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3 February 1986

MINI-CEMENT PLANTS*

A Technological Information Package

Prepared by the
Industrial Information Section
UNIDO TECHNOLOGY PROGRAMME

*The following report gives the names of some of the firms which are known to manufacture and/or trade in this commodity, but the list should not be regarded as exhaustive. Inclusion in the list does not imply any recommendation by UNIDO. The views and opinions expressed in this paper are those of the consultant and do not necessarily reflect the views of the Secretariat of UNIDO. This document has been reproduced without formal editing.

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Introduction

The compilation of this package was in response to an increasing number of inquiries from developing countries requesting UNIDO for information concerning specific aspects on the subject.

The objective of this information package is to assist local investors, companies and individuals by providing them with such information in their efforts to develop the possibilities of establishing a new or modernizing an existing facility.

This package, which is a compilation of collected material, contains basic information on the subject and other industry-related matters with emphasis on the experience of developing countries. It describes the preparation of raw materials, methods of production and processing, machinery and equipment needed. It covers technology, economic and financial aspects of specific projects. This package also provides a questionnaire on the subject and has reference to equipment and technology suppliers.

The information contained in this package is by no means exhaustive nor should it be considered a replacement of technology profiles. Any contribution from our readers for updating of, or inclusion in the package would, of course, be welcome.

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General Remarks*

The cement industry, as the producer of one of the most verstile building materials, is a key industry in national industrial development in the developing countries. During the period 1960-1981 the cement production in the developing countries rose from 42 million tons to 213 million tons and their share in the world production increased from 13 to 24 per cent. 1/

The tendency in the cement industry is to build increasingly large factory units. A normal size is now 3,000 t/d, while units with capacities of 9,000 to 10,000 t/d are now contemplated. They are highly capital-intensive. Smaller sizes more suitable for developing countries with smaller needs use older but modernized technology without much sophisticated instrumentation. Good Portland cement can also be produced economically in a 300 t/d plant.

Still smaller plants, called mini cement plants, with capacities as low as 20 d/t, are being built and have proved to produce clinker of a quality equal to that from a large rotary kiln. However, a continuous control of the burning process is essential, and if this size of kiln is contemplated in another country, it is recommended that full-scale tests be carried out in an existing kiln, as the chemical composition of the raw materials, which varies from location to location, is of great importance. The mini plants would be more appropriate where, for example, there is need for catering to the scattered localized demand and where transports costs from distant large plants would be exorbitant. Also, such small plants have a positive impact on employment and dispersal of industrial activity.

Clinker-grinding plants are another means to lower cement costs and distribute it over a wide area, especially as the product can be transported in bulk and can withstand long storage.

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*Source: Appropriate Industrial Technology for Construction and Building Materials, UNIDO January 1981, Re: ID/232/12.

1/ Use and Conservation of Energy in the Cement Industry, UNIDO/IS/540, 12 July 1985.

The production of cement for masonry purposes and Portland and pozzolana cements are other ways to increase the output of cement from a given clinker production. The first of these is produced by intergrinding the clinker with up to 50 per cent of an inert filler, usually limestone, while in the second the clinker is ground together with natural or artificial pozzolanas, which can be volcanic aggregates such as pumice or tuff or calcined clays or fly ash. The Portland-pozzolana cements are slower setting, but they may eventually gain a strength which is higher than that of cement, and they are usually also sulphate resistant and adequate for certain constructions such as harbours, foundations etc.

Cement production is not as flexible as many tradition building materials. Considerations of economy of scale make it practically impossible to build a cement plant with a conventional rotary kiln of less than 120,000 t/a production and where the availability of limestone, low-volatile fuels and the like permit the use of shaft-kiln technology, a minimum capacity of 6,000 t/a could be achieved. In some developing countries with low labour costs, smaller and less sophisticated plants appear to have been able to produce a comparable quality of cement at lower cost than the large conventional ones.

MINI-CEMENT PLANT*

Definition and processing

Cement is made by blending the desired proportions of crushed and pulverised argillaceous and calcareous rock. This material is then burnt at a high temperature (1350° to 1400°C). The materials used are :

- calcareous rocks, which mainly provide the lime ;
- argillaceous rocks, which largely provide the silica, alumina and iron oxides.

In order to combine these, the various constituent elements must be well blended in the form of powder or a slurry of very fine particles before burning. When powder is used, the manufacturing process is called the dry process, and the wet process when slurry is used. The materials are burnt in two types of kiln : vertical (stationary) and rotary kilns. The former is used for making cement by the dry process; the latter can be used for either process. The material which comes out of the cement kiln is called clinker; this hard blackish product is in fact the cement in lumps and it has only to be ground in order to obtain cement powder. Materials with hydraulic properties, such as blast - furnace slag (which is by-product of the steel industry), may be added to the manufactured cement (10 to 30%).

(a) The various successive operations in cement-making are as follows :

(a) (Quarrying) ;

(b) Crushing and grinding of raw materials ;

(c) Blending the raw materials ;

(d) Burning of materials ;

(e) Cement grinding ;

(f) Handling (storing, packaging etc) of the finished product.

Flow - sheet for cement manufacture is shown in Annexure I.

(b) Crushing and grinding.

The raw materials are brought from the quarries to the works by belt conveyors, aerial ropeways or overhead conveyors, lorries or small wagons depending on the distance, production flow and so on. Primary crushing usually takes place at the quarry. In the case of very hard limestone, it is necessary to reduce these fragments by secondary reduction in rollertype, flail or hammer mills. After crushing, the material must be reduced to a fine powder or slurry and for this purpose it is put through ball mills or tube mills.

* Source: UNIDO Project Profile BGD/072/V/1984-07.

(c) Blending the raw materials.

Dry process (alternative I).

The powder from the dry tube mills goes to several bins but its composition is not constant and it must be precisely and uniformly blended to obtain a perfectly homogeneous product. For this purpose, suitable equipment draws the powder from several storage bins and feeds it through a central duct where a screw conveyor mixes it and carries it to a bin in which the final proportioning is carried out. The material is extracted from the bottom of this bin and returned to the top by a bucket elevator, the cycle being repeated several times until a thoroughly homogenous mixture is obtained. When the powder has been properly mixed and proportioned, it has only to be burnt for cement to be obtained.

Wet process (alternative II).

The slurry that comes out of the tube mills is of a creamy consistency which facilitates the stirring to make it perfectly uniform. Mixing is done in tanks by compressed air and mechanical stirring. Stirring is done by means of an agitator rotating in a fairly small tank (mixer) or by the simultaneous rotation of several agitators fixed to a long horizontal metal beam which revolves freely and slowly about its mid point inside a large vessel as a result of the reaction of the paddles on the slurry (planetary mixer-agitator). The proportioned slurry from the homogenization vessels is pumped to the rotary kiln.

(d) Burning the raw material.

The rotary kiln is in most cases used in the dry or the wet process for burning the mixed and proportioned materials. After burning, the hot clinker from the rotary kiln is taken by a conveyor to a clinker store.

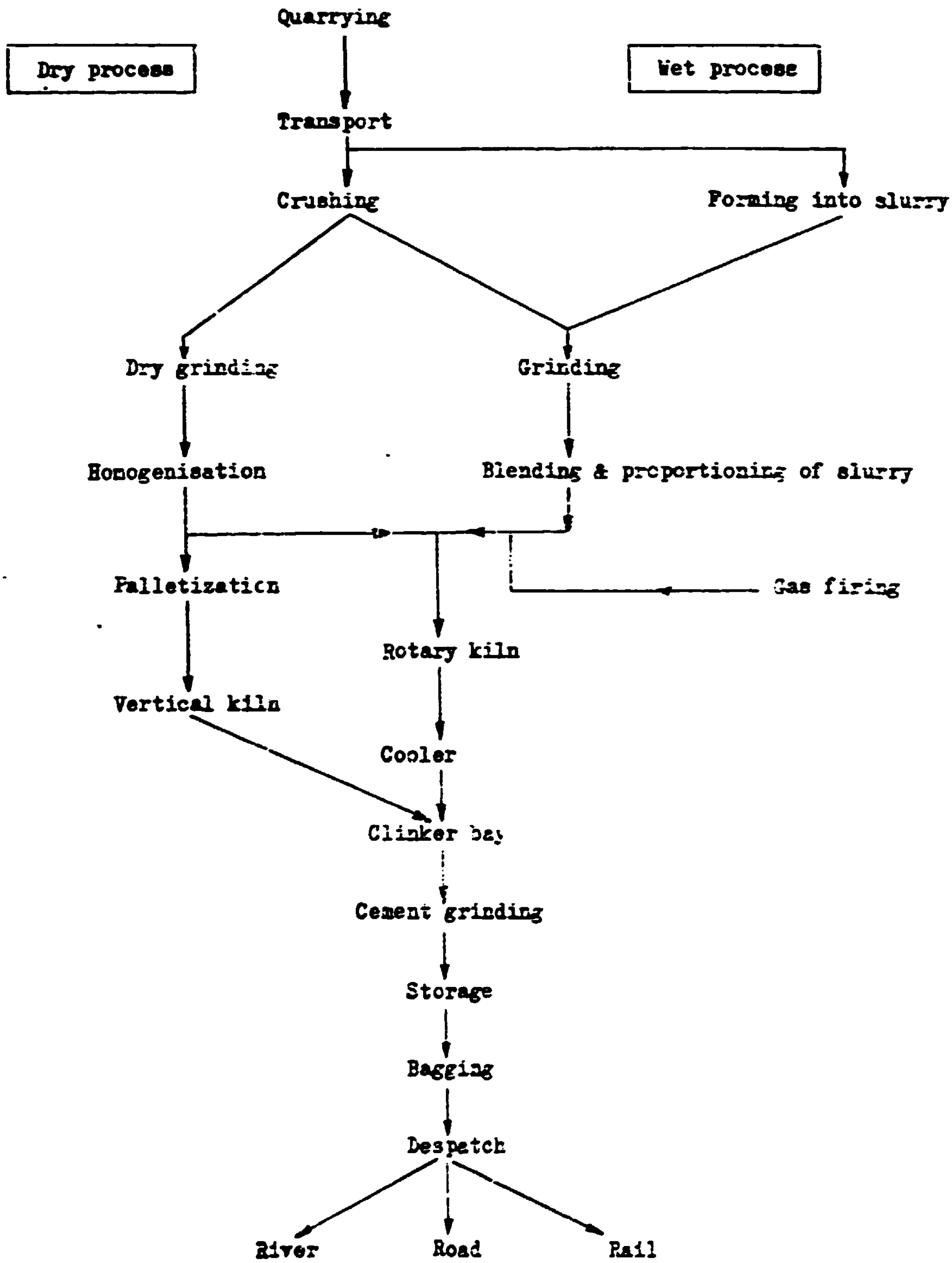
(e) Grinding the cement.

The clinker from the clinker store is blended with a little gypsum (2 to 6% of gypsum or purified phosphogypsum, slows down and regulates setting), and is then dry-ground to a very fine powder in cement mills similar to those used for final reduction of the quarried rock to powder.

(f) **Handling of the finished product.**

From the finish mills, the cement is carried to storage silos by elevator, screw conveyor, pump, or similar handling equipment. Bagging is generally performed automatically. The bags of cement are loaded for despatch on railway wagons or lorries.

