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GOVERNMENT OF INDIA.
INDIAN STORES DEPARTMENT.

**Report on Portland Cement of
Indian Manufacture**

by

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Superintendent, Government Test House.



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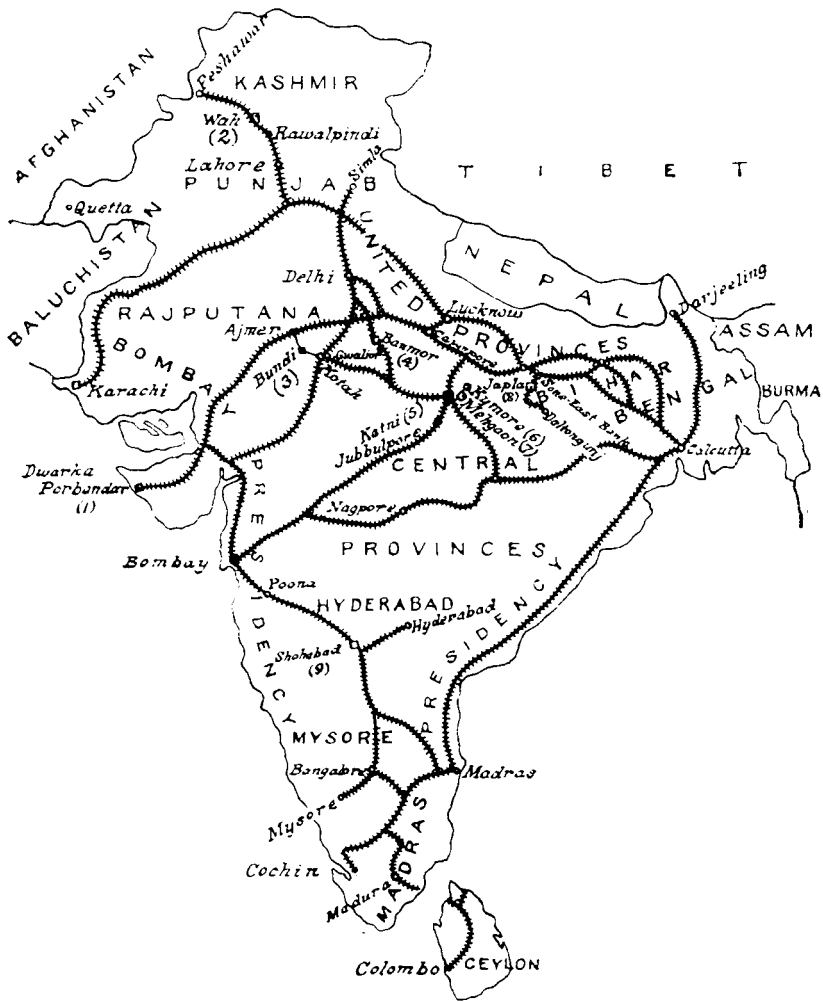
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REPORT ON PORTLAND CEMENT OF INDIAN MANUFACTURE.

PART I.—GENERAL.

INTRODUCTION.

In 1918 the Indian Munitions Board published a report by Mr. Henry A. F. Musgrave, Superintendent of Local Manufactures, on the then existing Portland cement factories in India. Since that time the increase in the number of cement factories and the development of the manufacture of Portland cement in India have rendered the report out of date and it has been decided to issue a fresh report showing the present state of the Portland cement industry in India.

CONSUMPTION OF INDIAN AND IMPORTED CEMENT.

The Portland cement industry in India is a comparatively new one. Manufacture began in 1914 in the Indian Cement Company's works at Porbandar and in the Katni Cement and Industrial Company's works at Katni. At the time of Mr. Musgrave's report these two factories and that of the Bundi Hydraulic Lime and Cement Company (now Bundi Portland Cement, Ltd.) at Bundi were in operation. The present report deals with nine cement factories, while the annual output of cement has increased from about 87,000 tons in 1918 to about 280,000 tons in 1924-25.

The following table shows the imports of Portland cement for the last twenty years:—

	Tons.
1905-6	89,421
1906-7	85,725
1907-8	89,386
1908-9	98,233
1909-10	100,609
1910-11	126,645
1911-12	116,951
1912-13	160,564
1913-14	146,518
1914-15	144,972
1915-16	131,625
1916-17	89,388
1917-18	85,755

	Tons.
1918-19	27,177
1919-20	77,230
1920-21	127,420
1921-22	119,593
1922-23	133,268
1923-24	112,458
1924-25	111,779

CAPACITY OF EXISTING FACTORIES.

It will be seen that the total consumption of Portland cement in India in 1924-25 was about 400,000 tons, approximately three times the pre-war consumption. Some 70 per cent. of this cement was of Indian manufacture. While this is in a measure satisfactory, considering the comparatively recent origin of the industry in India, the amount supplied from Indian factories is far below their capacity. The nine factories described below have among them thirteen rotary kilns of which the capacity may be taken, at a conservative estimate, as about 500,000 tons a year or considerably more than the whole of the cement used in India and nearly twice the present outturn. One large factory has closed down and if this were revived the capacity for production would be about 600,000 tons a year. In addition to this many factories are designed with a view to doubling or increasing the existing plant at proportionately less than the original expenditure. In short, the industry is suffering from over production or potential over production. At the same time the continuing increase in the proportion of Indian made cement used as opposed to imported cement and the increasing total amounts of cement used make future prospects more hopeful.

LOCATION OF THE INDIAN FACTORIES.

The location of cement factories is of importance because of the heavy freight charges which the material has, proportionately to its value, to bear. The choice of cement for any particular work depends therefore largely on the proximity or otherwise of the factories of competing manufacturers. The accompanying map shows the positions of the nine factories described in this report. It will be noticed that most of the factories lie within an area which is small considered in comparison with the size

of the country and particularly that in the Katni area there are three factories within a few miles of one another. These three factories contain five kilns out of the total of thirteen kilns.

In view of this crowding together of some of the biggest factories it is of interest that the factory most recently started, at Shahabad, is in Southern India which up to the present has possessed no cement factories.

FACTORS INFLUENCING THE RELATIVE CONSUMPTION OF INDIAN AND IMPORTED CEMENTS.

The relative consumptions of Indian and imported cements are influenced by several factors. One of these is referred to in the preceding paragraph and high freight charges place the products of any Indian factory at a disadvantage in distant localities, so that it may in some parts of India be cheaper to use imported cement. Secondly the fact that cement is imported in wooden barrels, while Indian cement is packed in bags, has its influence, especially as regards the smaller consumers, because of the more rapid deterioration of bagged cement. Finally the effect of tradition is considerable. It is easy to understand the preference of an engineer for a known and tried brand and this again must particularly affect the smaller consumer in view of the cost of testing which, while inconsiderable when spread over a large tonnage, is a serious matter when small quantities are involved. As far as large consumers are concerned, the increasing amount of Indian cement used is very noticeable. While some of the large consumers still use imported cement, the great majority now use cement of Indian manufacture.

QUALITY OF INDIAN CEMENT.

Taking these factors into consideration the fact that the consumption of Indian made cement has risen in the course of a comparatively few years from nearly nothing to 70 per cent. of the whole is an excellent testimonial to its quality. In point of fact the average quality of Indian cement is considerably higher than the average quality of imported cement, while the best Indian cements are of very high quality.

A serious defect in cement is an unduly short setting time. This is found in some brands of cements, both Indian and imported, and is very irregular in its occurrence. This is a point that requires the most careful attention of manufacturers and it is most important that factories should acquire a reputation for producing cement which can be trusted to be always of normal setting time.

The strength of cement is also, naturally, of importance. The various brands of Indian cement differ among themselves in this respect, but all are good and this is more than can be said of all imported brands. It may in fact be said that, apart from setting time, any inferior Portland cement now sold in India is imported.

MANUFACTURE OF CEMENT.

The manufacture of Portland cement started almost exactly a hundred years ago as a development of the burning of lime. Lime (calcium oxide) is produced by the burning of one of the forms of calcium carbonate, *viz.*, chalk and limestone. Carbon dioxide is driven off and calcium oxide remains. Lime as a building material has been used for at least many centuries, while it must early have been noticed that different limestones and chalks when burned produced limes of very different qualities. This knowledge was presumably empirical; but it is now known that the best limes for building purposes, that is those which make the strongest mortars, are produced by the burning of impure limestone containing silica and alumina. Pure lime hardens by the absorption of carbon-dioxide from the air, resulting in the formation of calcium carbonate (carbonate of lime), a relatively weak material, while limestones containing silica and alumina burn to a material containing calcium silicates and calcium aluminates arising from the combination of lime with silica and alumina respectively at the temperature of burning. These calcium silicates and aluminates are acted on by water in a manner not yet completely understood and when made into a paste, as in the manufacture of mortar, crystallise and form a mass which is extremely hard. Limes made from such impure limestone ("hydraulic limes") contain a certain amount of calcium silicates and aluminates and give much harder mortars than does pure lime. The strength, however, of these mortars is very

variable and in any case compares extremely poorly with the strength of Portland cement mortars. The principle of the manufacture of Portland cement is the selection of materials and their appropriate treatment to give a product which consists almost exclusively of calcium silicates and aluminates containing no or very little free lime. Limestones may be found in nature which, as in the case of the Bundi and Gwalior limestones, contain silica and alumina in the proportions required to make Portland cement. It is, however, usually necessary to add silica and alumina, generally in the form of clay, which is an aluminium silicate.

The British Engineering Standards Association defines Portland cement as a material "manufactured by intimately mixing together calcareous and argillaceous or other silica and alumina bearing materials, burning them at a clinkering temperature and grinding the resulting clinker." In India the calcareous and argillaceous materials are usually limestone and clay respectively. To these are sometimes added bauxite (aluminium hydroxide) or silica rock in the event of a shortage of alumina or silica respectively. It has already been stated that at Bundi and Gwalior the varieties of limestone used contain naturally the necessary alumina and silica and no addition of clay or other material is necessary.

From whatever raw materials it is made, Portland cement consists essentially of a mixture of calcium silicates and aluminates. Its essential constituents are accordingly lime, silica and alumina. Commercial Portland cement contains other materials also and the following is a typical analysis:—

	Per cent.
Loss on ignition	1.60
Insoluble matter	0.50
Silica	22.75
Iron oxide	2.29
Alumina	5.91
Lime	62.72
Magnesia	2.62
Sulphuric anhydride	1.61
	100.00

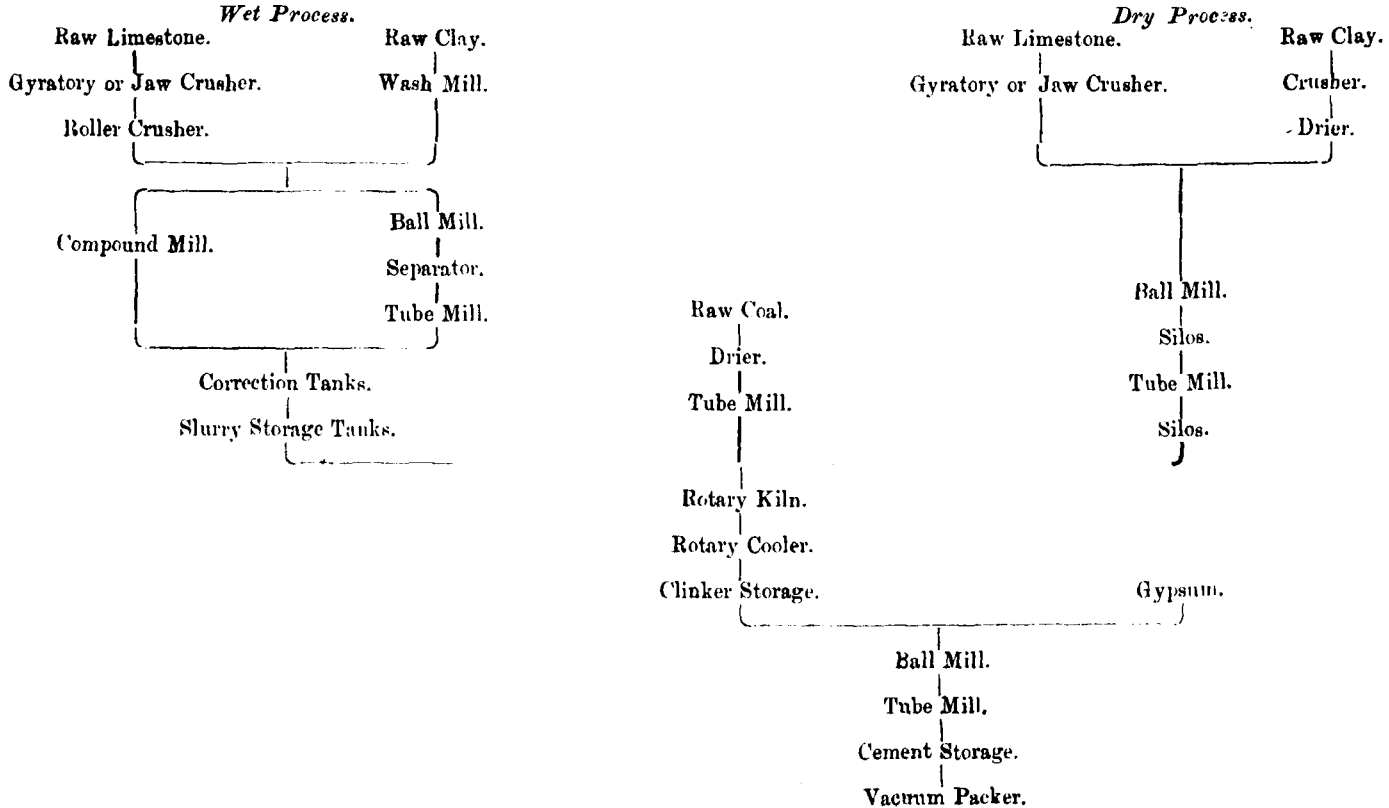
Sulphuric anhydride is derived principally from gypsum (calcium sulphate) which is added to cement after burning in order to regulate the setting time. Loss on ignition is mostly moisture. The remaining constituents are impurities present in the raw materials used.

