnesia</td>
<td>1 to 2.5</td>
</tr>
</tbody>
</table>

The different layers are properly proportioned, and after being ground and mixed are burned in a rotary kiln with pulverized coal. The factory has a capacity of 125 barrels a day. The factory is located about 500 feet from the hillside from which the raw material is taken. The plant was designed by Lathbury and Spuckman, of Philadelphia, and the erection was superintended by Mr. F. D. Wood.

OHIO.

The Alma Portland Cement Company, at Wellston, began operations in April, 1899. The materials are as follows:

Composition of Portland-cement materials from Wellston, Ohio.

<table>
<thead>
<tr>
<th>Limestone</th>
<th>Percent</th>
<th>Clay</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lime</td>
<td>84.45</td>
<td>Silica</td>
<td>69.40</td>
</tr>
<tr>
<td>Magnesia</td>
<td>9.44</td>
<td>Alumina and iron oxide</td>
<td>16.42</td>
</tr>
<tr>
<td>Silica</td>
<td>3.33</td>
<td>Lime</td>
<td>2.29</td>
</tr>
<tr>
<td>Alumina and iron oxide</td>
<td>1.14</td>
<td>Magnesia</td>
<td>6.78</td>
</tr>
<tr>
<td>Loss on ignition</td>
<td>88.74</td>
<td>Loss on ignition</td>
<td>5.43</td>
</tr>
<tr>
<td>Total</td>
<td>98.10</td>
<td>Total</td>
<td>94.41</td>
</tr>
</tbody>
</table>

ACKNOWLEDGMENTS.

For much of the above information in regard to new enterprises and the composition of the materials employed the writer is indebted to Messrs. Lathbury & Spuckman, engineers, of Philadelphia, Pa.
PORTLAND CEMENT.

SLAG CEMENT.

Slag cement, made by grinding together granulated slag and slaked lime, was manufactured in 1898 at three factories, located at South Chicago, Illinois; Youngstown, Ohio; and Sparrow Point, Maryland. The total product was 333,000 barrels.

MATERIALS.

The composition of marls, limestones, and clays used or to be used at several new factories is stated on the foregoing pages. The question of the relative advantages of marl or limestone as a cement material is one which admits of much argument on both sides. Since Portland cement of good quality can be produced only by artificial mixture of the raw materials in exact proportions, it is obvious that the same result can be reached with either marl or limestone, if of suitable chemical composition. From a mechanical point of view there can be no question that a soft, fine-grained marl may be intimately mixed with the necessary clay far more easily than a hard, crystalline limestone. The drawback of marl is that deposits are usually small and scattered, necessitating irregular working and much transportation of material. Limestone possesses great advantages in extent and uniformity of deposits and in yield of cement from a given volume. A cubic yard of limestone produces about eight barrels of cement, while the same volume of marl yields only about two barrels. Limestone containing approximately the amount of clay required for a correct Portland-cement mixture is of course a very favorable material, though it is always necessary to bring it to correct composition by careful grinding, with the addition of material higher or lower in lime, as may be required. Such limestone is found in inexhaustible quantities in the Lehigh Valley region of Pennsylvania and New Jersey. This stone is generally deficient in lime, and the addition of from 10 to 25 per cent of a nearly pure limestone is necessary to give the mixture the 78 or 74 per cent of carbonate of lime required. Through the kindness of manufacturers in that region the writer is enabled to give the following typical analyses of Lehigh Valley cement rock and limestone.
The writer's experiments, based upon those of Le Chatelier, have shown that the maximum of lime allowable in Portland cement may be represented by the following formula:

\[
\text{Lime} = \text{silica} \times 2.8 + \text{alumina} \times 1.1; \text{ or,}
\]

\[
\text{Carbonate of lime} = \text{silica} \times 5 + \text{alumina} \times 2.
\]

This maximum can be reached only by extremely fine grinding of the raw materials. In practice the preparation of the materials is always imperfect, and a certain part of the silica and alumina present remains inactive, as is shown by the occurrence of a small percentage of inessential matter in all commercial cements. For this reason the proportion of carbonate of lime is usually carried about 1 to 2 per cent lower than that called for by the above formula.