ANNEXURE - I



FLOW - SHEET FOR CEMENT MANUFACTURE

ANNEXURE - II

List of Equipment & Machinery for Mini Cement Plant

1. Jaw crushers
2. Ball mills
3. Rotary kiln
4. Bucket elevator
5. Rotary cooler
6. Pulverizer
7. Screening equipments
8. Packing machine
9. Accessories & spare parts
10. Miscellaneous & Lab. equipments.

MINI-CEMENT PLANTS*

BASIC PROCESS CONSIDERATION

1. SMALL-SCALE MINING OF CEMENT RAW MATERIALS

Mining methods in developing countries are very different from those used in industrialized countries. Naturally, the best methods depend on the type of rocks. Selective mining would be much more viable for small-scale operations and certainly would increase the raw materials quality.

In the smaller quarries for cement raw material, which use more reliable and simpler mining methods as well as smaller machines, quality control through selective mining and the elimination of sterile or harmful rock is also greatly simplified. Smaller operations can usually also react faster to sudden changes in the quality requirements of the plants they supply.

2. PREPARATION OF CEMENT RAW MIX

Whether wet or dry processing is more suitable to the kind of raw material, we see many possibilities of savings.

Beside the decreased requirement of grinding energy for washable materials, the wet process provides the chance of low cost transportation of the slurry via pipelines over long distances. Especially where the plant's location is far away from the quarry, slurry pipelines are economic.

As the dewatering of slurry by means of filter presses is less complicated for small operations, the application of the semi-wet process (with a dry process kiln plant) is recommended in above cases. Mixing and homogenizing will be very easy and less energy wasting.

*Source: AUSTROPLAN, Austrian Engineering Company Ltd.

If the raw material is relatively dry and the plant site is in the vicinity of the quarry, the dry process technology is recommended. Systems for prehomogenizing of crushed stone in the stockpile (buffer storage) prior to mixing (proportioning of raw mix components) have considerably reduced the expenditures in meal blending silos and related units in modern plants. We have inspected plants where as a consequence of above facts homogenizing silos have been degraded to storage silo function only.

By concentrating the processing stages of homogenizing and proportioning into one section (raw material buffer storage) in front of the raw mix drying cum grinding section, the conventional technique will be simplified to a large degree without any loss in product's quality. The difference will lie in investment and production (energy) expenditures.

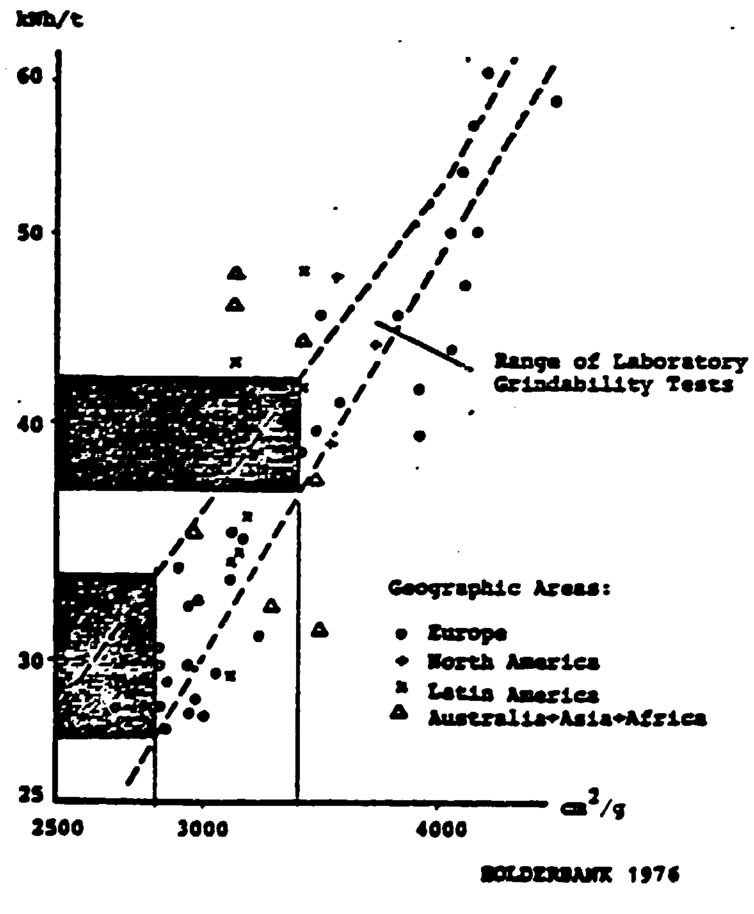
3. ALTERNATE GRINDING OF RAW MEAL AND CEMENT

For processing relatively dry raw materials, the opportunity of alternate grinding of raw material and cement is given. Ball mills would have the disadvantage of residue in the mill when the material to be ground is changed. Here the ROLLER MILL can favourably be used. Initial tests resulted in the new aspect to use such mills for clinker grinding also! As the grindability of raw material is usually better than that of clinker in the same ratio as the throughput is larger ($f = 1.6$), the mill size can be fully utilized in a very economic way. The investment for grinding equipment for a small-scale plant will become comparable with a conventional much larger plant. The reduction of construction volume will be tremendous.

Roller mills have the disfavourable character of uniform product particle size. To adjust the particle size distribution of the product to that normally yielded by the application of ball mills, we recommend grits grinding by vibrating mills in order to increase the percentage of fine particles. However, an optimum between specific surface (Blaine value) - grain distribution - clinker quality - energy requirement can be achieved by not too complicated means.

The following table shows how much energy can be saved by courser grinding. Well-burned clinker of high quality would permit to do so. About 1o kWh/t can easily be saved.

SPECIFIC ENERGY CONSUMPTION FOR GRINDING OF PORTLAND CEMENT.



4. CLINKER BURNING IN SMALL KILNS

Energy requirement for pyroprocessing at small-scale in simple rotary kilns is higher than in large sophisticated plants, expecially when short kilns with suspension preheater systems are installed.
The most feasible kiln type for mini-plants would be the "old" SHAFT-KILN fed with "black meal" (raw-mix with admixture of powdered coal) - nodules. When black-meal is burned the HAUENSCHILD reaktion +) between calciumcarbonate and carbon takes place, resulting in highest fuel economy ($CaCo3 + C = CaO + 2CO$). Examination of nodules confirmed the start of the reaktion already below 9oo°C. Heat requirement is equal to modern dry-process rotary kilns with suspension preheaters.
Shaft kilns for cement production have been installed on coal fuel basis only. Up to now, tests made with oilfiring systems for cement shaft kilns were not successful. Here further research has still to be done.

Rotary kilns with oil-or gas-firing might be economically justified when the fuel prices are low and no coal of suitable quality is available. In such cases emphasize is made on simple design for small units in order to keep electric energy requirements low. Long rotary kilns with waste heat utilization for raw material drying purposes could fulfil this concept because it makes no sense to be economical with fuel in complicated kiln/preheater systems when on the other hand drying heat is in most cases needed anyhow in the raw material preparation and mixing section of the plant. In the average, the moisture content in raw material is above 1o% and therefore predrying of raw material is often required. Above 15% H_2O the process selection is in favour of simple long rotary kilns.

+) Hauenschild: Zement 6(1917), 92
Kühl : Zement 17(1928),859
Spohn : ZKG 7 (1954),4o9

For small-scale cement plants, the system of a long rotary kiln should be modified to such degree as to allow simpler design of plant and less cost of civil construction. The acceptance of higher exit gas temperatures would lead to kilns of shorter length and the availability of heat energy for drying or other purposes.

A revival of the "oldfashioned" system of rotary kilns in compound with waste heat boilers (steam turbines) should also be investigated in detail as the permanent availability of electric power is often problematic in developing countries.

5. CRITERIA FOR THE CHOICE OF SEMI-WET PROCESS

In cases where the nature of the available raw material pre-determines wet processing and with a view to the constantly increasing cost of fuel energy, the semi-wet process of cement manufacture is gaining more and more applications.

This process combines the advantages of wet raw material preparation with the lower fuel consumption of dry pyro-processing. Dewatering of slurry is mostly done in automatically operated horizontal chamber-filter presses. In mini-plants this process will be less complicated than in large-scale operations with numerous parallel filter presses.

After dewatering of the slurry, the filter cakes are processed to briquetts (to be dried) or to nodules (pellets).

Attention is invited to the fact that investment and production cost can be reduced, because most cement raw materials can easily be suspended in water and accordingly power consumption will be lower for grinding and blending. The plant layout would be very simple and the expenditure in civil constructions could considerably be reduced.

The semi-wet process becomes very attractive when contaminations in raw materials (chlorine, alkalies, etc.) exceed permissible limits.

Appropriate technologies for small-scale production of cement and cementitious materials

*R. J. S. Spence**

Summary and recommendations

Small-scale Portland cement plants

There are economic advantages to be gained, in certain circumstances, from producing Portland cement in much smaller plants than are currently used. Such plants could:

(a) Be located wherever local demand for cement was large enough, in relation to the capacity of the plant, and suitable raw materials existed;

(b) Be locally manufactured and assembled, avoiding the need for imports and reducing dependence on foreign firms;

(c) Be erected and brought into production quickly;

(d) Make only a small localized additional burden on the existing infrastructure.

At present the smallest available plants made by cement machinery manufacturers in industrialized countries are vertical shaft kilns with outputs of 180–200 t/d. Plants of this size could be manufactured partly in local workshops. Much smaller mini-plants of 20–50-t/d capacity have been developed in India. Plants of this size could be manufactured completely independently of companies in industrialized countries, and would reduce capital costs per unit of output. But technical and institutional problems have so far prevented the designs for these plants becoming available for commercial production.

Lime-based cementing materials

Much of the production of Portland cement could be replaced by lime and lime-pozzolana mixtures. Technology for producing these materials is relatively simple, and can be utilized at a very small scale. Capital costs for the equivalent

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* Source: Appropriate Industrial Technology for Construction and Building Materials, UNIDO, Austria Jan. 1981

output are significantly lower than for Portland cement production and employment potential is considerable. Construction of plants could be entirely local. An extensive range of raw materials can be used; many of which are of widespread occurrence.

Other cementing materials

Other raw materials, gypsum, impure limestones and dolomites can be used to make different forms of cement. These processes could, in appropriate circumstances, be cheaper to establish and produce cheaper materials than Portland cement. Further processes for small-scale production of cement are also being developed.

Recommendations on institutional support needed to promote alternative cement manufacture

To promote the development of small-scale Portland cement plants:

(a) Capital to establish plants should be made available on generous terms;

(b) There should be no freight equalization charge or other distortion of the real cost of transporting cement throughout the country;

(c) A range of standards for cement should be instituted, rather than one single standard, to allow for different levels of manufacturing expertise;

(d) The development of these plants should be the responsibility of an institution entirely independent of large-scale cement manufacturers.

To promote the development of lime and alternative cement:

(a) The development of the materials should be the responsibility of a government-financed small industry development organization, whose responsibility will not only be the development of appropriate techniques for manufacture and establishing manufacturing units, but also the promotion of the material to potential users;

(b) New raw material surveys should be conducted to locate likely small-scale deposits of suitable materials;

(c) Some means should be found to encourage technically qualified people to work in industries in rural areas;

(d) The properties of alternative cements should form a part of all courses in building and civil engineering.