It will be seen from the definition quoted of Portland cement that it is made at a clinkering temperature, that is to say, the materials are heated short of the molten condition. In this only partially fused state action between the constituents of the mixture, that is between the lime and the silica and alumina, takes place much less rapidly than it would in the molten condition. It is therefore necessary that extremely intimate mixture of the materials should be attained beforehand. For this reason the limestone, clay, etc., are ground to an extremely fine state and mixed with the greatest thoroughness before introduction into the kiln. The finished Portland cement is re-ground equally finely in order that its adhesive properties may be fully developed. The remarkably high strength attained with modern Portland cements, compared with the best of limes or even with Portland cements made comparatively a few years ago, depends therefore on careful selection of the raw materials to give the best proportions of lime, silica and alumina, on the intimacy of the admixture of these materials that is now practised, on careful attention to the conditions of burning and on the extremely fine grinding of the finished cement that is universal in modern factories.

For the proper admixture of the raw materials of the cement, two processes, known as the wet process and the dry process respectively, are in use, the choice depending largely on the nature of the raw materials.

The following diagram gives the general scheme of operation of cement manufacture by either process. In this and in the description that follows it will of course be understood that there is considerable diversity of practice in different factories, so that the description, while showing the general procedure, is not necessarily applicable in all its details to every factory

Diagram showing the general scheme of operation of cement manufacture by wet and dry processes.



WET PROCESS.

The wet process was originally used to deal with comparatively soft materials, such as the chalk used in England for cement manufacture. It has, however, in recent years come largely into use for dealing with harder materials. This process is used in the majority of Indian factories.

The limestone is crushed in several stages, since the method of treatment appropriate for breaking down the large pieces is naturally unsuitable for the further comminution of small particles. The limestone as received into the factory is first crushed by a crusher of the jaw type or the gyratory type, the latter being a machine much on the principle of a coffee-mill. In this crusher the limestone is broken to a diameter of $2\frac{1}{2}$ " or 3" and is then usually further reduced by passing it through rollers which produce material of about an inch or less in diameter.

The softer nature of clay permits of simpler treatment and the clay is usually discharged together with water into a wash mill which consists of a large basin fitted with rotating paddles. The clay is thus broken up and mixed with water to form "clay slurry".

The subsequent treatment of the crushed stone and the clay usually takes place in two stages. The crushed limestone is fed together with clay slurry and water into a ball mill. This consists of a steel cylinder partially filled with steel balls and rotating on a horizontal axis. The sides of the cylinder are fitted with plates which carry the balls, the limestone, etc., to a certain height and then allow them to drop, so that a crushing action takes place by percussion. In the ball mill the limestone is reduced to much the size of sand, so that it will pass a sieve of 20×20 meshes to the square inch. The wet mixture then passes to a tube mill which consists, like the ball mill, of a rotating cylinder partially filled either with flints or, in modern practice, more often with steel bodies, either balls of smaller size than those used in the ball mill or bodies which present a larger grinding surface than balls. One form, for example, is much the shape of a dumb-bell and thus presents convex and concave surfaces

which give considerable effective surface for grinding. In modern practice compound mills are frequently used instead of separate ball and tube mills. These mills have two compartments corresponding to the separate mills of older practice. Some compound mills have three compartments. In any case the grinding takes place by attrition due to the motion of the grinding bodies as the drum revolves.

The mixture, which is known as "slurry", leaves the tube mill in the form of a thick liquid containing about 35 to 40 per cent. of water. The solid materials are in a state of extremely fine division, so that the great majority of the particles will pass a sieve of 180×180 meshes to the square inch. The slurry is passed by bucket elevators, ram pumps or suction conveyors to correction tanks in which the final composition is adjusted. In the correction tanks the slurry is maintained in a state of continuous agitation by means of compressed air, mechanical stirrers or both. The material is analysed to determine its composition and the amount of clay or limestone necessary for correction is added, also in the form of slurry. When the composition of the slurry has been passed as correct, the slurry passes to a storage tank in which it is again kept agitated. From the storage tanks the slurry passes finally to the kiln.

DRY PROCESS.

The dry process is used by two Indian companies, Bundi Portland Cement, Ltd., and the Indian Cement Company, Ltd. Admixture of the materials occurs in the dry state and, when clay is used, as by the Indian Cement Company, this implies drying of the clay as a preliminary operation, in order to avoid clogging of the mills. As in the wet process, grinding takes place in ball and tube mills and *mutatis mutandis* the general procedure is similar.

CLINKERING.

The modern method of producing Portland cement clinker is by the rotary kiln and such kilns are in use in all the Indian factories described. The rotary kiln consists of a cylinder, usually about 150 to 200 feet long and

7 to 9 feet in diameter. The diameter, however, is usually not uniform and most kilns have a greater diameter towards the lower, or burning, end. The kiln is inclined, generally at an angle of about 5° to the horizontal, and rotates slowly, *e.g.*, between 30 and 90 revolutions per hour. The shell of the kiln is built of steel plates and the lining is of fire-brick or other resistant material. To the shell are attached steel tyres which are supported on rollers on which the kiln rotates. The rotary motion is obtained by means of a pinion which engages with a circular steel rack attached to the shell of the kiln. The pinion is driven through reduction gearing, generally by a variable speed electric motor, so that the speed of the rotation of the kiln can be controlled.

The slurry from the wet process or "raw meal" from the dry process is fed in at the top end of the kiln. In the two Indian factories using the dry process the raw meal is damped before being fed. This is in order to prevent dust. The material passes along and down the kiln meeting increasing temperatures. Water is first expelled, then carbon-dioxide is driven off from the limestone and finally in the burning zone combination between the constituents takes place with the formation of cement clinker. The temperature at this stage is about $1,500^{\circ}\text{C}$. The clinker passes from the kiln into a rotary cooler, which is also a rotating cylinder but much smaller and shorter than the kiln.

The fuel used for the rotary kiln is powdered coal. The coal is first dried and finely powdered and is injected into the burning zone of the kiln by an air blast. The air for this blast is drawn from the cooler, so that the process is to this extent regenerative. The clinker from the cooler is despatched either to the mills or to the storage sheds, from which it is subsequently drawn for grinding. The grinding process is carried out, as in the case of the raw materials, by ball mills and tube mills or by compound mills. The clinker is fed into the ball mill or compound mill together with a small and regulated amount (usually about 2 per cent.) of gypsum, which is added to regulate the setting time. Intimate mixing of the gypsum with the clinker occurs during the process of grinding. The fineness of the finished cement is of much the same order.

as that of the raw materials before they enter the kiln, *i.e.*, it leaves a comparatively small residue on a sieve of 180×180 meshes to the square inch.

SETTING TIME.

The addition of gypsum in order to regulate the setting time of cement has been mentioned above. Rotary kiln clinker if ground by itself, without precautions to regulate the setting time, sets with extreme rapidity and would be unusable in this condition. It is found that the addition of a small quantity of gypsum (calcium sulphate) overcomes this defect, but the theory of its action is not completely known. Unfortunately, the action of gypsum is irregular and not permanent so that cements originally of normal setting time sometimes become quick setting on storage and in extreme cases may set completely almost as soon as they are mixed with water.

The importance of overcoming this serious defect has already been mentioned.

PACKING.

Finished cement from the mill is stored in silos and is drawn from these for packing by means of vacuum packing and automatic weighing machines. The bag into which the cement is to be packed is placed in a vacuum chamber connected to the silo by a tube. When the door of the chamber is closed, a partial vacuum is created by means of an exhaust pump and the cement flows through the tube into the bag. The bag is suspended from a counterweighted beam and, when the correct weight of cement has entered the bag, the beam falls and opens the chamber to the air, thus destroying the vacuum and stopping the flow of cement.

PART II.—MANUFACTURERS OF PORTLAND CEMENT.

BUNDI PORTLAND CEMENT, LTD.

(Agents: Messrs. Killick, Nixon and Co., Bombay.)

“ *B. B. B.* ” *Brand Portland Cement.*

The Company's works are situated at Lakheri in Bundi State, Rajputana, on the B. B. & C. I. Railway, 250 miles south of Delhi, on the Nagda-Muttra Section. The Company's lease covers an area of 101 square miles. The suitability of the limestone deposits at Lakheri for making Portland cement was accidentally discovered at the time the Nagda-Muttra Section of the B. B. & C. I. Railway was under construction. The stone had long been used for lime burning and was found to have hydraulic properties similar to those of the Blue Lias formations in England. The district was prospected and the present Company resulted. The attention of the Company was first directed to the manufacture of hydraulic lime and this is still manufactured by the Company. Later Portland cement was made on a small scale in vertical kilns. The present plant started in 1916. The works are situated about three miles from Lakheri Station and are connected with the B. B. & C. I. Railway by a broad gauge siding laid in 1922 and owned by the Company.

Staff and Labour.—The staff includes the manager, chemist, chief engineer, assistant engineer and electrical engineer.

The average number of labourers is over 1,200 and labour quarters are provided.

Raw Materials.—Limestone.—The Company works large deposits of argillaceous limestone and semi-pure limestone containing various percentages of calcium carbonate. These varieties of limestone are blended to give the correct proportions of lime, silica, and alumina. The extent of these deposits is extremely large and the outcrop extends for several miles along the foot of the hills adjacent to the works. The quarries that are being

worked at the present time are situated about three quarters of a mile from the works. The limestones are free from objectionable impurities and none of the quarried material needs to be discarded. The initial mixing of the stone takes place in the quarry and the final adjustment is made in the raw mill according to tests conducted at each stage of the process.

The following is a typical analysis of the limestone :—

	Per cent.
Loss on ignition	34.98
Silica	15.04
Iron oxide	0.98
Alumina	2.26
Lime	45.08
Magnesia	1.27
Total	99.61

Clay.—Clay exists only in small quantities and is not used or needed in the manufacture of the cement, since the limestone contains silica and alumina in the requisite proportions.

Gypsum.—Gypsum is imported from Jodhpur and Marwar. A small amount is also obtained from the Salt Range for use during the rainy season. This gypsum, being harder and denser than the local gypsum, does not absorb so much water and thus avoids any tendency to clog the feeding arrangement.

Coal.—Coal from the Bengal coal-fields is used.

Water.—For drinking purposes water is obtained from wells but, as these are not sufficient to supply water for the factory, a pumping station and a dam have been built at the River Mez, six miles from the works. Two electrically driven pumps supply the works by a 6" steel pipe line which connects a storage reservoir on the hill top above the river with a service reservoir at the works. The water is treated by a Lassen-Hjort softener which reduces the hardness from 20° to 5°.

Process of Manufacture.—The cement is manufactured by the dry process.

The plant, supplied by Messrs. F. L. Smidth & Co., consists of a gyratory crusher, hammer mill, raw mill, two rotary kilns, coal mill, cement grinding mill, power plant and cement store.

The quarried stone is conveyed in tip wagons holding 25 cubic feet each to the crushing plant which reduces the stone to a half inch and less. The crushed stone falls into bins below the crushing plant, whence it is transported to the ball mill in which the crushed stone is coarsely ground. The coarsely ground material is elevated and distributed for storage and mixing into three large silos. From the silos the material passes to a tube mill and thence to a second series of three silos where a further mixing of the material takes place.

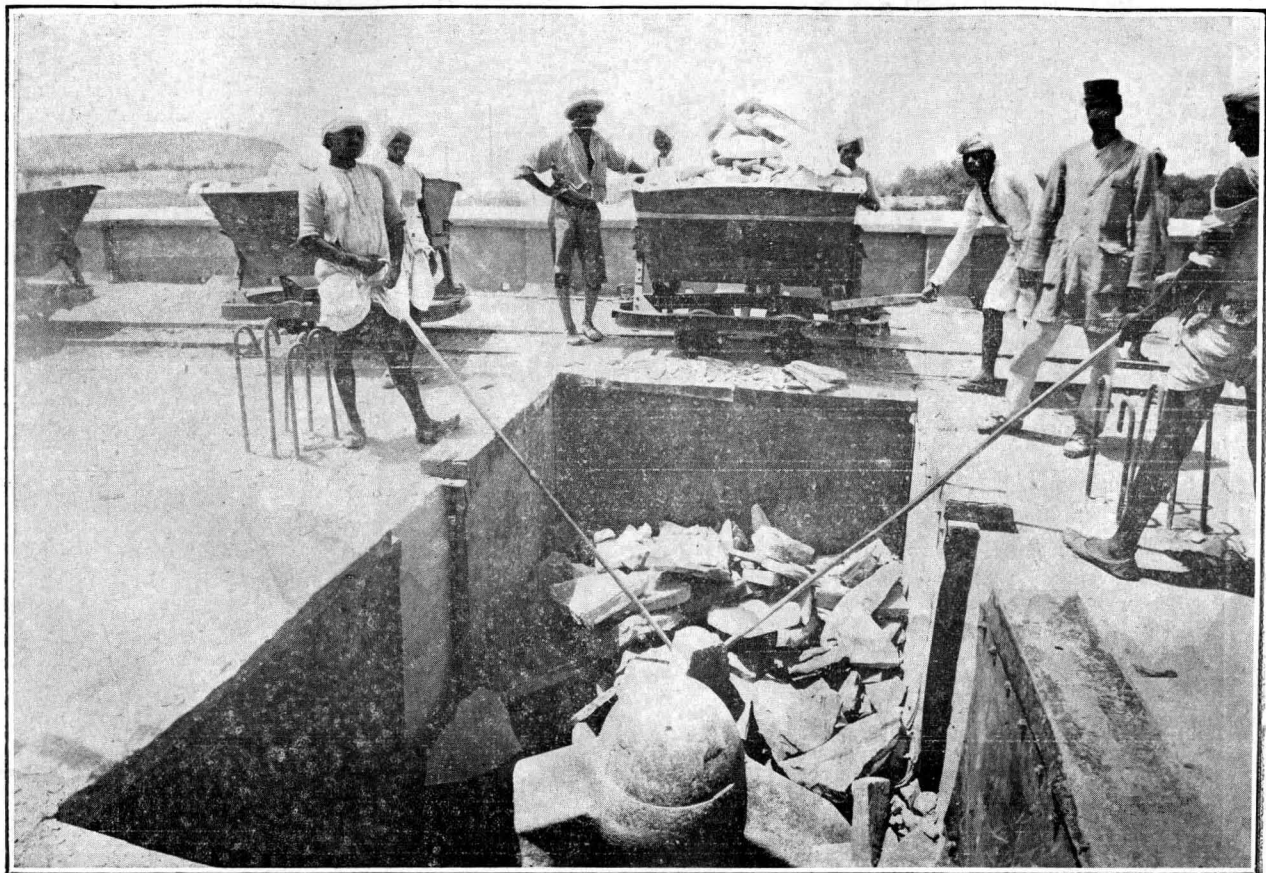
Power.—The electric current for driving the plant is generated by a 1,750 k. w. turbo-generator generating alternating current at 500 volts. This has superseded a high speed Belliss and Morcom power plant now used as a stand-by and consisting of three sets each of 340 k. w.