As an example of a simple method of calculating cement mixtures, let us apply the formula to the Northampton cement rock No. 1 and the Coplay limestone (assuming the latter to contain 1 per cent of alumina), as follows:

**Limestone.**

<table>
<thead>
<tr>
<th>Total carbonate of lime</th>
<th>94.35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica, (2.14 \times 8 = 10.70)</td>
<td>12.70</td>
</tr>
<tr>
<td>Alumina, (7.00 \times 2 = 14.00)</td>
<td>12.85</td>
</tr>
</tbody>
</table>

**Available carbonate of lime**

\(81.65\)

**Cement rock.**

| Silica, \(15.00 \times 5 = 95.00\) | 94.38 |
| Alumina, \(4.44 \times 2 = 8.88\) | 60.24 |

**Required carbonate of lime for 100 parts cement rock**

\(34.94\)

---

PORTLAND CEMENT.

The number of parts limestone required for 100 parts cement rock will then be—

\[
\frac{34.94 \times 100}{81.05} = 42.8
\]

The per cent of carbonate of lime in the mixture will then be—

- In 100 parts cement rock: 69.24
- In 42.8 parts limestone: 90.38
- In 142.8 parts mixture: 100.62

\[
\frac{109.62 \times 100}{142.8} = 76.7 \text{ per cent.}
\]

The other samples of cement rock will give practically the same result, varying slightly with the proportion of inert materials (magnesia and iron oxide) present. In practice, from 74 to 75 per cent carbonate of lime is found to be a good working proportion.

The following table shows the comparative product from limestone and marl in 1898 and 1899:

<table>
<thead>
<tr>
<th>Process</th>
<th>1898</th>
<th>1899</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Product</td>
</tr>
<tr>
<td>Factories using limestone</td>
<td>29</td>
<td>3,312,492</td>
</tr>
<tr>
<td>Factories using marl</td>
<td>11</td>
<td>576,762</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>31</strong></td>
<td><strong>3,889,254</strong></td>
</tr>
</tbody>
</table>

PROCESSES.

The use of the rotary kiln for burning cement continues to increase, as may be seen by the following table:

Amount of Portland cement made in kilns of various kinds.

<table>
<thead>
<tr>
<th>Kiln Type</th>
<th>1895</th>
<th>1897</th>
<th>1898</th>
<th>1899</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotary kilns</td>
<td>149,900</td>
<td>1,311,319</td>
<td>2,170,782</td>
<td>3,711,229</td>
</tr>
<tr>
<td>Vertical kilns (continuous and intermittent)</td>
<td>441,453</td>
<td>1,396,406</td>
<td>1,521,592</td>
<td>1,841,943</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>590,353</strong></td>
<td><strong>2,707,715</strong></td>
<td><strong>3,692,374</strong></td>
<td><strong>5,553,172</strong></td>
</tr>
<tr>
<td><strong>Per cent of total product burned in rotary kilns</strong></td>
<td><strong>25.2%</strong></td>
<td><strong>48.0%</strong></td>
<td><strong>58.8%</strong></td>
<td><strong>65.7%</strong></td>
</tr>
</tbody>
</table>
In 1899, rotary kilns were in use at 29 factories, and vertical kilns at 16.

The rotary kiln process of cement burning originated in England, having been patented by Siemens in 1869, and was first practically used by Rankine in 1885. The results at first obtained were, however, disappointing, and in spite of the evident advantages of the process the invention was dropped, apparently with little effort to discover or remove the causes of failure. The higher price of labor in the United States offered a special inducement to experiments in the direction of labor-saving machinery, and the rotary kiln was taken up in this country with most encouraging results. At present it appears destined to supplant entirely the older forms of kiln.

The rotary kiln has now again been introduced into Europe, with the benefit of improvements made and experience gained by American engineers. One has been installed by M. Candlot & Cie, at Denneumont, France; one by J. C. Gostling, and thirty-two by J. B. White & Bros., in England. In Germany, one kiln has been built at Lollar and four at Hemmoor. A full account of the results obtained at the latter factory is given in the report of the last annual meeting of the Association of German Portland Cement Manufacturers. The cement obtained is stated to be superior to that obtained from the Dietzsch kiln, and a saving in cost of manufacture of 44 pfennigs (11 cents) per barrel has already been attained. It appears probable that the use of the rotary kiln in European countries will extend no less rapidly than in the United States.