INTRODUCTION

The place of cement in development

Cement, or at least some form of cementing material, is an essential ingredient of virtually every type of construction in developing countries and hence a continuing and expanding supply of cement is essential to provide the infrastructure for development. A temporary shortage of cement in a developing country can, and frequently does, completely halt crucial construction programmes. Throughout the developing world precious resources are wasted on half-completed projects which cannot be finished because cement is not available.

Thus cement must be counted among the basic commodities on which development programmes rely, with an importance comparable to that of water, energy and fertilizer supply; consequently self-sufficiency in cement production is always given a high priority in development planning.

Until recently, the means by which most developing country planners sought to achieve an increase in the supply of indigenously produced cement had been the establishment of comparatively large-scale factories, on the model of those in the industrialized countries. These factories produce Portland cement and an associated range of products satisfying ISO standards. The factories have been either entirely imported, or, in the countries with a more highly developed industrial sector (e.g. India), locally manufactured in association with manufacturers from industrialized countries. This approach has certain undesirable consequences for the economies of the poorer countries, and it is being increasingly asked whether there are not alternative approaches by which a greater degree of local self-reliance, not only in the manufacture of cement, but also in the establishment of cement plants, could be achieved.

Two alternative approaches are being widely considered. The first is the manufacture of Portland cement, or a cementing material of comparable quality, in much smaller, locally made kilns which could be widely dispersed. This approach, already successfully adopted in China is under active consideration in India.

The second approach is the upgrading of village-scale technology based on lime and pozzolanas in order to produce a standardized, though comparatively low-grade cementing material that could serve as a partial or complete replacement for cement in a wide range of applications.

In addition to these two approaches, which depend on essentially the same raw materials as does Portland cement and are thus of similar general applicability, there are a range of other materials or techniques by which cement could be made under particular local circumstances. Some of these are little known, and could be profitably more widely used than at present in developing countries.

The introduction of new materials and techniques is always accompanied by unexpected problems of a socio-economic as well as a technical nature; that is particularly likely to be true in the case of a material with such a powerful developmental role to play as cement. Some of the social, economic and institutional problems that have been encountered or are likely to be encountered in introducing new or different cement-making technologies are also considered in this paper.

Existing cement production

The consumption of cement by developing countries has risen rapidly in the last 20 years as development expenditure has increased. Even more impressive has been the increase in levels of domestic production (see table 1).

TABLE 1. GROWTH OF DOMESTIC CEMENT PRODUCTION IN THE MACRO REGIONS OF THE WORLD AND IN CHINA AND INDIA, 1966–1975

Region or country	*1966*	*1975*	*Increase*
	(Million tonnes)		(Percentage)
Africa	12	23	92
North America	85	90	6
South America	17	34	100
Asia	82	168	105
Europe	176	248	41
Oceania	5	6	20
USSR	80	122	53
World	457	691	51
China	11	30	173
India	11	16	46

Source: United Nations Statistical Yearbook 1976.

In all the developing regions, cement production doubled during this period, while much smaller increases were recorded in the developed regions. The increase in cement production in the developing regions has, in fact, been a great deal faster than that of the average *per capita* income, reflecting perhaps the predominance of capital projects in the market for cement. Some particularly remarkable increases were those of China (from 11 million to 30 million [illegible] he Philippines (from 1.6 million to 4.4 million t/a) and Sri Lanka (from [illegible]00 to 393,000 t/a).

Correspondingly, imports of cement by developing countries have declined. A considerable number of developing countries are already, or soon will be, self-sufficient in cement.

The trend to large-scale plants

Details of the sizes and types of cement plants that have been established are not readily available on a world-wide basis. However, recent reports on the Indian cement industry [1] suggests that whereas the majority of the kilns established in the 1950s and 1960s were of 300–500 t/d capacity, those established more recently are of 600 t/d capacity and larger. However, in 1975 there was no kiln in India larger than 1,000 t/d capacity. In the same year the National Committee on Science and Technology in India was in an advanced stage of completing an exercise for single units of larger capacities – 2,000 t/d and above.

It would appear that the current trend in conventional cement manufacture in developing countries, as elsewhere, is towards larger and larger kilns. Indeed, the present dependence of so many developing countries on just a few cement-plant manufacturers in industrialized countries makes it inevitable that technological trends in the industrialized countries will be followed in the developing countries and, at first glance, the savings in capital cost and energy costs resulting from an increase in size of plant seem to present a good case for this trend.

Whatever the advantages of the use of large-scale cement plants in the industrialized countries (and these advantages are by no means undisputed),[1] their appropriateness for all situations in developing countries is being seriously questioned.

Problems

The problems associated with large-scale plants are:

- High capital cost per unit of output
- Long time-lag in construction
- Difficulties in satisfying infrastructure requirements
- High cost of transportation to outlying areas
- Dependence on imported machinery
- Low capacity utilization
- Limited number of locations where raw materials are adequate
- Difficulty in obtaining capital for new plants

Some of the problems are directly associated with the scale of production. The reserves of raw materials required to keep a plant in operation for a period of 30 to 40 years are considerable, and the number of locations where reserves of sufficient quantity and quality are found is limited. In India, a high proportion of cement is produced in the south of the country, while the largest markets are in the north. The scale of the machinery required to be manufactured, transported and installed creates further problems. The larger the plant needed, the smaller the number of workshops capable of producing it. For most countries, this means the entire plant must be imported. But even in the countries that have their own heavy workshop capability, the unit cost of machinery increases as the scale increases.

For smaller items which can be produced in many workshops there is keen competition leading to a lowering of price. The size of the infrastructural requirements, e.g. power, maintenance workshops, railways, and the specialized skills needed for a large plant, create further problems. Shortages or breakdowns can frequently result in plant shutdowns. In India, capacity utilization has been usually high, above 80 per cent, because of the large demand, but over recent years has been severely hit by shortages of coal, power

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[1]A recent report (unpublished) from a large cement manufacturer in the Federal Republic of Germany states that neither fuel nor capital costs have been substantially reduced by the installation of larger units. Greater expenditure on servicing personnel and reduced competition among machinery manufacturers are additional factors which in practice weigh against the larger plants.

and freight cars, causing a drop to 72 per cent capacity utilization in 1974. In other countries, with a less well-developed infrastructure, capacity utilization is frequently much lower. If low capacity utilization in large plants were calculated for at the planning stage, their economics would look far less attractive.

Because of the large-scale, high capital cost and long time-lag in construction (three to five years), the financial commitment in a large cement plant is immense. In developing countries there are few if any investors who have the resources for such an undertaking, leaving the expansion of the cement industry either to government or to foreign investors. This is one of the main reasons why expansion in production so frequently lags far behind, causing an almost universal scarcity of cement.

Another problem of growing importance associated with large-scale plants is that of transportation and distribution of the product. The level of demand for cement in developing countries is typically such that any large-scale plant must serve a large geographical region. India's area of 3.2 million km^2 is served by 53 cement plants, approximately the same number as in the much smaller area, 230,000 km^2, of the United Kingdom of Great Britain and Northern Ireland. Africa south of the Sahara (excluding South Africa), an area of more than 16 million km^2, is served by no more than 25 plants. Thus transportation costs must represent a substantial proportion of the price buyers pay for cement. In India, where most of the cement is transported to district distribution centres by rail, distribution costs are equalized throughout the country, with a freight equalization charge of approximately 15 per cent of the consumer price. This arrangement, though advantageous to the consumer, reduces the incentive for new cement plants to be located near large markets so that transportation costs would be lower.

In many other countries, where rail networks are less developed and cement must be transported by truck, bullock cart, boat or even by air, transportation costs are much higher, particularly where these have to account for numerous handlings and for the inevitable loss and deterioration in transit. Thus, throughout Indonesia the price of cement is above $100 per tonne; in parts of Sumatra it is as high as $500 per tonne; and the price of cement in the interior of the United Republic of Tanzania can be as much as two or three times that in Dar es Salaam, where the factory is situated.

Finally, the centralization of production resulting from the use of large-scale cement plants is entirely inconsistent with a policy of regional self-sufficiency.

Because of the problems, there is now considerable interest in the possibility of smaller-scale cement plants which could be:

(a) Widely distributed wherever there is a demand for cement and suitable raw materials are found;

(b) Manufactured and assembled locally, avoiding the need for imports and reducing technological dependence on foreign firms;

(c) Erected and brought into production quickly;

(d) Cheap enough to be financed locally;

(e) Only a small localized additional burden on existing power and transportation infrastructure.

Such smaller plants would also need to be of low capital cost per unit of output, and economical in their use of energy; otherwise the cost of the cement produced in them would not compete with that produced in large-scale plants. The straightforward scaling down of existing technology used in large rotary plants is unlikely to meet this requirement because of the economies of scale in rotary plants. Different technologies, more appropriate to the specific requirements of a small plant, are therefore needed.

I. SMALL-SCALE PORTLAND CEMENT PLANTS

Background

The earliest Portland cement kilns were like lime kilns. They consisted of a conical or bottle-shaped shaft and were operated intermittently. One of the reasons why shaft kilns were susperseded, early in the twentieth century, by rotary kilns, is that the rotary kiln could be operated continuously, thus considerably improving fuel efficiency, and making it possible for a more uniform product to be produced. As demand grew, so longer and larger kilns came into use, and with each increase in scale came a reduction in fuel consumption and in capital costs. Shaft kilns could not be scaled up in this way, and so they ceased to be economical for situations where there was a large concentrated demand.

The reasons for this can be explained as follows:

"The main difference between the vertical shaft and rotary types of kiln is that the principle of heat transfer by conduction plays a more important role in the vertical shaft kiln than radiation, whereas in the rotary kiln radiation is more important than conduction. Heat transfer by conduction can be efficient in a relatively small space; beyond a certain size heat transfer efficiency drops due to high radiation losses. On the other hand, heat transfer by radiation is progressively more efficient in a larger space due to lower heat losses. This basic fact led to the development of larger and larger plants based on rotary kilns. The vertical shaft kiln can be efficient with a capacity of as low as 1 t/d, and has a maximum efficient capacity of 200 t/d. The rotary kiln, however, has a minimum efficient capacity of 300 t/d and nowadays capacities of 3,000 t/d and more are preferred." [2]

In fact, vertical shaft kilns virtually went out of use until the 1930s when new designs with continuous, as opposed to batch operation, were developed. Such continuous operation vertical shaft kilns continue to be used in some European countries for a small proportion of their cement production. Overall, some 5 per cent of world output today is still being produced in vertical shaft kilns.

Because of the heat-transfer principle used, shaft kilns tend to have lower fuel consumption than rotary kilns. A recent report on the European cement industry [3] gives an average fuel consumption for the main processes used (see table 2).

TABLE 2. REPRESENTATIVE ENERGY CONSUMPTION OF COMMON PROCESSES OF CEMENT MANUFACTURE IN EUROPE

Process	*Energy consumption per kilogram of cement*[a]	
	(kcal)	*(kJ)*
Dry (long kiln)	860	3 600
Wet (long kiln)	1 300	5 400
Semi-dry (great pre-heater, Lepol type)	850	3 600
Dry (suspension pre-heater)	790	3 300
Shaft kiln	750	3 100

Source: [3].