The steam is supplied by four Babcock and Wilcox boilers at a working pressure of 160 lbs. per square inch. A waste heat boiler is now being installed. The heat of the kiln gases will be utilised to produce power sufficient to work most of the plant.

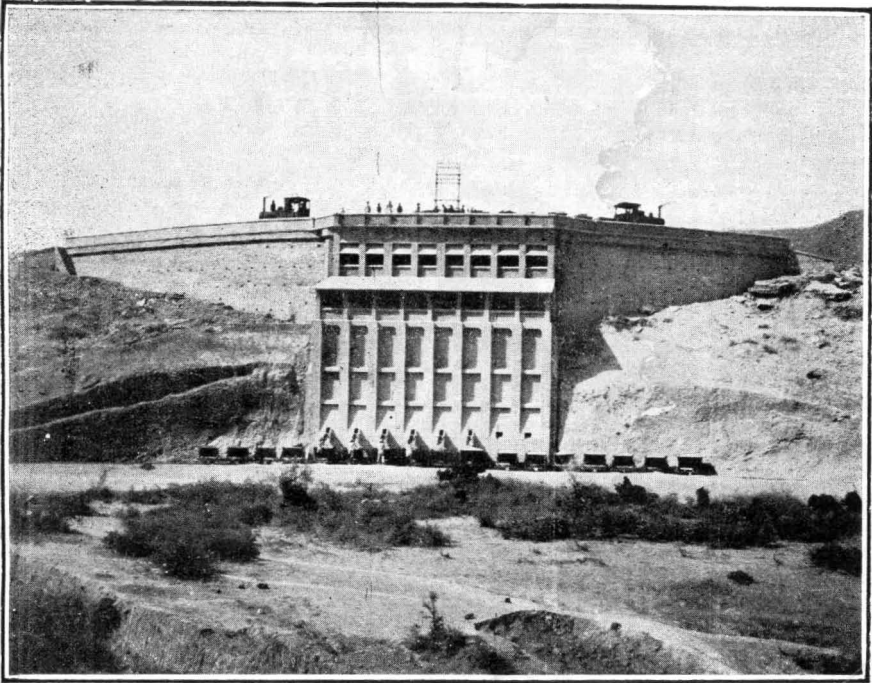
Capacity.—The capacity of the works is 60,000 tons a year.

Hydraulic Lime.—The Company also manufactures hydraulic lime, for the burning of which there are eight shaft-kilns, each 40 feet high from the grate to the loading platform. The output of each kiln is about 15 tons a day.

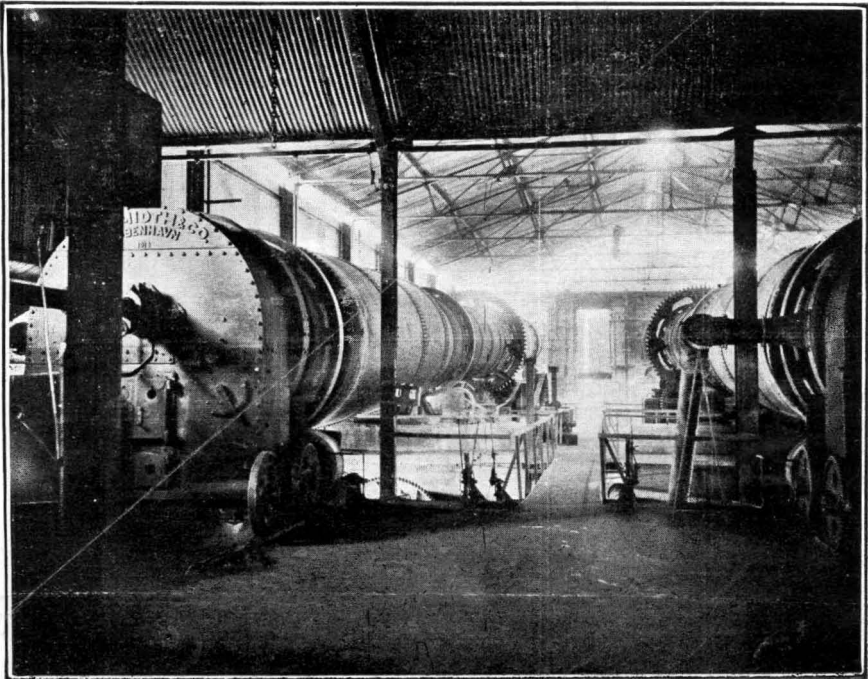
BUNDI PORTLAND CEMENT CO., LTD.



BUNDI PORTLAND CEMENT CO., LTD.



LOADING OF LIMESTONE INTO TUBS.



GOVERNMENT OF INDIA.
INDIAN STORES DEPARTMENT.

GOVERNMENT TEST HOUSE,

Alipore, Calcutta.

TEST CERTIFICATE.

No. 3271-M.

Dated Alipore, Calcutta, the 3rd March 1926.

Issued to Messrs. Killick Nixon & Co., Post Box No. 109, Bombay, with reference to letter No. B.-30-35, dated the 6th January 1926, from the General Manager, The Bundi Portland Cement, Ltd., Lakheri.

Register No. 463-P. C., dated 9th January 1926.

Test No. 950.

BRITISH STANDARD TEST FOR PORTLAND CEMENT.

Name and Brand of Cement. "B. B. B." Brand Portland Cement.

Nature of Sample. Representing "Mill's output for December 1925."

—	Results obtained.	Standard (1925).
1.—FINENESS OF GRINDING.		
Residue on Mesh 180 × 180 .	5.40 %	Not more than 10 %
Ditto 76 × 76 .	0.07 %	Ditto 1 %
2.—CHEMICAL COMPOSITION.		
Lime		
Silica		
Alumina		
Iron Oxide		
Magnesia		Not more than 4 %
Sulphur calculated as SO ₃		Ditto 2.75 %
Total loss on Ignition		Ditto 3 %
Insoluble Residue		Ditto 1.5 %
Nett proportion of Lime to Silica and Alumina		Between 2.9 and 2.0 %

	Results obtained.	Standard (1925).
3.—TENSILE STRENGTH (NEAT).		
7 days (average of 6 briquettes) lbs.	725	Not less than 600 lbs.
4.—TENSILE STRENGTH (CEMENT AND SAND).		
7 days (average of 6 briquettes) lbs. (W_s).	424	Not less than 325 lbs.
28 days (average of 6 briquettes) lbs.	578	Ditto $W_s + \frac{10,000}{W_s}$ = 448 lbs.
5.—SETTING TIME.		
Initial	137 mins.	Not less than 30 mins.
Final	2 hours 52 mins.	Not more than 10 hours for normal setting cement.
Classification	
6.—SOUNDNESS.		
Expansion after boiling 6 hours in Le Chatelier Mould.		
(a) Cement aerated 24 hours.	$\frac{1}{2}$ mm.	Not more than 10 mm.
(b) Ditto 7 days test (a) having failed.	...	Ditto 5 mm.

Proportion of water used in gauging.

(a) Neat briquettes	21%
(b) Cement and sand briquettes	7 $\frac{1}{4}$ %
Temperature during period of testing	70°.—85°F

REMARKS.

The sample complies with the physical requirements of the B. S., Specification No. 12-1925 for Portland Cement.

N. BRODIE,

Superintendent,

Government Test House, Alipore, Calcutta.

THE CENTRAL PROVINCES PORTLAND CEMENT CO., LTD.

“Swastika” Brand Portland Cement.

The Company's works are situated at Kymore in the Central Provinces, 25 miles from Katni and 14 miles from Jukehi on the G. I. P. Railway. The factory was completed about the middle of 1923, and cement was manufactured and put on the market about the same time.

Staff and Labour.—The staff includes the general manager, chief chemist, chief engineer and chief burner. These are Europeans and the only Europeans on the staff. Indians have been systematically trained and there are now several in the factory, who are stated to have become highly efficient in their work.

The number of workmen employed is 525 and the average monthly wage is about Rs. 19. Chawls are provided for the housing of 400 workmen.

Raw Materials.—Limestone.—Limestone is found in the firm's own property at a distance of about half a mile from the factory. The stone is dug up from the quarries by Bucyrus shovels and loaded into tipping wagons, which are hauled to the crushers over a broad gauge railway line. The following is a typical analysis of the limestone:—

	Per cent.
Loss on ignition	40.59
Insoluble matter	} 5.44
Silica	
Iron oxide	} 0.68
Alumina	
Lime	51.67
Magnesia	1.56
Total	99.94

Clay.—An abundance of clay is found on the property, usually overlying the limestone. This is also got by mechanical diggers. A typical analysis is as follows:—

	Per cent.
Loss on ignition	9.98
Silica	62.05
Alumina	14.47
Iron oxide	6.21
Lime	4.78
Magnesia	1.66
Total	99.15

Gypsum.—Gypsum is imported from the Punjab and also from Jodhpur and Rajputana.

Coal.—Coal for the kilns is obtained from the Bengal coal-field; that for the boilers is obtained from the Central Provinces collieries which are close to the works.

Water.—A good water supply is obtained from wells about a thousand feet deep. The water contains about 20° of hardness and is softened.

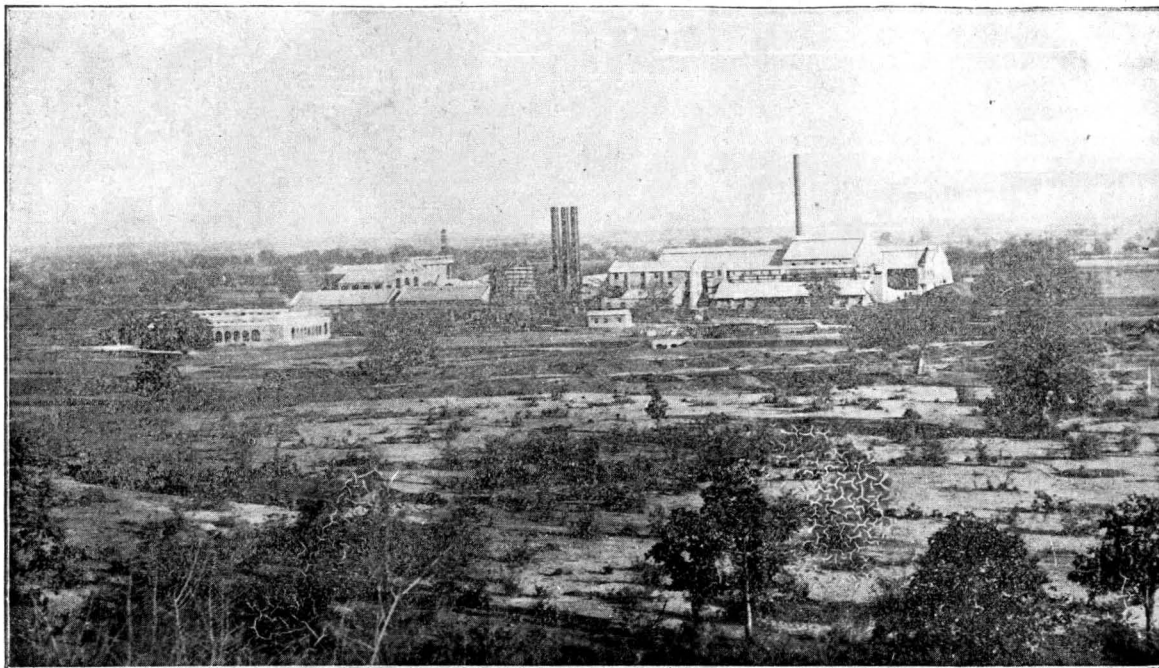
Process of Manufacture.—The wet process is used.

The plant consists of a crusher house, wash-mill for clay, raw mill with three tube mills, two rotary kilns, coal plant, three grinding units, power plant and two large silos for cement storage.

The crushing plant is made by Messrs. Allis Chalmers. The remainder of the cement making plant is by Messrs. F. L. Smidth.

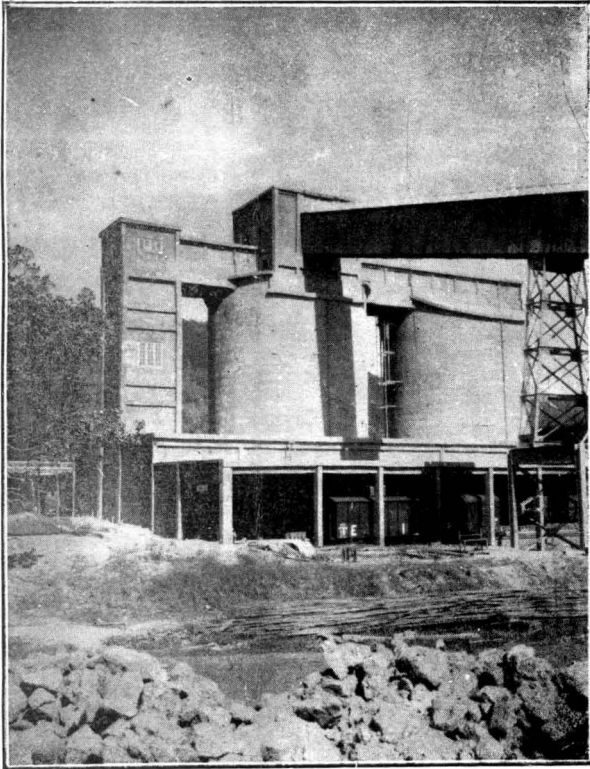
The limestone arriving at the works in six-ton wagons is fed into two large gyratory crushers. From these it passes to four smaller crushers and is then elevated above the raw mills in storage hoppers. These feed the stone to small crushers, whence it passes into the tube mills together with the clay slurry. The slurry falls by gravity into four correction tanks and then again by gravity into three large storage mixers. From these the slurry is elevated by pumps to the kilns. The clinker is ground in tube mills and carried by a belt conveyor into two silos capable of holding 7,000 tons of cement.