[a]Not including the electrical energy consumed, which amounts to 0.1 kWh, or 86 kcal (360 kJ).

Lower fuel consumption enables vertical shaft kilns to remain competitive with rotary kilns in spite of the difference in scale of operation. However, there are differing views both on the scale and on the technology best suited to small Portland cement plants in developing countries. Some recent work is summarized below.

Indian development work on small-scale vertical shaft kilns

Between 1965 and 1970 the Regional Research Laboratory, Jorhat, India developed designs for small shaft kilns with capacities of 2, 30 and 100 t/d. Pilot kilns of 2 and 30 t/d were installed.

In 1965, the Uttar Pradesh State Planning and Action Research Institute decided to design, build and operate a 25 t/d plant in India, on which the design of future commercial plants could be based. The design was in many respects similar to the Jorhat design, based on a disc nodulizer feeding a vertical shaft kiln. The kiln was designed to use as raw material a mixture of kankar (impure secondary limestone found in the plains of northern India) and rock limestone. The fuel was coke breeze with some coal added. Production trials took place in 1970/71 during which 10,000 tonnes of cement were produced, most of which satisfied the Indian Standards Institution specification for Portland cement, except for the expansion ratio, which was somewhat high. Further work to develop this design was initiated in 1978 by the Appropriate Technology Development Association, Lucknow, India.[2]

A similar project is that of the Cement Research Institute of India (CRI), New Delhi, at its Tamil Nadu centre where a 25 t/d plant has been developed and is working on an industrialized commercial basis.[3]

[2]See "Proposal and Feasibility Study for a 25 t/d Mini Cement Plant" in this monograph.

[3]Several research reports on mini cement plants are available from CRI. See, too, the paper prepared by CRI contained in this monograph.

Medium-scale vertical shaft kilns

During 1976, a mission for UNIDO was undertaken by a cement consultant whose main aims were:

To organize and undertake an exploratory mission to producers of equipment for shaft kilns and cement manufacturers experimenting or working with shaft installations;

To make observations and recommendations on the requirements for the establishment of shaft kiln pilot plant installations [4].

The consultant recommended the use of vertical shaft kilns of a size considerably larger than the Indian designs and proposed a plant with an annual output of 80,000–120,000 t, from two conventional shaft kilns of 180–200 t/d or, alternatively, one kiln working on the newly developed Reba process. Such a plant would be large enough to take advantage of highly developed existing kiln designs yet small enough to be fabricated locally and to make substantial savings through standardization. The advantages of a vertical shaft kiln installation are:

Substantial savings in space

Simple construction with no heavy castings

Fewer problems with starting and stopping

High degree of reliability due to the durability of refractory bricks

Kiln and cooler form an integrated unit

Production of low-alkali clinker possible

Possibility of low-cost do-it-yourself construction

The consultant pointed out that conventional shaft kilns might not be suitable for all raw materials as they require the use of high strength pellets and low-volatile fossil fuel. The Reba process, however, would enable shaft kilns to be oil-fired.

The compact cement plant

A different approach was suggested in a recent article in *World Cement Technology* [5]. The author underlined the need for small cement plants in developing countries in order to achieve dispersal of industrial activity for local economic development. He argued, moreover, that the smaller the plant, the lower the unit cost, because of the increased competition among the much larger number of workshops able to produce it.

He did not, however, accept the vertical shaft kiln as the answer, except at the mini-plant level of 10–50 t/d. Above 100 t/d, he argued, the vertical shaft kiln had major disadvantages because:

"Nodulisation of cement raw mix and fuel (coke breeze only can be used and this normally has to be brought from steel plants at comparatively high cost, when compared to low/medium grade coals normally used in the cement making process) in the correct proportion is necessary for charging the nodules to the vertical kiln. This process requires additional equipment and auxiliaries which increase costs. Adequate control of the burning process, once the nodules are charged to the kiln (to achieve uniformly burnt clinker) is difficult to achieve in a shaft kiln and results in an uneven quality of clinker which after selective screening does not produce a good quality clinker cement. In view of the additional equipment necessary in a shaft kiln plant the operational costs are also relatively higher when compared with an SP kiln system."

He therefore proposed a "compact" plant of 150 t/d capacity, with a rotary suspension pre-heater kiln, using the dry process of manufacture. The kiln would be fired by pulverized coal.

Cement production in China *

According to a 1977 report [6] more than half of China's cement production comes from small-scale plants. The standard plant has an annual production of 32,000 t, approximately 100 t/d. The technology is described as follows:

(a) The feed is uniform nodules obtained from a simple disc nodulizer;

(b) The kiln is fed more or less continuously by a team working on the top of the kiln;

(c) Clinker formation is confined to the upper portion of the kiln;

(d) Draught is usually induced and heat exchange takes place in the lower portion of the kiln;

(e) Clinker discharge is usually discontinuous;

(f) Fuel economy is good because:

(i) Fuel is being interground into the nodules;

(ii) There is sufficient heat exchange within the kiln;

(iii) There are porous clinkers, which need less energy for grinding.

Comparison of small- and large-scale plants

The information available on operating costs of small plants in developing countries based on long-term production experience is generally scanty.[4] However, production costs are such that, with an equivalent selling price (including packing and transport), the return on capital for two plants, one 25 t/d vertical shaft and one 1,200 t/d rotary, would be approximately the same. In practice, however, it is envisaged that cement from the 25 t/d plant would be bought unbagged straight from the silo with customers providing their own transport, and consequently the selling price would be some 25 per cent lower than bagged cement from the large plant.

The economic advantages, under Indian conditions, of a small plant, compared with a large rotary kiln plant, can be summarized as follows:

(a) Lower (40–50 per cent) capital investment per unit of annual cement production. This is an important factor, as capital costs account for about 50 per cent of the cost of production in a large rotary plant;

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[4]CRI has, however, published some information in its recent publications.

* For more information, see UNIDO report ID/WG.326/20 - Feb. 1981 "Interregional Seminar on Cement Technology" Beijing, China, 9-24 October 1980

(b) Lower fuel cost per unit of cement produced, due to utilization of cheaper quality coal or coke and slightly lower fuel consumption;

(c) Electric power consumption no greater;

(d) Lower consumption of grinding media and kiln refractories;

(e) Lower transport and distributive costs due to proximity of consumer market and possibility of selling unpacked cement to local consumers. Packing, transport and distribution account for about 25 per cent of the cost of cement to the consumer;

(f) Simpler machinery, allowing faster development of machinery manufacturing capacity due to possibility of using less sophisticated, less capital-intensive workshops;

(g) Simpler operation, allowing quicker spread of know-how among less skilled personnel;

(h) Lower spares and maintenance costs due to simpler machinery and smaller inventory of spare parts;

(i) Greater flexibility in rate of production to meet fluctuating demand due to lower costs of shutting down and starting up and possibility of operating several kilns at the same time;

(j) Capability of producing from the same kiln a variety of different cementitious products to suit local needs;

(k) Quicker installation and running-in of new plants (one year as against five years), which improves cash flow and makes faster build-up production possible;

(l) Utilization of small of calcareous materials that are widely scattered throughout many countries but cannot be utilized economically by large plants;

(m) Possibility of dispersal of production in rural areas, creating better balance of regional development;

(n) Creation of more employment per unit of investment–an important consideration in developing countries.

Comparison of experiences in China and India

During 1965–1975 cement production in China more than tripled, from 15 million to 48 million tonnes. More than half of this total was produced in small shaft kilns dispersed in rural areas. The number of these kilns increased from 200 in 1965 to 2,800 in 1975. Their average capacity was approximately 10,000 t/a.

Over the same period, cement production in India increased from 11 million to only 16 million tonnes. Although during this period there were a number of experiments with small-scale production using shaft kilns, the whole of India's production continued to come from rotary kiln plants, ranging in size from the rather small 20,000 t/a capacity plant at Srinagar to the giant 1,080,000 t/a plant at Jamul.

There are at least four reasons for the differences between the two countries in their choice of technology.

First, it is probable that small-scale plants have been used in China primarily for reasons of development policy rather than of production economics. The policy is to decentralize production and to create rural self-sufficiency wherever possible. Such a policy favours small cement plants in rural agricultural areas, financed by capital raised at country or commune level, with equipment built in local workshops and with a locally trained work-force. Large plants are still used for the larger demand in cities.

Secondly, China's policy of decentralized production is encouraged because of the nature of its transportation network. In order to reach district centres, cement from large centralized plants frequently has to be transported by road, and the cost of this would add considerably to the price of the cement. In India, on the other hand, an extensive railway system enables cement to be transported cheaply.

Thirdly, India's freight equalization system reduces the economic benefit from the establishment of small plants. One of the strongest arguments in favour of small plants is that they enable raw materials near to markets to be exploited, thus reducing transportation costs. A national freight equalization system eliminates this potential advantage.

The fourth difference is in the standards adopted for cement quality. In China, there are six classes of cement, with compressive strengths ranging from 200 to 600 kg/cm^2 (20 to 60 N/mm^2). For different types of construction, different cements may be used. Most small plants are said to produce cement class 400 (400 kg/cm^2), which could be used for most rural construction (though it has been suggested that these claims may be overstated [6]. But, in any case, the range of standards available ensures that whatever cement is produced, it can find some use. Obviously, for projects requiring higher quality cement than the local plant could produce, cement would have to be imported from plants elsewhere. In India, by contrast, there is only a single standard for Portland cement, and if a plant does not produce cement fully satisfying this standard, the cement cannot be sold for general use. A major problem with the Lucknow plant was that, although it produced a cement acceptable for most purposes, the cement sometimes failed to satisfy the expansion-ratio test specified by the standard. Thus national control of distribution and rigid insistence on a single standard (following the practice of the industrialized nations) has greatly inhibited the development of the small cement plant in India.

The precise conditions in China and India are not found in other countries, whose experience will probably be different. Local conditions must be carefully considered by policy makers if small-scale cement plants are to be succesfully established in developing countries.

A NEW VERTICAL KILN CEMENT PLANT IN INDIA*

The new vertical cement kiln was commissioned in November, 1981 at Dalmiapuram works in Tamilnadu, owned by Dalmia Cement (Bharat) Limited. The plant operates on the GOTTLIEB FUEL SLURRY process.

Small cement plants, which cannot be established economically on any of the conventionally adopted cement manufacturing processes, can now be based on this new type of vertical kiln which may operate on low volatile coals, coke or chars made of lignites, peats or agricultural wastes. Production capacity of these plants may range between 40,000 to 140,000 tonnes per year.

The new plant in Dalmiapuram operates on a blend of Rourkela coke fines and Neyveli char, produced by the Government Lignite Mine at Neyveli. It is ground with 50% water to an easy flowing "char slurry" with a fineness of 18-20% residue on 170 mesh (90 microns). This slurry is fed through a density and flow controlling/regulating device into a double paddle mixing conveyor which blends it to the accurately proportioned raw meal, producing an earth-moist consistency which is then pelletized on an inclined rotating pan.