THE CENTRAL PROVINCES PORTLAND CEMENT CO., LTD.



VIEW OF THE WORKS.

**THE CENTRAL PROVINCES PORTLAND
CEMENT CO., LTD.**



CEMENT SILOS.

Power.—The electric current for driving the plant is generated by two 1,500 K. W. turbo-generators supplied by Messrs. Metropolitan-Vickers. About eighty motors supplied by the English Electric Company are used to drive the machinery throughout the factory.

The steam is supplied by a mechanically fired boiler plant by Messrs. Babcock and Wilcox.

Capacity.—The capacity of the works is 100,000 tons per annum from the existing plant. Provision has been made for the addition of a third kiln when required.

GOVERNMENT OF INDIA.
INDIAN STORES DEPARTMENT.
GOVERNMENT TEST HOUSE,
Alipore, Calcutta.
TEST CERTIFICATE.

No. 3269-C.M.

Dated Alipore, Calcutta, the 3rd March 1926.

Issued to F. E. Dinshaw, Esquire, Trustee for the Debenture Holders of the Central Provinces Portland Cement Co., Ltd., Bombay, with reference to letter No. K.-8337, dated the 31st December 1925, from the General Manager, The C. P. P. C. Co., Ltd., Kymore.

Register No. 452-P.C., dated 5th January 1926.

Test No. 948.

BRITISH STANDARD TEST FOR PORTLAND CEMENT.

Name and Brand of Cement. "Swastika" Brand Portland Cement.

Nature of Sample. Marked Special XF.

—	Results obtained.	Standard (1925).	
1.—FINENESS OF GRINDING.			
Residue on Mesh 180 × 180	5.63 %	Not more than	10 %
Ditto 76 × 76	0.03 %	Ditto	1 %
2.—CHEMICAL COMPOSITION.			
	%		
Lime	64.54		
Silica	22.35		
Alumina	4.71		
Iron oxide	2.31		
Magnesia	2.90	Not more than	4 %
Sulphur calculated as SO ₃	1.64	Ditto	2.75 %
Total loss on ignition	0.88	Ditto	3 %
Insoluble residue	0.40	Ditto	1.5 %
	99.73		
Nett proportion of Lime to Silica and Alumina.	2.69	Between	2.9 and 2.0

	Results obtained.	Standard (1925).
3.—TENSILE STRENGTH (NEAT) 7 days (average of 6 briquettes) lbs.	823	Not less than 600 lbs.
4.—TENSILE STRENGTH (CEMENT AND SAND). 7 days (average of 6 briquettes) lbs. (W_s).	524	Not less than 325 lbs.
28 days (average of 6 briquettes) lbs.	576	Ditto $W_s + \frac{10,000}{W_s}$ = 543 lbs.
5.—SETTING TIME.		
Initial	102 mins.	Not less than 30 mins.
Final	2 hours 42 mins.	Not more than 10 hours for normal setting cement.
Classification	
6.—SOUNDNESS.		
Expansion after boiling 6 hours in Le Chatelier Mould.		
(a) Cement aerated 24 hours.	1/2 m m.	Not more than 10 mm.
(b) Ditto 7 days test (a) having failed.	...	Ditto 5 mm.

Proportion of water used in gauging.

(a) Neat Briquettes	21 %
(b) Cement and sand briquettes	7½ %
Temperature during period of testing	70°—85°F.

REMARKS.

The sample complies with the B. S. Specification No. 12-1925, for Portland Cement both physically and chemically.

N. BRODIE,
Superintendent,
Government Test House, Alipore, Calcutta.

THE GWALIOR CEMENT CO , LTD.

“ Sun ” Brand Portland Cement.

The Company's works are situated at Banmor on the G. I. P. Railway, 12 miles north of Gwalior Station, close to the main Bombay-Delhi line. The Company was registered in 1919 and started manufacture in April 1923.

Staff and Labour.—The staff includes the manager, assistant manager, chief chemist, engineer and head burner. The manager and the head burner are Europeans and the remainder of the staff are Indians.

Semi-skilled and cooly labour is obtained chiefly from the neighbouring villages.

Raw Materials.—Limestone.—The deposits of limestone are very extensive and occur at the village of Kailaras, which is some 34 miles away from the factory. The limestone is quarried from a hill, about $1\frac{1}{2}$ miles in circumference and 300 feet high. It is brought in special wagons of 16 tons capacity by the Gwalior Light Railway to the works siding. The stone is classified into two varieties: one variety contains calcium carbonate between 78 and 86 per cent. and is known as “ high limestone ”, the other contains calcium carbonate between 70 and 77 per cent. and is known as “ low limestone ”. The two varieties are discharged into two separate hoppers and mixed together so as to obtain the required composition.

Typical analyses of the two limestones are as follows:—

	High limestone.	Low limestone.
	Per cent.	Per cent.
Loss on ignition	38.56	32.76
Insoluble matter	8.48	22.08
Silica		
Iron oxide	3.88	4.48
Alumina		
Lime	46.66	39.71
Magnesia	2.02	0.94
Total	<u>99.60</u>	<u>99.97</u>

Clay.—Clay occurs in abundance about a mile away from the factory, but is little used, as the limestone is

suitable for cement manufacture with no further addition of argillaceous material. The clay is therefore required only for correcting purposes. A typical analysis is as follows :—

	Per cent.
Loss on ignition	9.88
Silica	54.16
Iron oxide	} 28.92
Alumina	}
Lime	1.82
Magnesia	2.73
Alkalies	5.49
Total	100.00

Gypsum.—Gypsum is mostly obtained from Marwar.

Coal.—Coal is obtained from the Bengal coal-fields and from the Central Provinces collieries.

Water.—Water is supplied by the Gwalior Durbar from Tigra Lake through a canal about 15½ miles long.

Process of Manufacture.—The wet process is in use.

The limestone is fed into a gyratory crusher having a capacity of 25 tons per hour, which reduces the limestone to a size of 3". The stone is further crushed by a roller mill to 1" size and then passes to a three-chambered compound mill. The slurry is carried by bucket elevators to one of the three concrete correction tanks and then is run by gravity into a storage basin of 60 feet diameter having a capacity of 1,200 tons of slurry. The slurry is extracted from the storage basin and fed to the rotary kiln by a double acting ram pump. The clinker is ground in a compound mill of similar type to that used for grinding the slurry.

The whole of the cement making machinery is by Messrs. F. L. Smidth & Company.

Power.—The plant is electrically driven and current is generated by two 1,000 K. W. turbo-generators generating three phase alternating current at 440 volts.

Synchronous motors of 300 H. P. are used to drive the raw material and cement grinding compound mills and a synchronous motor of 150 H. P. drives the coal grinding mill. Electric motors were supplied by Messrs. the International General Electric Co. and the British Thomson-Houston Company. Steam is obtained from two water tube boilers by Messrs. Babcock and Wilcox.

Capacity.—The capacity of the factory is 40,000 tons a year and the works have been so designed as to permit of doubling the output.

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GOVERNMENT OF INDIA.

INDIAN STORES DEPARTMENT.

GOVERNMENT TEST HOUSE,

Alipore, Calcutta.

TEST CERTIFICATE.

No. 3338-C.M.

Dated Alipore, Calcutta, the 9th March 1926.

Issued to Messrs. The Gwalior Cement Co., Ltd.,
Bombay, with reference to letter No. F.-1335, dated the
10th January 1926, from the Manager, The Gwalior Cement
Co., Ltd., Gwalior.

Reg. No. 470-P. C., dated 3rd January 1926.

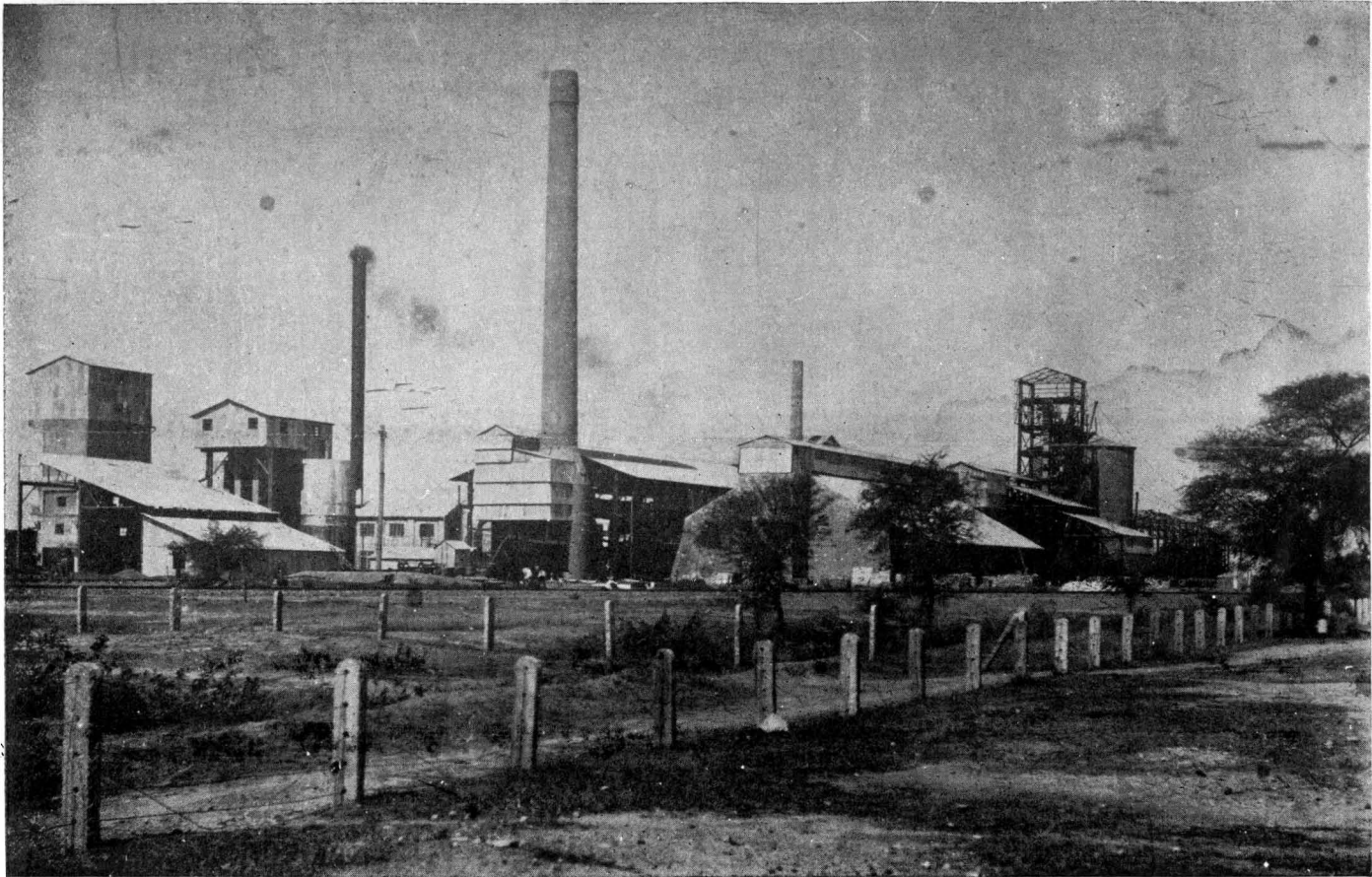
Test No. 963.

BRITISH STANDARD TEST FOR PORTLAND
CEMENT.Name and Brand of cement. "Sun" Brand Portland
Cement.

Nature of Sample. Not stated.

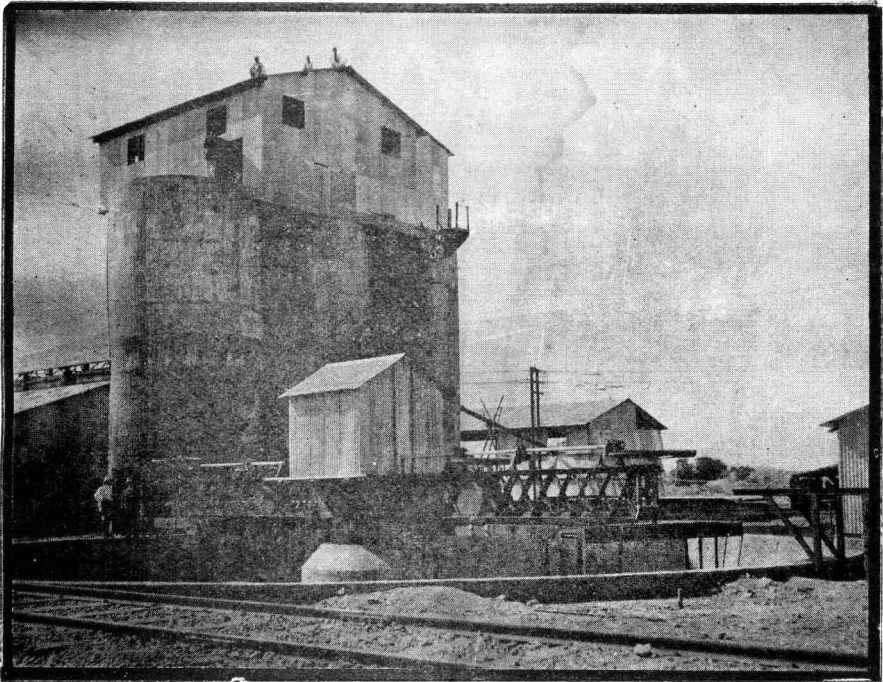
—	Results obtained.	Standard (1925).	
1.—FINENESS OF GRINDING.			
Residue on Mesh 180 × 180	5.02 %	Not more than	10 %
Ditto 76 × 76	0.04 %	Ditto	1 %
2.—CHEMICAL COMPOSITION.			
Lime	62.86		
Silica	22.19		
Alumina	6.98		
Iron oxide	2.58		
Magnesia	1.94	Not more than	4 %
Sulphur calculated as SO ₃	1.34	Ditto	2.75 %
Total loss on ignition	1.31	Ditto	3 %
Insoluble residue	0.58	Ditto	7.5 %
	99.78		
Nett proportion of lime to silica and alumina	2.52	Between	2.9 & 2.0

THE GWALIOR CEMENT CO., LTD.