When grinding the "char" with water to slurry, the fuel particles surround themselves with thin layers of water which convert into tiny "mud layers" when mixed with the raw meal. In the pre-heating zone of the kiln these "mud layers" dry out and become quite dense and hard. They protect the fuel particles from partial conversion into CO by the upward streaming CO_2 gases

* Dr. Steven Gottlieb and R.K. Swamy, this paper was presented at the "National Seminar on Mini-Cement Plants" organised by "Cement Research Institute of India", May 1982.

which attack the fuel particles according to the reaction $C + CO_2 = 2\,CO$. This is the Boudouard reaction which is variable, depending on temperature, pressure and the degree of exposure of the fuel particle surfaces to the CO_2 gas stream. - In the earlier vertical kilns this reaction caused havoc at times by its variation of the heat input into the kiln, which led to serious operational difficulties, notwithstanding the great care taken to proportion the fuel accurately.

During the short period of kiln operation up to date, the following observations were made :-

1) There is no dust discharge into the kiln stack, only steam and a light alkali haze is escaping with the f gases + the CO_2 driven out of the raw materials. - The low alkali content in the clinker is ofcourse an importan qualitative advantage.

2) There is no easy formation of relatively low melting eutectics which in earlier kilns led to severe cloggings of clinker to the firebrick lining in the hot zone, which necessitated unpleasant manual work, loss of production, increased heat and firebrick consumption.

3) The shape of clinker discharged from the ki can be regulated by slight variations of fuel input :- thus the degree of clinker agglomeration to grape like bunches can be adjusted or totally avoided, if so wished, producing loose, well sintered porous pellets of clinker Consequently, great savings in cement grinding costs can be achieved by the reduction of wear on the grinding media, diaphragms and liner plates.

Uniform pelletizing with appropriate surface conditioning ensure dust-free operation of the Pan Pelletizer and smooth sintering to clinker in the kiln at a rate of 200 tonnes per day, using upto 170 n cub.m air per minute, at a resistance of up to 1600 mm WC of the pellet bed to air/gas flow. With uniform raw meal, fuel and air proportioning, operation of the kiln is uneventful and simple, - all that must be watched is to keep the visible fire on the top of the pellet bed well covered at constant height. For continuous discharge of the high quality clinker, the speed of the conventional (flat) grate is kept between 2 - 4 revolutions per hour.

For checking the preheating and sintering zones, occasionally a sample of pellets is withdrawn fromthe kiln's drying, preheating and sintering zones, to check the progress of calcining and sintering.

The cement produced by the Fuel Slurry Process is of uniformly high quality. Clinker samples taken over 24 hours of continuous production and ground with 5% gypsum in a laboratory mill to a fineness of about 3200 sq.cm per gram (Blaine) yielded the following quality results :-

Loss of Ignition	2.5 %
LeChatlier expansion	0.5 mm
Autoclave expansion	0.1 %

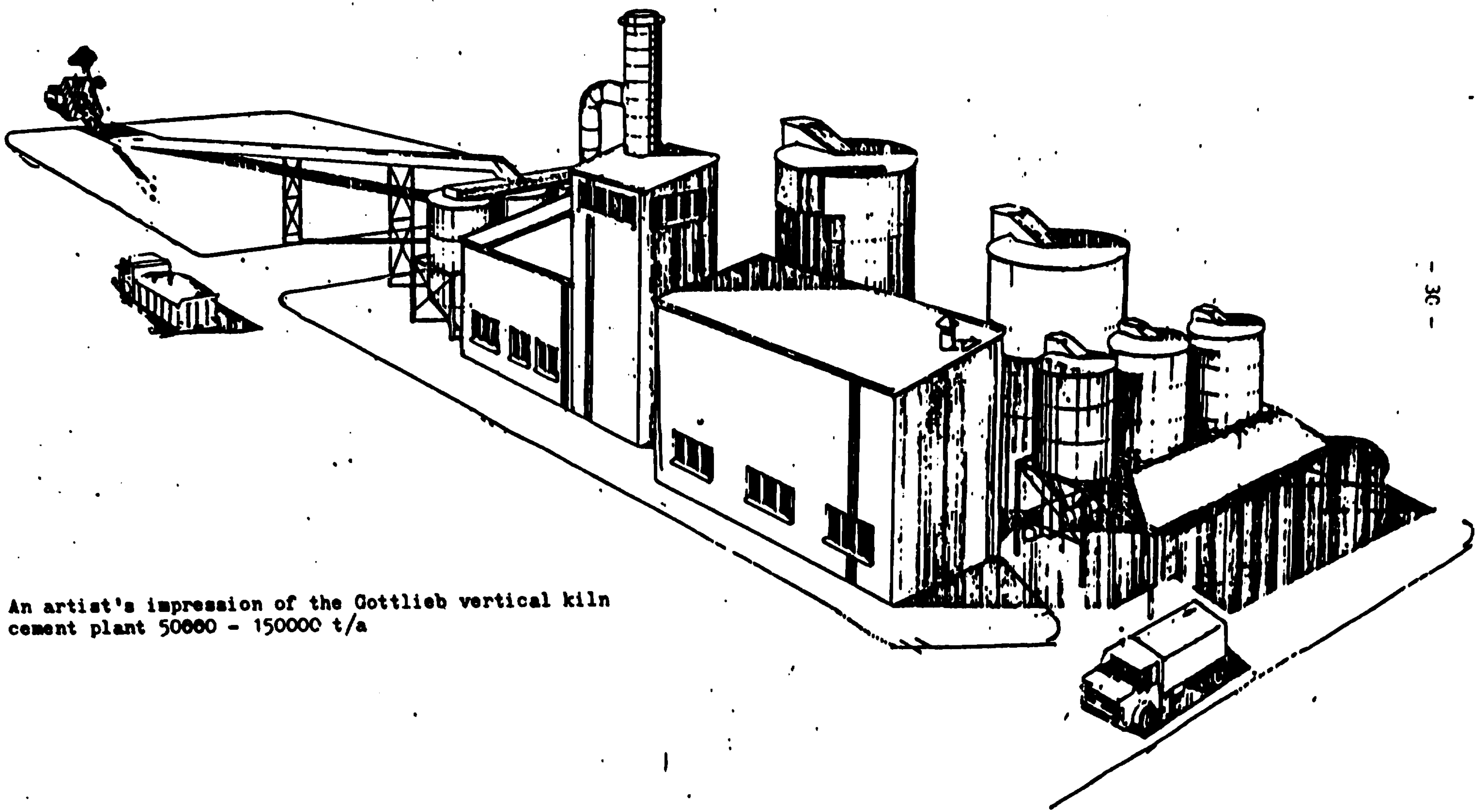
3 days Compressive Strength	:	203 Kg/cm^2
7 days Compressive Strength	:	274 Kg/cm^2

Operating the kiln on Rourkela fines, fuel consumption has been 960 Kcal/Kg clinker.

The raw meal for this kiln is produced in a 50 tph capacity LOESCHE Roller Mill, fired through 2 tube heaters for drying and grinding in one operation to a normal fineness of 15% residue on 170 mesh. The excess capacity from the mill is utilised for the existing semi-dry process rotary kiln.

The Fuel Slurry Process is patented in Australia, U.S.A., and India and applications are being processed in other countries.

Detail design drawings of the new plant in Dalmiapuram by the new Fuel Slurry fired Vertical Kiln plant were completed by the engineering staff of Dalmia Cement (Bharat) Ltd., and they were based on engineering and construction guide drawings prepared by Gorresen's Pty Ltd., Consulting Engineers, Australia who also carried out the raw material and fuel investigations and advised on all aspects of design, erection and initial plant operation.



An artist's impression of the Gottlieb vertical kiln cement plant 50000 - 150000 t/a

The Gottlieb Cement Process*

A small capacity cement plant is based on the modernised pellet fed vertical kiln which, in its initial form with briquetted feed, has been in use since the turn of the century, particularly in Europe. However, these early kilns, whilst producing cement which suited the standards of their time, would not be accepted in today's conditions. The industrial revolution of the 20th century with its higher and more sophisticated quality requirements for cement, favoured the better automated, larger rotary kiln which thus had virtually replaced the vertical shaft kiln. It permitted also the building of very large plants to meet the increasing cement requirements of major industrial centres.

In the early fifties substantial improvements in vertical kiln technology lifted the efficiency of its production, its fuel consumption and the quality of the cement it produced, and then, in the late sixties there was a further improvement by the wet preparation of its fuel. This modernised vertical kiln became particularly important for two main reasons:

a) the new highly sophisticated, computerised and automated rotary kiln cement plants became very expensive which made it impossible to establish them on a relatively small scale, such as below ¼ of a million tonne per year cement production;

b) the rotary kiln must be fired with high grade fuel, such as fuel oil, natural gas or bituminous coal, which has become very much dearer during recent years.

The new vertical kiln can be fired with low grade fuels such as coke-breeze, low volatile coals or waste timber, peat, brown coal and various agricultural wastes, such as sugarcane bagasse or coconut husk, carbonized to char. The relatively low cost of a modern vertical kiln cement plant permits establishment of cement manufacture on a small scale, in the 40,000-140,000 tonnes per year production range. There are many areas in the world where small markets would not permit the economical establishment of conventional cement manufacture using rotary kilns. The cement needs for such areas must of necessity be transported over long distances adding significantly to unit cost. This high unit cost also precludes the economic manufacture of many basic items based on cement such as concrete pipes, blocks, roofing tiles and low cost road construction using cement stabilisation techniques.

Dalmia Cement (Bharat) Limited offers complete design, engineering, and construction of the Gottlieb Cement Process which is licensed to them in India and other Asian and Middle East countries.

Dalmia Cement (Bharat) Limited (DCB) was incorporated in 1951 to take over the erstwhile Dalmia Cement Limited, which was a pioneer among the cement manufacturers in India. Dalmia Cement (Bharat) Ltd. has subsequently recorded a steady growth in the last three decades and is today one of the largest cement manufacturers in India, with a total experience of more than 40 years. It has also diversified its activities into Magnesite, Iron ore and electronics. In addition, it has a cashew processing plant, primarily catering to exports.

The technical performance of DCB is recognised to be of high order and its plants have consistently operated at high capacity. The Government of India awarded a Certificate to DCB for its capacity utilisation of 125% in its cement p nt in 1977. The Iron ore mined by DCB is exported through the state-owned Minerals & Metals Trading Corporation to Japan and is widely recognised in the Japanese market for its very high grade quality (+67% Fe). DCB has now diversified into the electronics field by taking over the former Indian subsidiary of Telefunken, West Germany. If you are seeking a sound approach to profit maximization through cement production, we believe this brief booklet will be profitable.