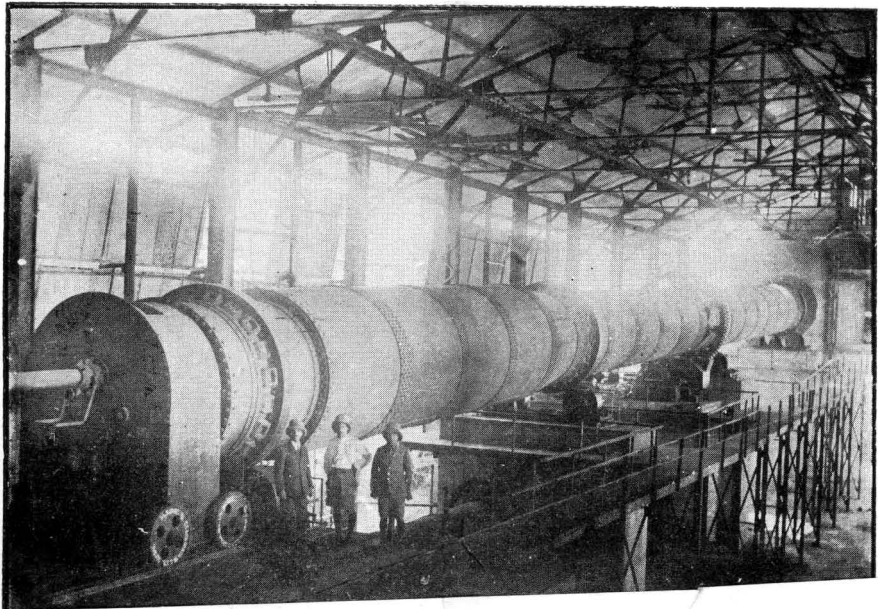


GENERAL VIEW OF THE WORKS.

THE GWALIOR CEMENT CO., LTD.



**SUN AND PLANET TYPE OF MIXER BASIN AND
CORRECTION BASINS.**



	Results obtained.	Standard (1925).
3.—TENSILE STRENGTH (NEAT) 7 days (average of 6 briquettes) lbs.	739	Not less than 600 lbs.
4.—TENSILE STRENGTH (CEMENT AND SAND).		
7 days (average of 6 briquettes) lbs. (W_s)	444	Not less than 325 lbs.
28 days (average of 6 briquettes) lbs	538	Ditto $W_s + \frac{10,000}{W_s}$ = 467 lbs.
5.—SETTING TIME.		
Initial	113 mins.	Not less than 30 mins.
Final	3 hrs. 18 mins.	Not more than 10 hours for normal setting cement.
Classification	
6.—SOUNDNESS.		
Expansion after boiling 6 hours in Le Chatelier Mould.		
(a) Cement aerated 24 hours	$\frac{1}{2}$ mm.	Not more than 10 mm.
(b) Ditto 7 days test (a) having failed	Ditto 5 mm.

Proportion of water used in gauging.

(a) Neat briquettes	22 %
(b) Cement and sand briquettes	8 %
Temperature during period of testing	72°—87°F.

REMARKS.

The sample complies with the B. S. Specification No. 12-1925, for Portland Cement both physically and chemically.

N. BRODIE,
Superintendent,
Government Test House, Alipore, Calcutta.

THE INDIAN CEMENT COMPANY, LTD.

Agents.—Messrs. Tata Sons, Ltd., Bombay.

“Ganapati” Brand Portland Cement.

The Company's works are situated at Porbandar, Kathiawar, on a site adjacent to the docks and having a wharf frontage, so that cement can be shipped direct for distribution to ports in India, Persia, etc. A railway siding from the Gondal-Porbandar State Railway gives direct connection to Delhi, etc., and transshipments can be made at Viramgaum on the B. B. and C. I. Railway. Cement manufacture started in 1914 and manufacture by rotary kilns was adopted in 1918.

Staff and Labour.—The staff consists of the manager, chemist, two assistant chemists, chief engineer and two assistant engineers. The manager and the chemist are Europeans and the remainder of the staff Indians.

No difficulty is found in obtaining unskilled and semi-skilled labour of the class required. About 350 labourers are employed, exclusive of those engaged in quarrying. Men are paid eleven annas a day, and women eight annas a day.

Raw Materials.—Limestone.—The limestone quarries, from which the Porbandar limestone used so much for building purposes in Bombay is obtained, are situated near Ranawao, some 13 miles from the works, and chips are sent by rail from the quarries to the cement factory. Chippings sufficient for the factory's needs for many years have accumulated and the deposit of limestone is practically inexhaustible. The composition is very uniform and selection is unnecessary.

A typical analysis is as follows:—

	Per cent.
Loss on ignition	41.16
Silica	1.80
Iron oxide	} 1.80
Alumina	}
Lime	53.72
Magnesia	1.08
Total	99.56

Clay.—Clay beds six to ten feet deep and covering an area of several square miles exist near the factory. The beds are almost submerged at high tide and excavation is carried out when the clay lands are above tide level.

A typical analysis is as follows:—

	Per cent.
Loss on ignition	16.70
Silica	42.34
Iron oxide	7.16
Alumina	18.04
Lime	8.60
Magnesia	4.20
Total	97.04

Siliceous stone.—The silica content of the limestone and clay is insufficient and a small addition is made of a siliceous stone known as “Barda Stone”, of which a deposit extends along the base of the Barda hills. A typical analysis is as follows:—

	Per cent.
Loss on ignition	0.80
Silica	69.60
Iron oxide	8.30
Alumina	14.88
Lime	3.30
Magnesia	0.65
Total	97.53

Gypsum.—Deposits of gypsum mixed with clay occur on the marshes within a few miles of the works. These deposits supply about half the factory’s requirements and the balance is obtained from other places in Kathiawar.

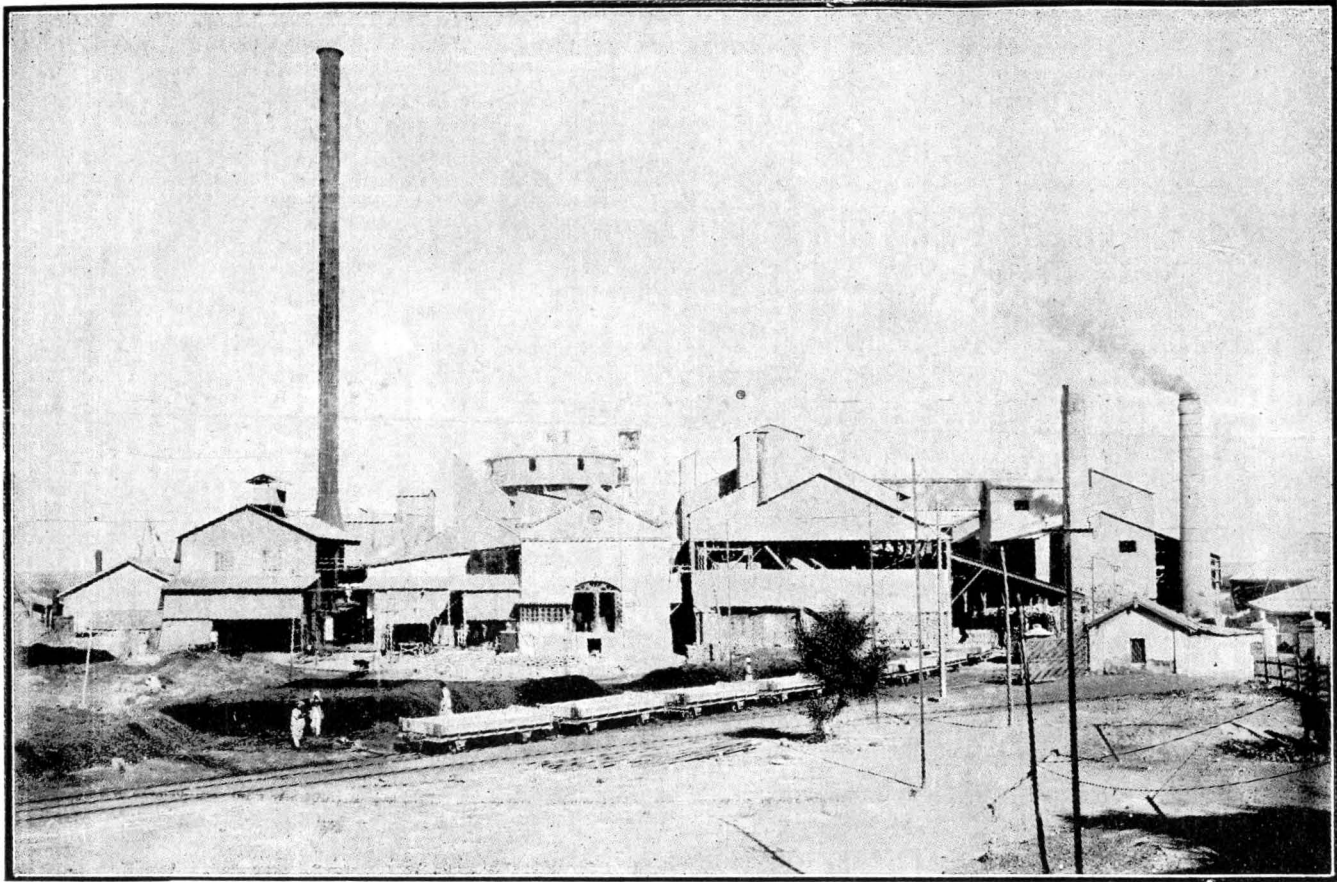
Coal.—First class Bengal coal is used mixed with Pench Valley slack coal.

Water.—Water is obtained from the Porbandar State. It has an average hardness of 58° and is softened in a Lassen-Hjort plant to about 6° of hardness.

Process of Manufacture.—Since Mr. Musgrave’s report was issued this factory has been entirely remodelled. Two rotary kilns have been installed together with new cement machinery, etc., bringing the factory into line with other modern cement works.

The dry process is used.

THE INDIAN CEMENT CO., LTD.



VIEW OF THE WORKS.

THE INDIAN CEMENT CO., LTD.



Clay is dug from the river bed and sun-dried. It is then raised by an inclined belt conveyor into a pair of toothed rolls which break it up into small pieces. These are dried in a rotary coal-fired dryer and subsequently elevated into a steel silo of 100 tons capacity. The limestone is crushed in a 30"×18" jaw crusher and elevated into another 100-ton silo. The siliceous Barda stone is similarly treated. The three silos are arranged side by side and feed tables regulate the proportions of materials drawn from them. The materials are mixed in a shaker type conveyor and delivered by an elevator into hoppers which feed two ball mills where the material is ground to pass through 30×30 mesh sieves. The granulated material passes to a tube mill where it is ground fine enough for 93 per cent. to pass a sieve having 180×180 meshes to the square inch. Four silos each of 120 tons capacity receive the pulverised raw material which at this stage is known as "raw meal". Any necessary further adjustment of the composition of the raw meal is made by mixing material from two or more of the silos. The adjusted raw meal passes by means of a mixing conveyor and a belt conveyor to hoppers above the rotary kilns. The raw meal is fed into the kilns, of which there are two, by an adjustable feed screw. The clinker is ground in a compound mill of three chambers.

The raw grinding plant originally installed was supplied by Messrs. Krupps; but all additions to this department, the two rotary kilns, coal pulverising plant and cement grinding mills, have been supplied by Messrs. F. L. Smidth.

Power.—Current is supplied by two alternators, one by the International General Electric Company and one by Messrs. Siemens, driven respectively by an 840 H. P. horizontal compound steam engine by Messrs. Hick Hargreaves and Co., and a 250 H. P. steam engine by Messrs. Ruston and Proctor. Steam is generated by a Babcock and Wilcox boiler with chain grate stoker and three old Lancashire boilers are used as a stand-by. The motors throughout the works are by Messrs. Siemens, International General Electric Co., and Messrs. Mather and Platt.

Capacity.—The capacity of the works is 30,000 tons a year.

GOVERNMENT OF INDIA.
INDIAN STORES DEPARTMENT.

GOVERNMENT TEST HOUSE,

Alipore, Calcutta.

TEST CERTIFICATE

No. 3514-C. M.

Dated Alipore, Calcutta, the 1st April 1926.

Issued to Messrs. Tata and Sons Ltd., Bombay, with reference to letter, No. ——— dated the 10th February 1926, from the Manager, the Indian Cement Co. Ltd., Porbandar, (Kathiawar).

Test No. 1031.

BRITISH STANDARD TEST FOR PORTLAND CEMENT.

Name and Brand of Cement. "Ganapati" Brand Portland Cement.

Nature of Sample. Marked Sample No. 14, dated 10th February 1926.