*Source: Corresen's P.T.Y. Edgecliff Centre, 2027 Australia, 6 Sep.1982

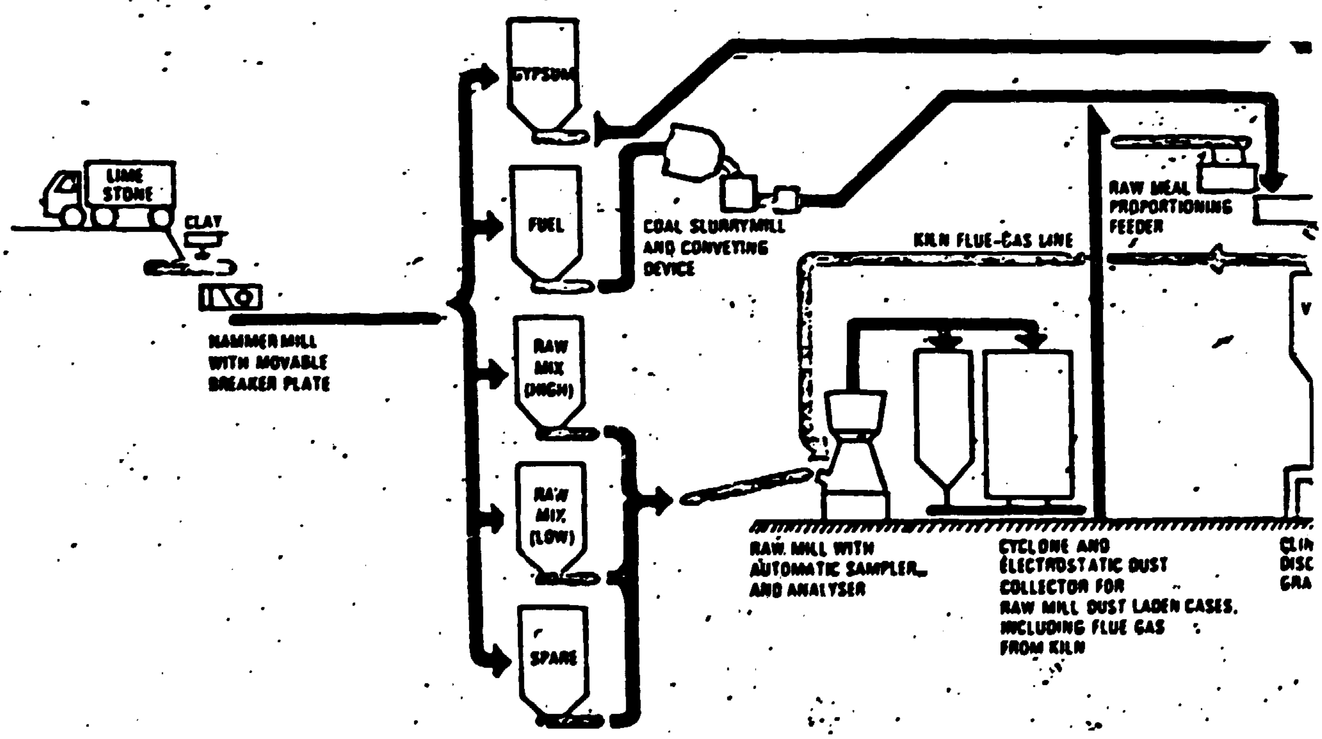
VERTICAL KILN CEMENT PLANT

The first such plant was established by Dr.Steven Gottlieb in Australia in 1954 and from a small initial output of 30,000 tonnes per annum, is now producing 120,000 tpa and will be expanded still further. During its 27 years of operation the plant has supplied uniformly high quality cement for major government complexes such as power stations, dams, bridges, oil drilling wells in the sea bottom as well as the premixed concrete industry and the building trade. It also pioneered the manufacture of sulphate resistant and masonry cements in Australia, based on manufacturing concepts as detailed in a paper presented by Dr. Gottlieb to the Australian Road Research Board's first conference in 1962.

In 1980 the Australian Government invited Dr. Gottlieb to participate at a Technical and Scientific Exchange Convention (TECHEX) in Atlanta Ga., USA, where government research organisations, universities and companies from many parts of the world exhibited their innovations and new manufacturing processes which were judged by an international jury of 5 eminent scientists and industrial experts selected from the US, UK, France and Japan. Dr. Gottlieb's consulting engineering company, Gorresen's Pty. Ltd., was awarded first prize in the industrial category for their work over the years on the perfection of the vertical kiln cement plant and another major innovation, the Pellet Bed Precalciner.

Process :

In conventional cement manufacture the raw materials, limestone and clay or shale, are processed to a raw mix which must have an accurately defined chemical composition and fineness. To achieve this, the limestone must be crushed and ground either wet or dry, together with the clay or shale, homogenized to obtain the required chemical composition and heated to a temperature of 1450 °c to form the clinker minerals which, when ground with about 5% gypsum, produce the finished cement. The procedures involved in the processing of limestone and clay, homogenizing of the raw mix and its sintering to clinker in a rotary kiln, require a great deal of space for the equipment and buildings. Long conveying systems are involved.



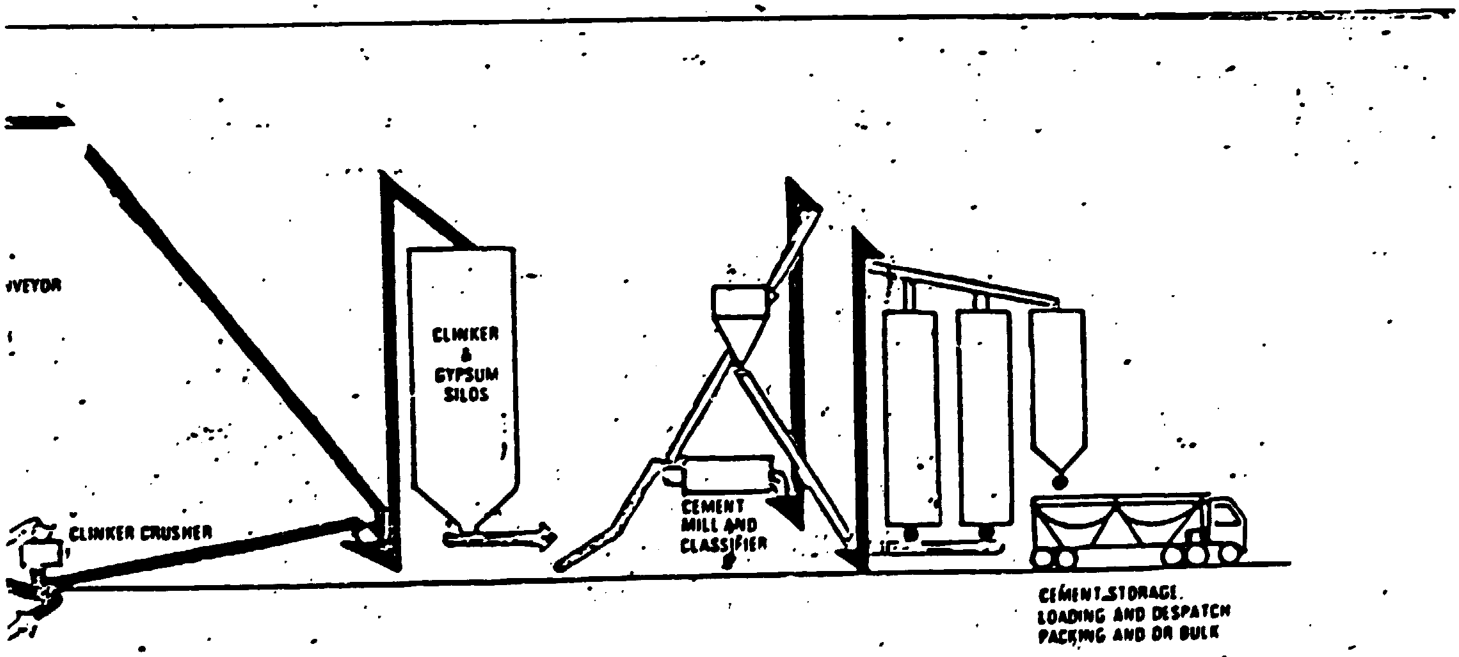
All this lifts costs to levels which prohibit the establishment of conventional cement manufacture for relatively small outputs.

The economics involved in a vertical kiln cement plant are affected by its exceptional flexibility, its easy stopping and restarting procedures which have profoundly affected plant design. Capital, and also operating costs may become exceptionally favourable if the required chemical composition of the raw mix can be obtained from two suitable raw material constituents. In such case a non clog hammermill crushes two limestone/clay (or shale) blends by adding a bucketload of clay (of shale) to every truckload of limestone. One larger and one smaller bucketload is used to yield 2 blends which are fed into a roller mill, equipped with a radioactive Ca⁻ monitor which analyses the $CaCO_3$ level in the raw mix continously, thus adjusting the feeders accordingly, without any need for after blending in homogenizing and storage silos.

In such a plant, kiln and mill start, operate and stop together with only a 15 tonne capacity surge hopper for raw mix between them. This would, of course, be impossible with a conventional rotary kiln where starting and stopping procedures take several hours. If more than two raw material components are needed the Ca⁻ monitor must be replaced by a more expensive computer, analysing and directing the three feeders.

A complete Gottlieb vertical kiln cement plant requires a site area of only 50 x 70 metres, thus the very great difference in capital costs in comparison with rotary kiln plants is not only caused by the lower cost of the vertical kiln itself and the small area it occupies, but by the use of less equipment, much smaller built in area for the whole plant and the shorter conveying systems. In a rotary kiln cement plant the raw mix storage and homogenizing section occupies about one third of the total plant area.

The new vertical kiln cement manufacturing process in its modified form as described previously, is protected by patents in several countries.



Technical Highlights Give Gottlieb Process Many Advantages

The pan pelletizer, introduced by Dr. Gottlieb in Australia in 1950 revitalized the vertical kiln process for producing cement clinker. With the pelletizer, coal, char or "semi char" are embedded in the raw mix, and stable pellets produced. Improved sintering conditions are obtained because the kiln is fed with pellets that are completely stable as confirmed by the Feasibility study. The thermally and physically stable pellets provide a uniform and even distribution of gas flow at elevated pressures through the kiln.

However, there were still short-comings. The CO_2 contained in the kiln gases in the upper portion of the kiln reacted with the coal particles embedded in the pellets to form CO as they slowly moved towards the hot zone. The reaction, sensitive to temperature, pressure, degree of exposure and fuel reactivity, caused the temperature in the combustion zone to fluctuate because of the varying amounts of fuel left when the coal particles arrived at the sintering zone. This 'cycling' was a problem often experienced with the pellet fed vertical kiln.