—	Results obtained.	Standard (1925).
1.—FINENESS OF GRINDING.		
Residue on Mesh 180 × 180	10.43 %	Not more than 10 %
Ditto 76 × 76	0.07 %	Ditto 1 %
2.—CHEMICAL COMPOSITION.		
Lime	61.49	
Silica	22.57	
Alumina	7.05	
Iron oxide	3.62	
Magnesia	1.97	Not more than 4 %
Sulphur calculated as SO ₃	1.83	Ditto 2.75 %
Total loss on ignition	0.79	Ditto 3 %
Insoluble residue	0.62	Ditto 1.5 %
	99.94	
Nett proportion of lime to silica and alumina.	2.41	Between 2.9 & 2.0

	Results obtained.	Standard (1925).
3.—TENSILE STRENGTH (NEAT).		
7 days (average of 6 briquettes) lbs.	859	Not less than 600 lbs.
4.—TENSILE STRENGTH (CEMENT AND SAND.)		
7 days (average of 6 briquettes) lbs. (W_s)	415	Not less than 325 lbs.
28 days (average of 6 briquettes) lbs.	455	Ditto $W_s + \frac{10,000}{W_s}$ = 439 lbs.
5.—SETTING TIME.		
Initial	82 mins.	Not less than 30 mins.
Final	2 hours 30 mins.	Not more than 10 hours for normal setting cement.
Classification	
6.—SOUNDNESS.		
Expansion after boiling 6 hours in Le Chatelier Mould.		
(a) Cement aerated 24 hours	2½ mm.	Not more than 10 mm.
(b) Ditto 7 days test (a) having failed.	...	Ditto 5 mm.

Proportion of water used in gauging.

(a) Neat briquettes	21 %
(b) Cement and sand briquettes	7¼ %
Temperature during period of testing	85°—90°F.

REMARKS.

The sample complies with the requirements of B. S. Specification No. 12-1925 for Portland Cement both chemically and physically except as regards the Residue on the 180×180 mesh sieve which is slightly in excess of the maximum specified.

E. F. G. GILMORE,

Superintendent,
Government Test House, Alipore, Calcutta.

THE JUBBULPORE PORTLAND CEMENT CO., LTD.

(Agents: Messrs. C. Macdonald and Co., Bombay.)

“ Lotus ” Brand Portland Cement.

The Company's works are situated on the G. I. P. Railway, near Jukehi, in the Central Provinces. Construction was begun during 1921 and the works were completed and brought into operation in September 1922.

Staff and Labour.—The staff includes the general manager, chief engineer, four shift engineers, assistant engineer, chief chemist, four testers, three samplers and gaugers, head burner, three shift burners and three mill foremen.

The number of workmen is 428.

Free quarters and medical attention are provided.

Raw materials.—Limestone.—Limestone is found in large quantities near the factory. The deposits are owned by the Company and cover about 800 acres. The limestone contains about 94 per cent. of calcium carbonate.

Clay.—Clay is also found close to the factory on the Company's estate and the following is a typical analysis:—

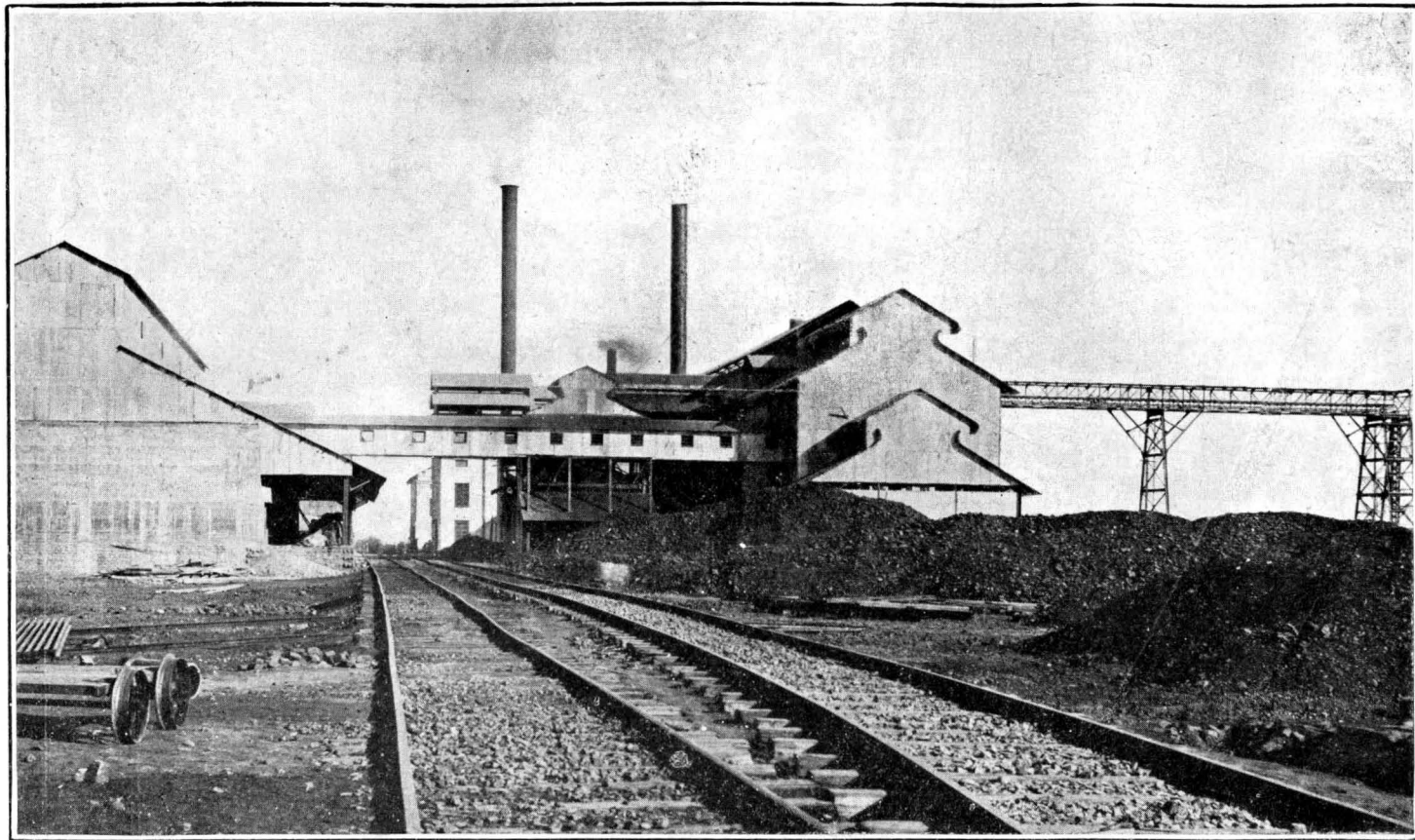
	Per cent.
Loss on ignition	7.10
Silica	65.80
Iron oxide	8.00
Alumina	13.94
Lime	3.65
Magnesia	1.04
Total	99.89

Gypsum.—Gypsum is obtained from Marwar State.

Coal.—Bengal coal is used for the kilns and coal from the Barakar State collieries for the boilers.

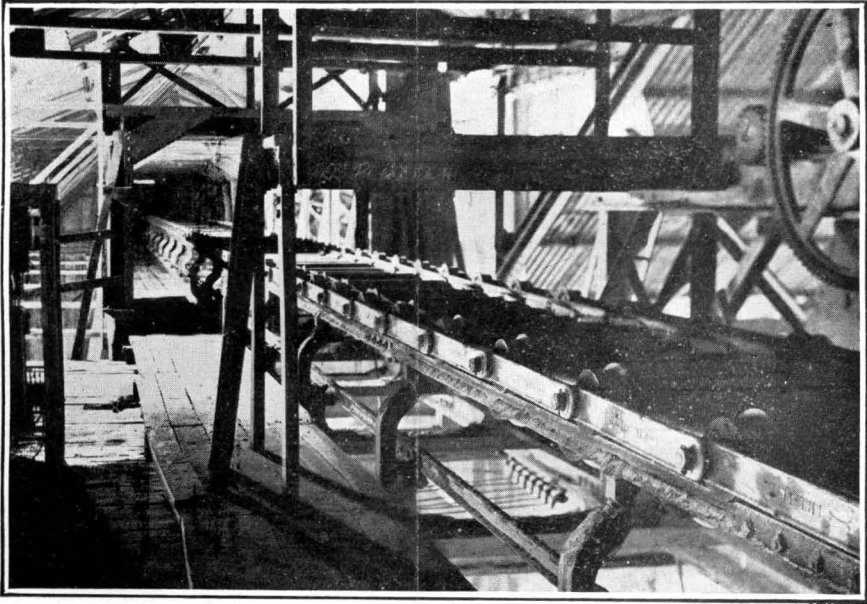
Water.—The water used has 9° of hardness and is softened in a Lassen-Hjort plant to 2°.

THE JUBBULPORE PORTLAND CEMENT CO., LTD.

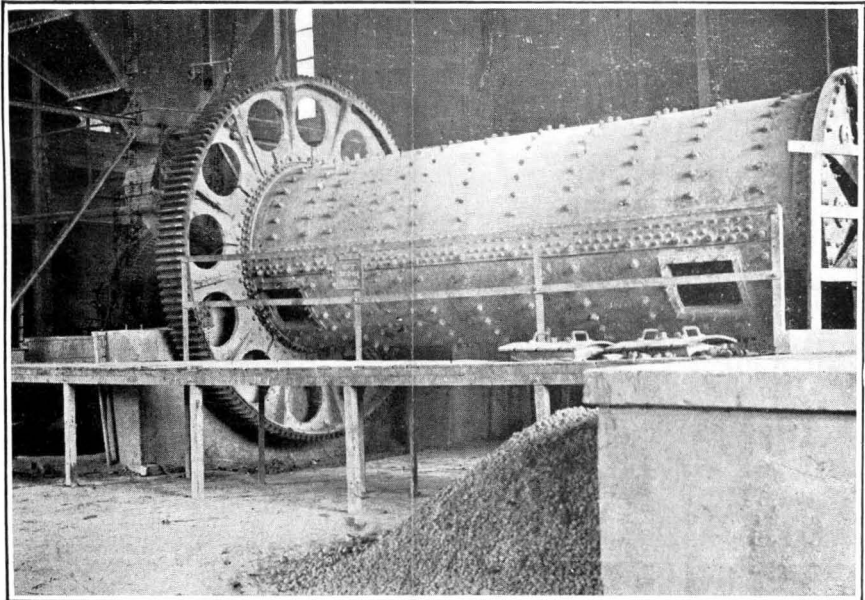


GENERAL VIEW OF THE WORKS.

THE JUBBULPORE PORTLAND CEMENT CO., LTD.



LINK BELT CONVEYOR.



BALL MILL.

Process of Manufacture.—The wet process is used.

The plant was designed by the Allis-Chalmers Manufacturing Company. All machinery was furnished by them, including the motors and turbo-generators. Boilers were supplied by Messrs. Babcock and Wilcox.

The limestone is taken inside dump cars over a short length of track to the crushing plant, which consists of a large gyratory crusher and a set of rolls. The clay is brought in the same type of car and dumped into a clay disintegrator from which it is carried by a belt conveyor to a washmill of the usual type. Fine grinding is carried out in a "No. 722 Wet Compeb Mill," a compound ball and tube mill. The slurry is pumped by means of compressed air into large storage tanks and thence to smaller correction tanks from which it is pumped into the kiln-feed tank. The clinker is carried to a storage shed and subsequently ground in a No. 722 Compeb Mill, similar to that used for grinding the raw materials. Any coarse materials are returned to the mill by a 14-foot Emerick Air Separator.

Coal for the kilns passes through a roller crusher and, after drying in an Ebert coal dryer, is ground in a No. 522 Compeb Mill of similar general construction to those previously mentioned.

Power.—All machinery in the works is motor driven and all but the smallest machines have separate motors. Synchronous motors of 400 H. P. and one of 175 H. P. are used for driving the mills. These incidentally help to improve the power factor of the system. The power plant consists of two Parsons reaction type turbo-generators, each of 1,000 K. W., generating three-phase alternating current at 2,300 volts. This voltage is used for the synchronous motors, while the smaller motors, of which there are about 65, are supplied with current at 440 volts. A small 100 K. W. impulse type turbo-generator is installed as a standby set for running the kiln and lighting when the grinding mills are stopped. The boiler house is equipped with three Babcock and Wilcox water tube boilers, fitted with superheaters and chain grate stokers, and a Green's economiser.

Capacity.—The capacity of the works is 60,000 tons annually.

GOVERNMENT OF INDIA.
INDIAN STORES DEPARTMENT.
GOVERNMENT TEST HOUSE,
Alipore, Calcutta.

TEST CERTIFICATE.

No. 3373-M.

Dated Alipore, Calcutta, the 11th March 1926.

Issued to Messrs. C. Macdonald & Co., Post Box No. 121, Bombay, with reference to letter No. 7-150-G.-9, dated the 18th January 1926, from the General Manager, The Jubbulpore Portland Cement Co., Ltd., Jubbulpore.

Register No. 484-P. C., dated 21st January 1926.

Test No. 979.

BRITISH STANDARD TEST FOR PORTLAND CEMENT.

Name and Brand of Cement. "Lotus" Brand Portland Cement.

Nature of Sample. Representing average grinding of cement for the 1st week of January 1926, marked the "1st week January 1926, Bins 2 and 4".

—	Results obtained.	Standard (1925).	
1.—FINENESS OF GRINDING.			
Residue on Mesh 180 × 180	4.98 %	Not more than	10 %
Ditto 76 × 76	0.05 %	Ditto	1 %
2.—CHEMICAL COMPOSITION.			
Lime			
Silica			
Alumina			
Iron Oxide			
Magnesia		Not more than	4 %
Sulphur calculated as SO ₃		Ditto	2.75 %
Total loss on Ignition		Ditto	3 %
Insoluble Residue		Ditto	1.5 %
Nett proportion of Lime to Silica add Alumina.		Between 2.9 &	2.0

	Results obtained.	Standard (1925).
3.—TENSILE STRENGTH (NEAT).		
7 days (average of 6 briquettes) lbs.	782	Not less than 600 lbs.
4.—TENSILE STRENGTH (CEMENT AND SAND).		
7 days (average of 6 briquettes) lbs. (W _s)	468	Not less than 325 lbs.
28 days (average of 6 briquettes) lbs.	576	Ditto W _s + $\frac{10,000}{W_s}$ = 489 lbs.
5.—SETTING TIME.		
Initial	31 mins.	Not less than 30 mins.
Final	2 hours	Not more than 10 hours
Classification	6 mins.	for normal setting cement
6.—SOUNDNESS.		
Expansion after boiling 6 hours in Le Chatelier Mould.		
(a) Cement aerated 24 hours.	1 mm.	Not more than 10 mm.
(b) Ditto 7 days test (a) having failed.	...	Ditto 5 mm.