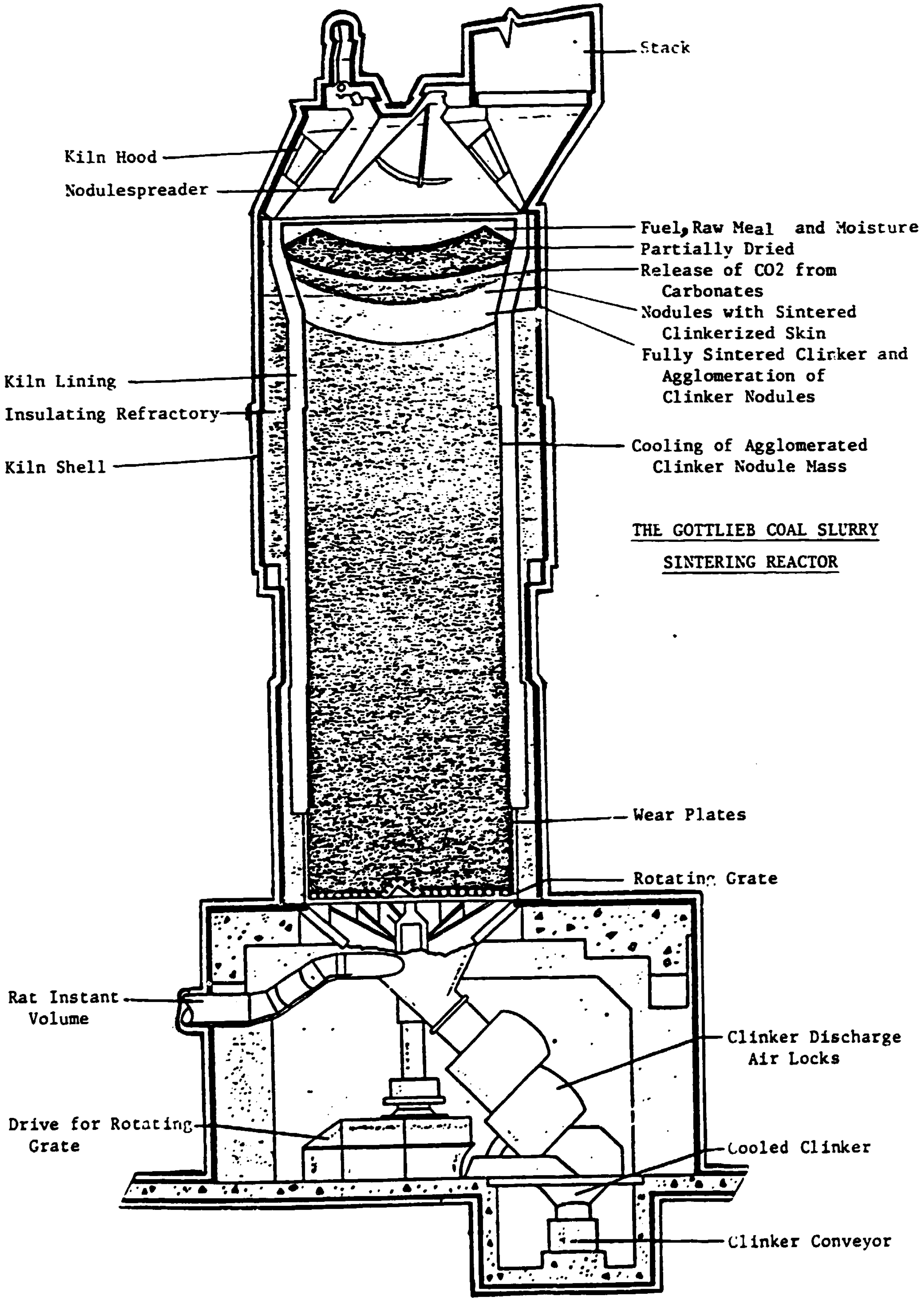
Furthermore, the CO formed may reduce some of the Fe_2O_3 in the raw mix to feO, causing disintegration of $3CaO \cdot SiO_2$ into $2CaO \cdot SiO_2$ and free CaO— even in delayed reaction during clinker storage.

In the Gottlieb Process, grinding of the coal causes water to adhere to the surfaces of the coal particles which change into tiny "mud layers". These dry out in the preheating zone thus forming protective layers of adhered raw mix around the fuel particles which prevent their premature and incomplete combustion. This protection ends when the carbonates in the raw mix dissociate. However, at this stage sufficient oxygen is available to ignite the fuel particles, causing the temperature to rise rapidly to the sintering temperature of about 1450 c over a distance of only half a metre. Also, Fe_2O_3 that was reduced to FeO is re-oxidized to Fe_2O_3 thereby preventing the undesirable disintegration of $3CaO \cdot SiO_2$ to $2CaO \cdot SiO_2$ and free CaO.

The previously used method of water spraying on raw meal and fuel mixtures on a pan pelletizer does not provide the required adhesion of water layers to the surfaces of the fuel particles. Further the continuous blending of coal (char or semi-char) slurry in the grinding mill— in the mechanically agitated sump into which the mill discharges— in the air agitated slurry tank— and finally, when mixed with raw meal and rolled on the pelletizer— smoothes out variations in fuel quality. Consequently, sintering is achieved at such uniformity that full automation of the process is obtainable and control can be exercised from a central control station.

The exact sintering condition thus achieved by constant hot zone temperature provides well controlled incipient fusion and agglomeration of the clinker pellets into grape like pieces which the rotating grate breaks up easily; hence a conventional flat grate can be used.

The coal or ... -char' slurry fired in the vertical kiln does not push any dust in the form of belching smoke into the atmosphere, only steam and some alkali fumes:— operation at the designed rate of 200 tonnes per day does hardly produce any visible evidence that the kiln is working.



THE GOTTLIEB COAL SLURRY SINTERING REACTOR

INNOVATIVE CEMENT MANUFACTURING PROCESS FROM AUSTRALIA

The manufacture of Portland Cement is performed in three stages:- in the first stage, the raw materials are mined, crushed, ground and homogenized to a blend having the required chem. composition and fineness. In the second stage, this blend is subjected to heat treatment, reaching temperatures of 1450°C at which the clinker minerals with the desired hydraulic characteristics are formed. In the third stage the clinker is ground upon addition of gypsum to the finished cement.

Conventional cement manufacture is based on the rotary kiln with a great variety of heat exchangers, - preheaters and/or precalciners. However, the capacity of such plants must be at least 300,000 tons per year to make them economical. This fact effectively prevented the building of plants in many areas of the world where markets were small, - in the range of 30,000 to 300,000 tonnes per year and made them reliant on imports burdened with the high cost of storage, transport by sea, road or rail and packaging.

The introduction of the Pan Pelletizer in the early fifties permitted the establishment of vertical kiln cement plants for small production capacities on economically sound lines. However, a peculiar feature of the vertical kiln prevented full acceptance of the concept of the economical small plant:- in a vertical kiln fuel and combustion air move in opposite directions, - in a rotary kiln their movements are parallel. In a vertical kiln combustion gases, together with CO_2 escaping upward from the raw meal may react with the fuel particles embedded in the pellets moving downward, to form varying amounts of CO and thus causing fluctuating heat inputs into the hot zone of the kiln, even if great care was taken to proportion the fuel accurately. The resulting uneven air/gas flow may lead to variations of clinker quality as underburnt pellets disintegrate to dust, while overburnt pellets get stuck to the firebrick lining, leading to interruption of production to scrape off lumps of oversintered clinker from the firebricks with steel rods in difficult or even dangerous manual operation. However, if production of cement clinker in a vertical kiln becomes safely uniform, the pellets will retain their shape during calcining and sintering which will make it possible to interlock operations of kiln and raw mill so that they become one integral unit of production.

The Fuel Slurry Process vertical kiln cement plant (FSP) could achieve this aim. If fuel slurry is blended with the pulverized raw meal to produce an earth-moist consistency suitable for pelletizing, - the fuel particles become very effectively protected by tiny, hardening mud layers which prevent their premature reaction with the flue gases and their incomplete combustion. This protection ends when the carbonates in the raw meal dissociate, leaving a porous and permeable matrix behind, - however at this stage sufficient air is already available to ignite the fuel particles, provided that they do not contain too much volatile matter which could crowd out the air and thus slow down combustion, lowering temperature in the hot zone. However, if this disturbing influence is absent (i.e. the volatile content in the fuel is not too high), - the very good heat transfer (mainly by convection) in the hot zone causes the temperature to rise rapidly to the required level of 1450°C over a distance of only half a metre of kiln length.

Fuel Slurry permits a very uniform distribution of the fuel particles within the pellets, the quality of which become greatly improved. If a pellet is cut into two halves, the cut faces are of uniform colour, showing the completely even distribution of fuel over the whole cross sectional area. Due to the cover around every fuel particle by the minute mud layer, sharp edges will not cut the pellet apart:- if thermal stability is satisfactory, their shape will be

maintained throughout the preheating, calcining and sintering phases, causing air and gas to flow evenly through the voids formed by the pellets and the channels within them, - maintaining uniform temperature levels in the hot zone. The formation of over-sintered pellets getting stuck to the firebrick lining, or disintegration of the pellets into dust, cannot occur in the Fuel Slurry Process.

The building of cement plants without storage - and homogenizing silos for raw meal became now a reality with the complete plant to be placed into one building, achieving savings of capital - and operating costs which in cement manufacture could not be attained before. Kiln and raw mill can now be electrically interlocked to operate as one integral unit, - not only due to the flexibility of vertical kiln operation, its easy stopping and re-starting facility, - but also (and mainly)because of its uneventful production which makes it suitable for automation. - These objectives were attained on an industrial scale quite recently and very successfully in a plant where commissioning is still in progress, searching for the most suitable fuel to optimize production.

The fuel earmarked for use in the FSP must have low volatile content and good reactivity, though this should not be as high as to absorb gases on heat treatment. Selecting a suitable charing process, low grade fuels, such as brown coal, lignite, hardwood and some agricultural wastes, can be converted to chars. These, as well as coke fines or anthrazites are suitable fuels for the FSP.

SUMMARY OF ADVANTAGES OF FSP:-

(1) Production is smooth and uneventful as pellets retain their shape during decarbonization and sintering to clinker. Resistance to air/gas flow in the kiln remains constant, with no possibility of over sintered pellets getting stuck to the firebrick lining, - or pellets disintegrating to dust, interfering with production.

(2) There is no discharge of dust with the exit gases either, - only steam and some alkali haze.

(3) The flexibility of operation, easy re-starting and stopping of FSP vertical kilns, permit electrically interlocked operation of vertical kiln and raw mill as one integrated unit, which can eliminate storage - and homogenizing silos for raw meal, provided that suitable raw materials are available. This simplifies raw material preparation, permitting the use of a very small operational area so that the whole plant can be placed into one building which means less conveying equipment and lower labour requirements, reducing capital - and operating costs very considerably.

(4) Fuel consumption is very economical even if the ash content in the fuel - including low grade charred fuel - is very high. The use of fuel in slurry form permits the ironing out of fluctuations in the qualities of the coke or char produced from lignite, brown coal, peat or agricultural wastes. The homgenizing effect during grinding the fuel to slurry, its mechanical agitation using a stirrer in the sump into which the slurry discharges, agitation by compressed air in the fuel slurry tanks and the thorough blending in the double shaft mixing conveyor where the fuel slurry and the raw meal are homogenized into an earth-moist blend fed into the Pelletizer, achieve uniform fuel feed into the kiln even if the fuel is delivered to the plant fluctuates wildly in its quality.

(5) Application of the FSP improves the quality of the pellets to such extent that resistance to air/gas flow becomes constant, permitting far reaching automation of plant operation.

The Interground Fuel System in LOESCHE Compact Vertical Kiln Cement Plants*

INTRODUCTION

The Interground Fuel System comprises:
the weigh feeding of raw materials,
the proportioning of fuel,
the raw materials grinding mill,
the Fuel-Meal blending system,
the vertical kiln for the production
of Portland Cement Clinker.
The system is referred to from hereon as "Fuel-Meal Process".