Proportion of water used in gauging.

(a) Neat briquettes	22 %
(b) Cement and sand briquettes	8 %
Temperature during period of testing	72°—87°F.

REMARKS.

The sample complies with the physical requirements of B. S. Specification No. 12-1925 for Portland Cement.

N. BRODIE,
Superintendent,
Government Test House, Alipore, Calcutta.

THE KATNI CEMENT AND INDUSTRIAL CO., LTD.

(Agents: Messrs. C. Macdonald and Co., Bombay.)

“ Castle ” Brand Portland cement.

The Company's works are situated at Tikuri village, about $2\frac{1}{2}$ miles from Katni Junction, on the Great Indian Peninsula and Bengal Nagpur Railways. The works were completed in October 1914 and manufacture began in 1915.

Staff and Labour.—The staff includes the general manager, chief engineer, chemist and kiln supervisor.

Labour is obtained mainly from the surrounding district and when the quarries are in full operation the Company employs about 2,000 labourers. The Company has provided over 300 separate quarters for housing of its staff, different quarters being allotted to artisans and other workers. Many of the other employees reside in Tikuri village which is owned by the Company.

Raw Materials.—Limestone.—Large deposits of limestone are found in the neighbourhood of the works, about three quarters of a mile away. The overburden at these quarries averages about 40 feet. A typical analysis of this limestone is as follows:—

	Per cent.
Loss on ignition	39.20
Silica	9.60
Iron oxide	}
Alumina	} 2.06
Lime	46.79
Magnesia	1.80
	<hr/>
Total	99.45
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In 1920 work was started on the Deosari quarries belonging to the Company. This stone lies near the surface and is higher in calcium carbonate content than the average Katni stone. The Deosari stone has to be

railed about 20 miles, 13 miles on the G. I. P. Railway and 7 miles on the Company's siding. The following is a typical analysis of the Deosari stone:—

	Per cent.
Loss on ignition	42.60
Insoluble matter	0.50
Soluble silica	2.20
Iron oxide	0.25
Alumina	0.50
Lime	51.20
Magnesia	1.60
Total	98.85

Clay.—Large quantities of clay are found in the neighbourhood of the factory. A typical analysis of the clay is as follows:—

	Per cent.
Loss on ignition	7.64
Silica	63.46
Alumina	16.87
Iron oxide	8.88
Lime	2.15
Magnesia	0.72
Total	99.72

Gypsum.—Gypsum is obtained from Marwar State.

Coal.—Slack coals from the Bengal fields are now being successfully used in the kilns in place of high class coals. Central Provinces coal is used to the extent of 33 per cent. to 35 per cent., but experiments using this coal alone have not been successful.

Water.—Water is obtained from a river about half a mile from the works. It is pumped through 18" diameter pipes into a ferro concrete reservoir which has a capacity of 1½ million gallons and stands about 135 feet above the works. The hardness of the water varies from 8° to 22° and it is softened by a Lassen-Hjort apparatus to 3° before use.

Process of Manufacture.—The cement is manufactured by the wet process.

The cement making plant was designed and constructed by Messrs. F. L. Smidth. In 1921 the then existing plant was duplicated by the same firm and two rotary kilns are now in use.

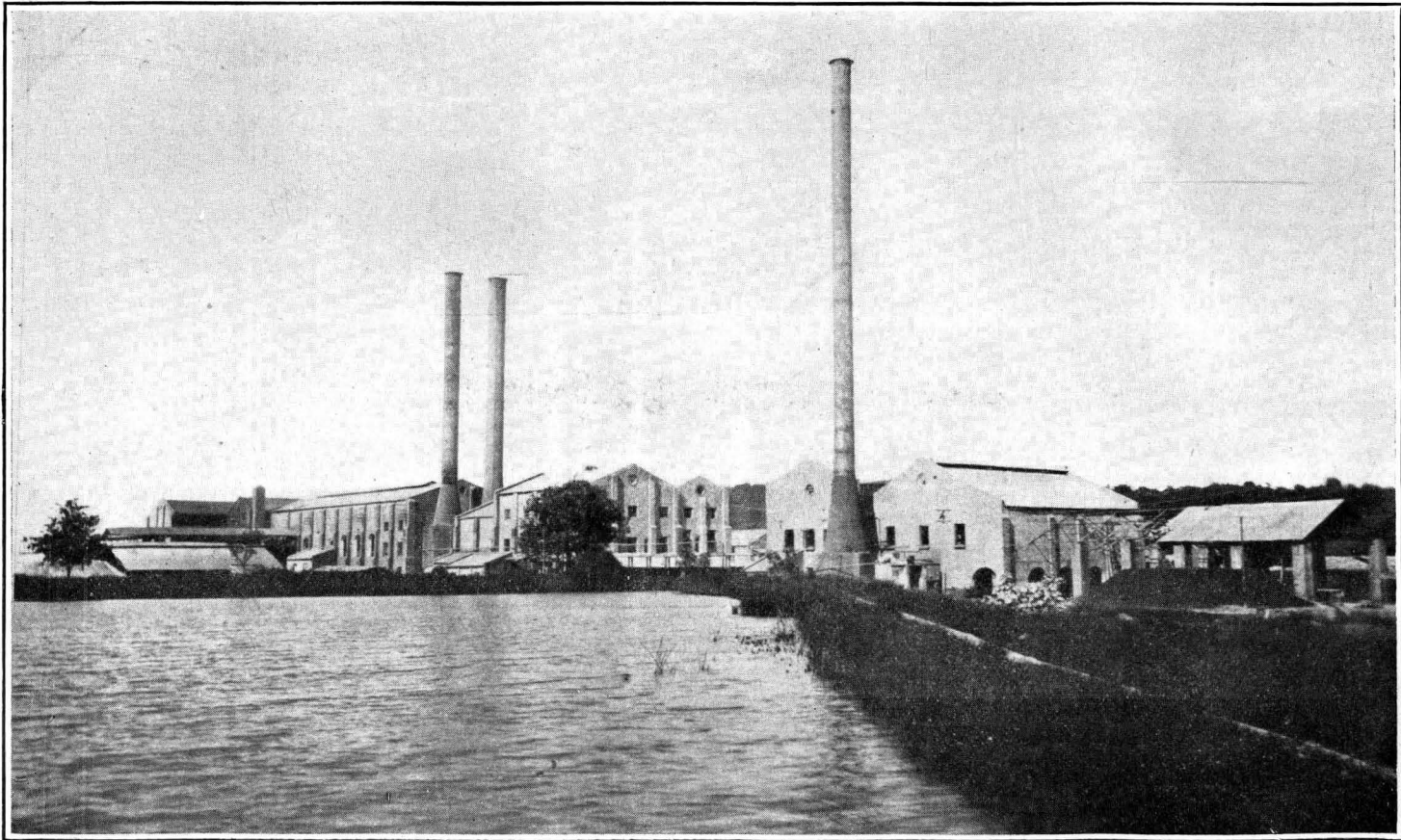
The limestone arriving at the works is dumped into jaw crushers from which it is elevated to reinforced concrete hoppers over the ball mills into which it is fed by automatic feed tables. The clay is reduced to slurry in the washmill and pumped to the ball mills. On passing the ball mills, the material is raised by a spiral conveyor to the tube mills and then by spiral conveyors to four correction tanks. The clinker is ground in ball and tube mills of normal type.

Power.—Three phase alternating current at 500 volts is generated by a 1,500 K. W. turbo-generator by Messrs. Metropolitan Vickers and two 650 K. W. turbo-generators, turbines by Messrs. Richardson, Westgarth and Company and generators by Messrs. Siemens Bros.

Steam is supplied by four Babcock and Wilcox boilers, each of 9,900 lbs. per hour evaporative capacity.

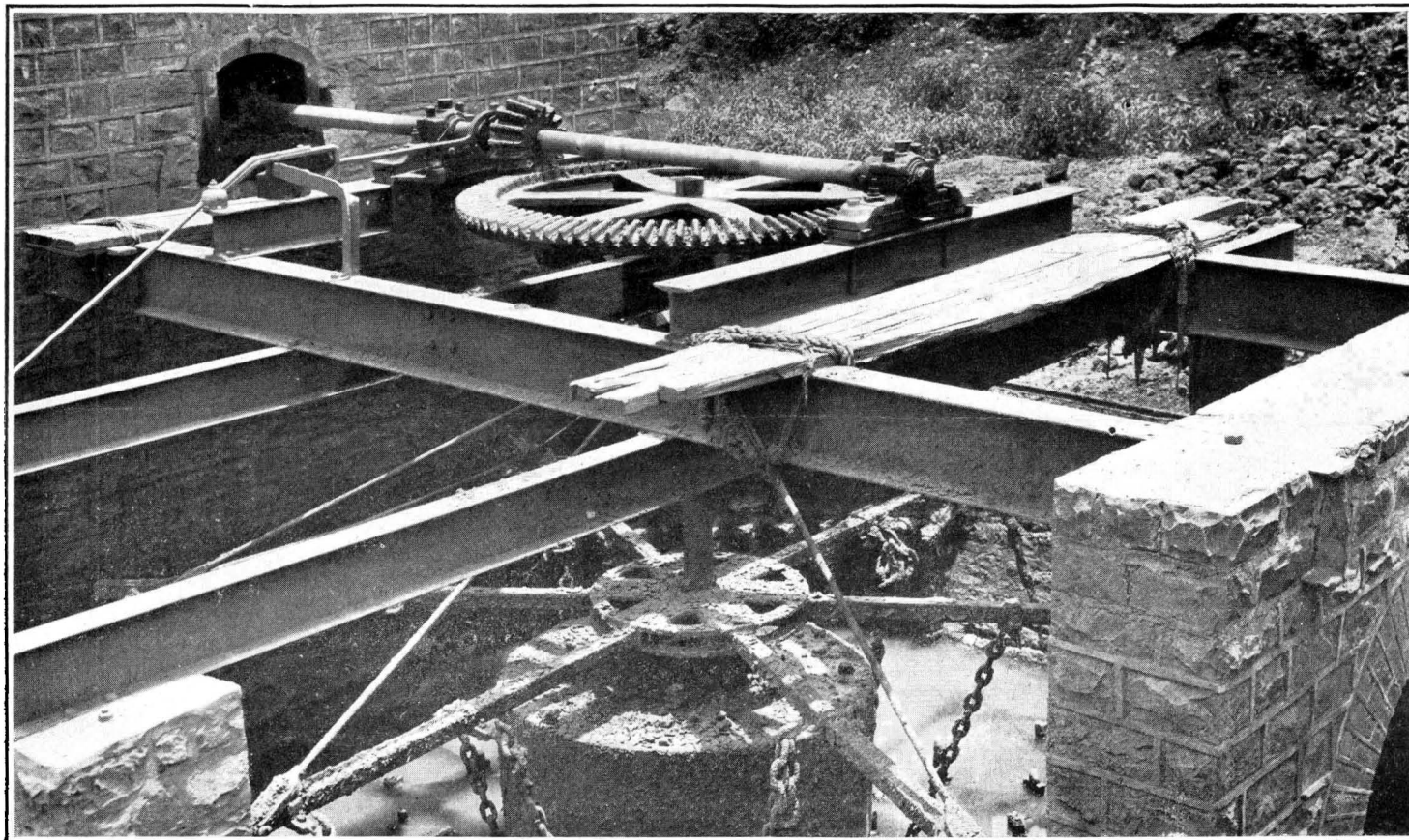
Capacity.—The capacity of the works is 72,000 tons a year.

THE KATNI CEMENT AND INDUSTRIAL CO., LTD.



GENERAL VIEW OF THE WORKS.

THE KATNI CEMENT AND INDUSTRIAL CO., LTD.



CLAY WASH MILL.

GOVERNMENT OF INDIA.
INDIAN STORES DEPARTMENT,
GOVERNMENT TEST HOUSE.
Alipore, Calcutta.

TEST CERTIFICATE.

No. 3374-M.

Dated Alipore, Calcutta, the 11th March 1926.

Issued to Messrs. C. Macdonald & Co., Post Box No. 121, Bombay, with reference to letter No. 5015-1-22, dated the 20th January 1926, from the General Manager, The Katni Cement and Industrial Co., Ltd., Katni.

Register No. 486-P. C., dated 22nd January 1926.

Test No. 982.

BRITISH STANDARD TEST FOR PORTLAND CEMENT.

Name and Brand of Cement. "Castle" Brand Portland Cement.

Nature of Sample. Marked K.C.-2-1, dated 18-1-26.

	Results obtained.	Standard (1925).
1.—FINENESS OF GRINDING.		
Residue on Mesh 180 × 180	7.58%	Not more than 10%
Ditto 76 × 76	0.38%	Ditto 1%
2.—CHEMICAL COMPOSITION.		
Lime		
Silica		
Alumina		
Iron Oxide		
Magnesia		Not more than 4%
Sulphur calculated as SO ₃		Ditto 2.75%
Total loss on Ignition		Ditto 3%
Insoluble Residue		Ditto 1.5%
Nett proportion of Lime to Silica and Alumina.		Between 2.9 and 2.0

	Results obtained.	Standard (1925).
3.—TENSILE STRENGTH (NEAT).		
7 days (average of 6 briquettes) lbs.	766	Not less than 600 lbs.
4.—TENSILE STRENGTH (CEMENT AND SAND).		
7 days (average of 6 briquettes) lbs. (W_s).	483	Not less than 325 lbs.
28 days (average of 6 briquettes) lbs.	576	Ditto $W_s + \frac{10,000}{W_s}$ = 504 lbs.
5.—SETTING TIME.		
Initial	93 mins.	Not less than 30 mins.
Final	3 hours	Not more than 1½ hours
Classification	47 mins.	for normal setting cement.
6.—SOUNDNESS.		
Expansion after boiling 6 hours in Le Chatelier Mould.		
(a) Cement aerated 24 hours.	1 mm.	Not more than 10 mm.
(b) Ditto 7 days test (a) having failed.	...	Ditto 5 mm.

Proportion of water used in gauging.

(a) Neat briquettes	22%
(b) Cement and sand briquettes	8%
Temperature during period of testing	72°—87°F.

REMARKS.

The sample complies with the physical requirements of the B. S. Specification No. 12-1925 for Portland Cement.

N. BRODIE,

Superintendent,

Government Test House, Alipore, Calcutta.

PUNJAB PORTLAND CEMENT, LTD.

(Agents: Messrs. Killick, Nixon and Co., Bombay.)

“ Five Rivers ” Brand Portland Cement.

The company's works are situated at Wah on the main line of the N. W. Railway between Delhi and Peshawar, 28 miles north of Rawalpindi, with sidings into the Company's property. The Company's lease covers an area of over 80 acres and the quarry is adjacent to the works. The construction of the factory was completed and the manufacture of cement begun in 1923.

Staff and Labour.—The staff includes the manager, two engineers, chemist and burner, all Europeans.

Office assistants, time-keepers, fitters and skilled hands are Indians recruited from the Punjab.

General labour is obtained from the surrounding districts and numbers on an average 500, of whom about one-third are housed in the Company's quarters situated close to the works.

Raw Materials.—Limestone.—Limestone is quarried from a hill which is close to the raw mill. The deposits are extensive and so uniform in analysis that selection is unnecessary. The stone is claimed by hand-drilling and blasting and conveyed to the crushing plant by means of 27 c. ft. tip tubs running on a 2-foot gauge tram-line. An average analysis of the limestone is as follows:—

	Per cent.
Loss on ignition	41.56
Silica	1.93
Iron oxide	} 2.58
Alumina	
Lime	53.42
Magnesia	0.53

Total	100.02

Clay.—Clay is found in abundance near the works.

Gypsum.—Gypsum is imported from Dandot in the Salt Range, about 250 miles away.

Coal.—Bengal coal is chiefly used, but a certain amount is also obtained from the Makerwal colliery about 120 miles away.

Water.—An ample supply of water is obtained from a series of natural springs, some two miles from the works. The water contains 23° of hardness and is treated in a Lassen-Hjort water softener.

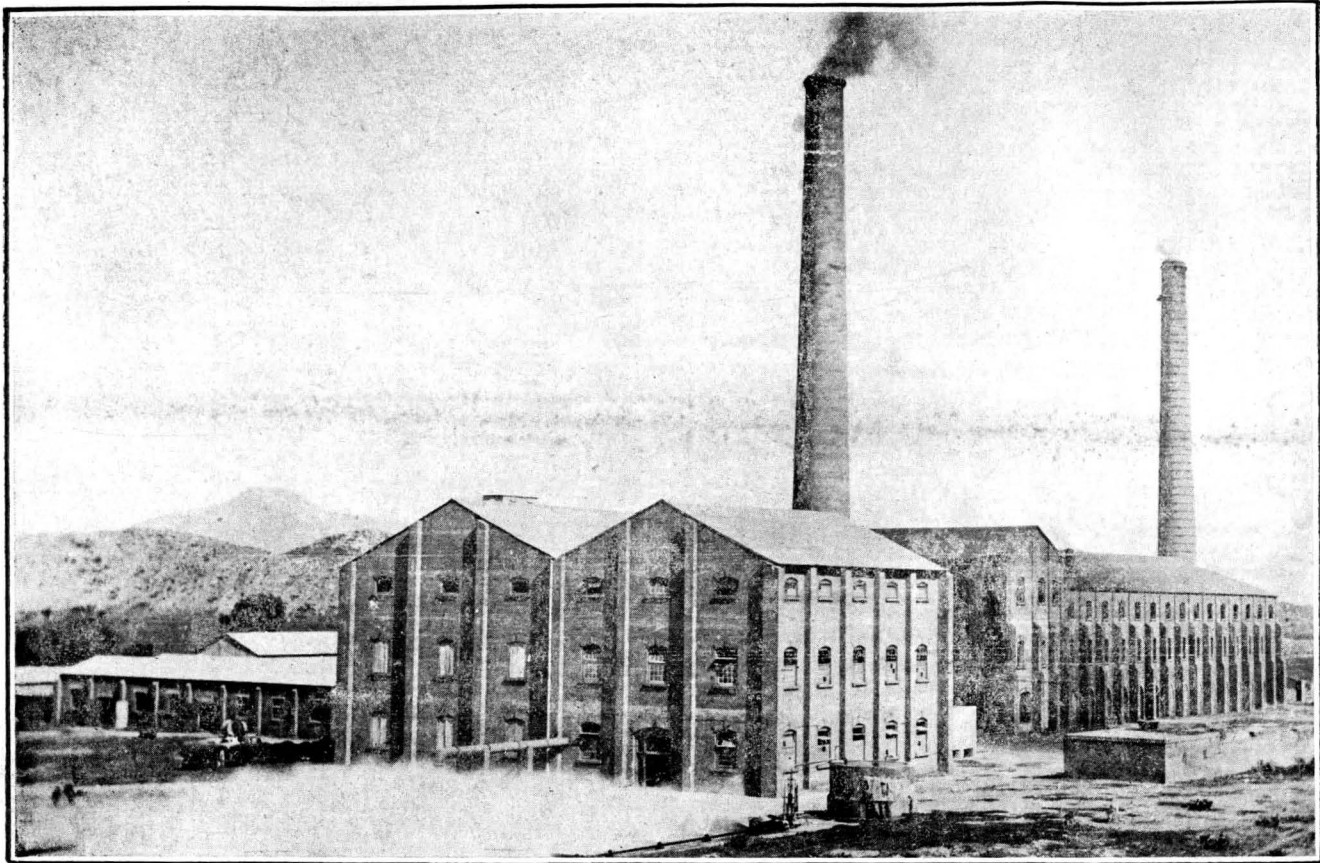
Process of Manufacture.—The wet process is in use.

Limestone is conveyed from the quarries in tip tubs and is fed into the crushers through a chute. The crushed stone is elevated into large reinforced concrete bins from which it passes by gravity through a roller crusher and thence into a ball mill. Clay is treated in the washmill in the usual manner and the clay slurry is pumped to the ball mill. From the ball mill the mixture passes through a separator which returns the coarser particles to the ball mill. The fine material is passed on to the tube mill. Clinker is ground in a compound mill known as the "Unidan Mill".

Power.—Alternating current is generated at 500 volts by a 1,750 K. W. turbo-generator set. A step-up transformer to 3,500 volts is used for supplying power to an overhead line to the water-works and a step-down transformer to 400 volts for lighting. The turbine is of Messrs. Daniel Adamson's manufacture and the alternator was supplied by the English Electric Company. The steam supply is obtained from three Babcock and Wilcox boilers fitted with chain grate stokers. Each boiler has a total heating surface of 3,260 square feet. The present maximum load is 750 K. W. and 35 motors ranging from 5 to 300 H. P. are situated in various parts of the works driving the machinery.

Capacity.—The capacity of the works at present is 33,000 tons a year and all buildings have been designed with a view to doubling the plant at a future date.

PUNJAB PORTLAND CEMENT LTD.



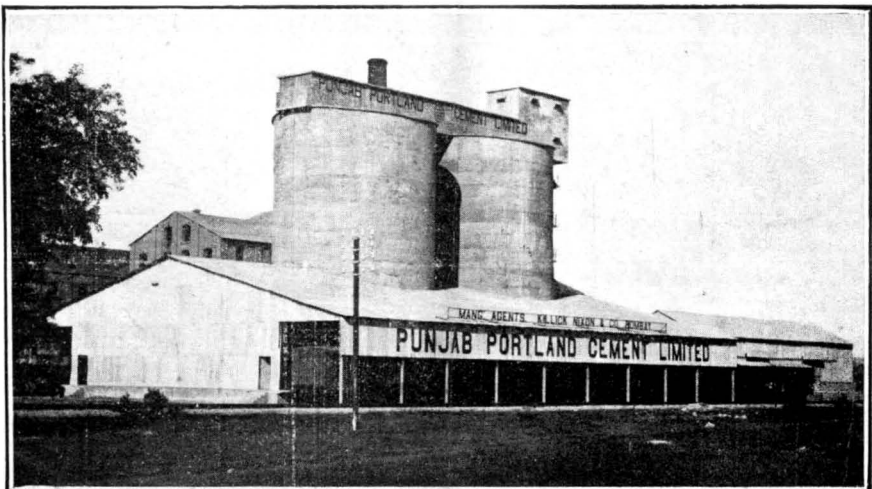
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VIEW OF THE WORKS.

PUNJAB PORTLAND CEMENT LTD.



EXILOR BAGGING MACHINE.



CEMENT SILOS.

GOVERNMENT OF INDIA.
INDIAN STORES DEPARTMENT.

GOVERNMENT TEST HOUSE,
Alipore, Calcutta.

TEST CERTIFICATE.

No. 3366-M.

Dated Alipore, Calcutta, the 10th March 1926.

Issued to Messrs. Killick, Nixon & Co., P. O. Box No. 109, Bombay, with reference to letter No. G.-1006, dated the 12th January 1926, from the General Manager, The Punjab Portland Cement Co., Ltd., Wahi.

Register No. 478-P. C., dated 15th January 1926.

Test No. 972.

BRITISH STANDARD TEST FOR PORTLAND CEMENT.

Name and Brand of Cement. "Five Rivers" Brand Portland Cement.

Nature of sample. Representing Mill Output for the month of December 1925.

	Results obtained.	Standard (1925).
1.—FINENESS OF GRINDING.		
Residue on Mesh 180 × 180	5.77 %	Not more than 10 %
Ditto 76 × 76	0.09 %	Ditto 1 %
2.—CHEMICAL COMPOSITION.		
Lime		
Silica		
Alumina		
Iron Oxide		
Magnesia		Not more than 4 %
Sulphur calculated as SO ₃		Ditto 2.75 %
Total loss on Ignition		Ditto 3 %
Insoluble Residue		Ditto 1.5 %
Nett proportion of Lime to Silica and Alumina.		Between 2.9 & 2.0

	Results obtained.	Standard (1925).
3.—TENSILE STRENGTH (NEAT).		
7 days (average of 6 briquettes) lbs.	680	Not less than 600 lbs.
4.—TENSILE STRENGTH (CEMENT AND SAND.)		
7 days (average of 6 briquettes) lbs. (W_s)	535	Not less than 325 lbs.
28 days (average of 6 briquettes) lbs.	558	Ditto $W_s + \frac{10,000}{W_s}$ = 554 lbs.
5.—SETTING TIME.		
Initial	127 mins.	Not less than 30 mins.
Final	3 hrs. 32 mins.	Not more than 10 hours for normal setting cement.
Classification		
6.—SOUNDNESS.		
Expansion after boiling 6 hours in Le Chatelier Mould.	...	
(a) Cement aerated 24 hours.	$\frac{1}{2}$ mm.	Not more than 10 mm.
(b) Ditto 7 days test (a) having failed.	...	Ditto 5 mm.

Proportion of water used in gauging.

(a) Neat briquettes	22%
(b) Cement and sand briquettes	8%
Temperature during period of testing	72°—87°F.

REMARKS.

The sample complies with the physical requirements of the B. S. Specification No. 12-1925 for Portland Cement.

N. BRODIE,

Superintendent,

Government Test House, Alipore, Calcutta.

THE SHAHABAD CEMENT CO., LTD.

(Agents: Messrs. Tata Sons, Ltd., Bombay.)

“ *Charminar* ” Brand Portland Cement.

The works of the Shahabad Cement Company, Ltd., are situated at Shahabad, Deccan, on the G. I. P. Railway main line from Madras to Bombay, with sidings into the works.

The Company was registered on the 5th of November 1921, with the object of exploiting the cement making raw materials in H. E. H. the Nizam's Dominions and providing Southern India with cement. Manufacture began in August 1925.

Staff and Labour.—The staff consists of the manager (European), kiln burner (European), engineer (Parsi) and chemist (Indian) with Indian assistants.

Labour is obtained locally. Untrained coolies are paid eight annas a day per man and five to six annas per woman. Tradesmen, millers, etc., are paid twelve annas to two rupees and eight annas a day.

Raw Materials.—Limestone.—The limestone used is the Shahabad limestone which is excavated from the Company's quarries situated about $3\frac{1}{2}$ miles from the works site and is brought into the factory on the Company's own light railway.

The following is the analysis of a sample of Shahabad limestone :—

	Per cent.
Loss on ignition	37·64
Silica	10·80
Alumina	0·60
Iron oxide	0·40
Lime	49·20
Magnesia	1·20
Total	99·84

Clay.—The clay used is the Shahabad black clay which is found within a few hundred feet of the factory.

The following is the analysis of a sample of Shahabad clay:—

	Per cent.
Loss on ignition	15.12
Silica	45.98
Alumina	19.03
Iron oxide	7.93
Lime	9.44
Magnesia	1.85
Total	99.35

Gypsum.—Gypsum is obtained from Badwari in Jodhpur State.

Coal.—Seventy per cent. of the coal consumed is obtained from the Singareni collieries in H. E. H. the Nizam's Dominions of Hyderabad, Deccan, and 30 per cent. from the Bengal coalfields.

Water.—Water is obtained from the Kogna river situated about one mile from the works. An electrically driven centrifugal pump with an auxiliary steam pump has been installed for pumping the water. The water is soft and free from salt.

Process of Manufacture.—The cement is manufactured by the wet process.

Supplies of limestone and clay are brought in in 1-ton capacity tip trucks. The clay is unloaded direct from the trucks into the 22-foot diameter wash mill where it is incorporated with water and in the form of "clay slurry" passes by gravity through gratings into a storage basin where it is kept continuously agitated by a mechanical triple mixing device. From this basin it is drawn by double acting ram pumps and forced into either the raw material wet grinding mill or the adjusting clay tank fixed above the slurry correcting tanks as may be desired.

The limestone is dumped directly into a gyratory crusher having a capacity of 25 tons per hour. The limestone is crushed down to a size of 3" and is then elevated into two reinforced concrete hoppers each of 100 tons capacity. From these hoppers the limestone is extracted on adjustable feed tables delivering into a double roller mill