RAW MATERIALS AND FUEL

The Fuel-Meal Process differs from all other cement clinker producing systems by the intergrinding of solid fuel with the cement raw materials. Only solid fuel containing a low percentage of volatile matter, preferably less than 20%, can be used. The ash content of these fuels does not influence the function or the economy of the process since it is a raw material component and turned into cement clinker together with the others during the burning process.

Anthracite, coke breeze, petrol coke or charcoal can be used without any preference for one or the other. The suitability of the fuel is solely decided by the economy, i. e. the price per Giga Joule at site.

PROPORTIONING

The weigh feeders 1 for the raw materials extract the various components from the feed bins in such a relation to each other as chemical composition requires it. The fuel is proportioned in relation to the total weight of the raw materials whereby the ash of the coal is calculated as part of the raw mix. The amount of fuel is adjusted according to pre-determination in the laboratory. All components together with the fuel are fed by a belt to the raw materials grinding mill whereby the total feed is automatically controlled by the pressure drop across the mill. While the total feed can vary according to this control, the relation of the components to each other and the fuel to the sum of them remains as set.

GRINDING

The Loesche Roller Mill 2 as designed for this process has proven to be most effective with regard to fractioning of the finely ground Fuel-Meal. At the same time drying is effected in this mill by the introduction of hot air. For simplicity reason, the air-heater is using fuel oil. The fuel oil consumption is automatically controlled by the exit gas temperature from the mill. The Fuel-Meal as collected from the dust precipitation plant is perfectly blended for fuel/raw meal ratio as well as for the particle size distribution of all components.

*Source: LOESCHE GMBH, D-4000 Düsseldorf 1, Steinstrasse 18, FRG.

HOMOGENIZATION

The Fuel-Meal is transported mechanically to the blending silos. There are two silos provided, each with a capacity of about 12 hours' mill production. They are operated batchwise so that one silo can be used for blending while the other is refilled.

The blending is effected pneumatically by aeration systems on the bottom of the tanks.

The blending silos are mounted on two storage silos which can be filled alternately. Means for correcting the Fuel-Meal composition are provided. The storage silos are also discharged pneumatically.

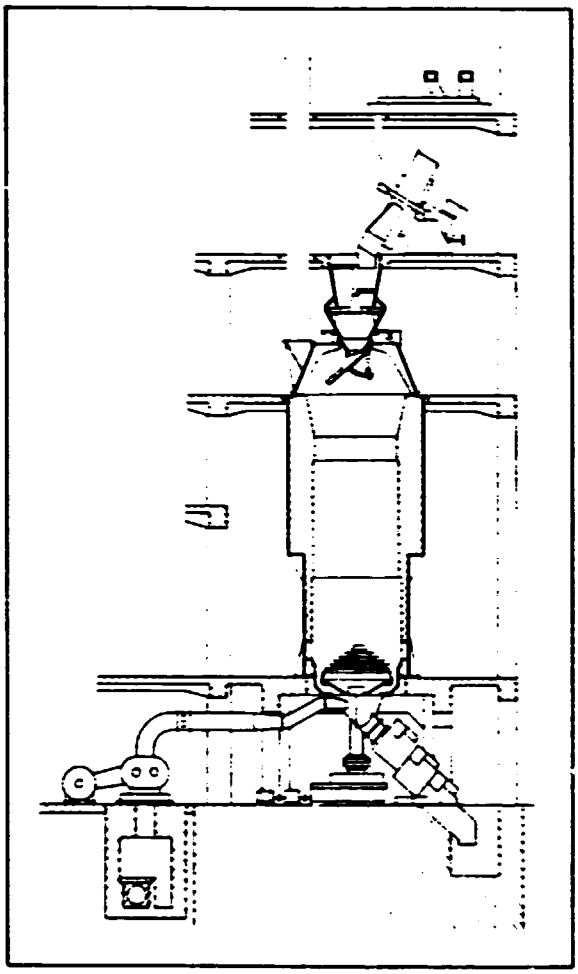
VERTICAL KILN PLANT

After careful homogenization the Fuel-Meal is transported by means of an elevator to the kiln feeding station. A drag chain conveyor takes over from the elevator and transports the Fuel-Meal to the kiln. This drag chain conveyor is kept filled at all times, and the overflow which is not required for the kiln goes back into the storage silo. By this method the Fuel-Meal is de-aerated.

To feed the individual kiln, the Fuel-Meal is extracted from the drag chain conveyor by a special belt conveyor which is very wide and has devices which effect a further de-aeration resulting in an absolutely even flow of Fuel-Meal to the nodulizer.

In order to produce nodules of even size and constant bulkweight, the amount of water to be sprayed onto the nodulizer is kept proportional to the amount of feed going through the kiln. A special pump is used to attain an even spray independent of the exact volume of water used.

The system ensures that the nodules have the necessary porosity so that they do not tend to collapse when being exposed to heat. The adjustment of the nodulizer which can be changed in inclination, height of the ring that surrounds the nodulizing plate and the area of applying the water are the means to ensure sufficient strength of the nodules to endure the drop through the kiln feed chute and onto the upper layer of material in the kiln.



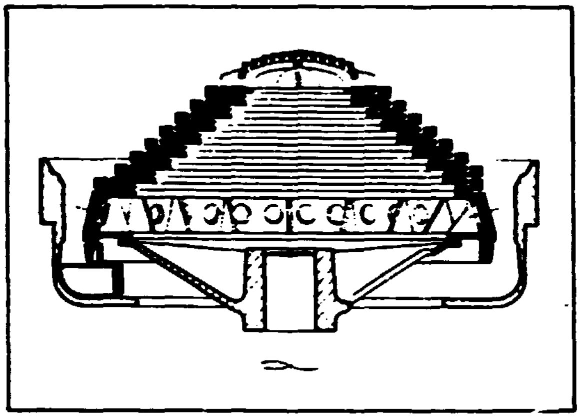
VERTICAL KILN

The feeding of the nodules and the distribution on the surface of the kiln section is effected by a revolving chute which can be adjusted in its angle of inclination. The chute is mounted in the kiln hood 3 underneath the central feed chute. The chute drops the nodules around the circumference of the material layer so that a shape like a crater is formed which is desirable as the combustion air tends to penetrate the layer of nodules at the periphery rather than at the centre of the kiln. The kiln hood is provided with a number of doors that permit access to the kiln surface from all sides at any time, while during normal operations these doors should be kept shut. The kiln hood is connected to the dust precipitator or directly to the kiln stack. After the initial ignition the kiln is filled up with nodules upto the kiln operating platform. The fire can be supervised at all times and, if necessary, attended to. The upper layer of nodules serves as preheating zone where the nodules are first dried and then calcined. The actual burning zone is about 600 mm to 800 mm below the surface near the end of the concial part of the kiln 5. This conical part is compensating for the shrinkage of the clinker during burning, so that the burning zone is not disrupted.

Once the Portland Cement Clinker has formed, at a temperature about 1450 C., it is cooled by the up-coming air whereby very good heat exchange is achieved.

CLINKER EXTRACTION

To extract the clinker at a steady rate regardless of its consistency, a grate is employed which slowly revolves and at the same time crushes the clinker if it has agglomerated to larger pieces. At the same time the grate is designed to distribute the up-coming air evenly across the section of the kiln.

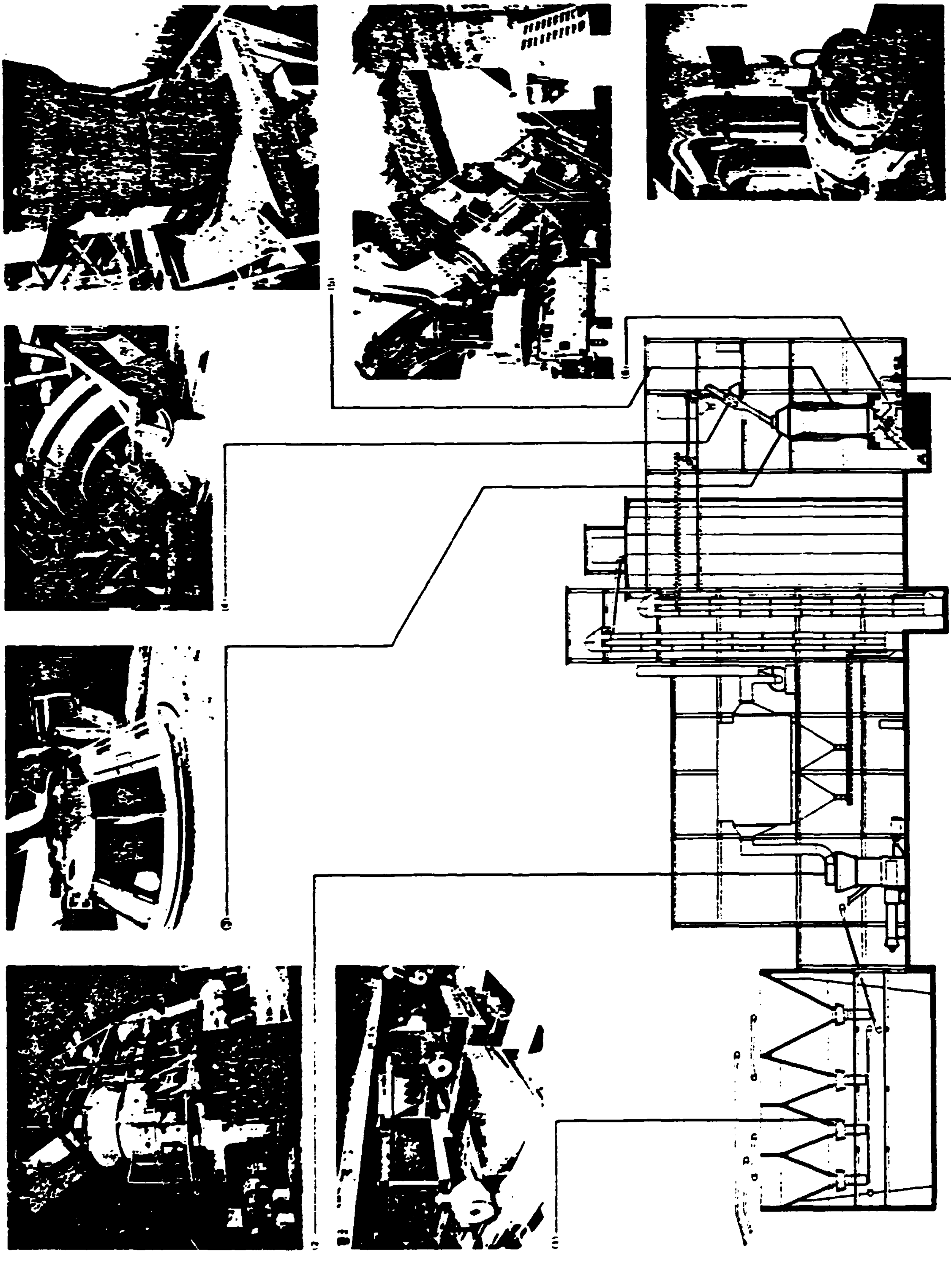


Clinker discharged through the grate is collected in a cast-iron chute and transferred through a hydraulically operated discharge gate 5 onto the clinker conveyor.

Thus, the lower part of the kiln has multiple functions. Clinker has to be evenly extracted regardless of its shape and temperature. Air has to be pressed into the kiln at a normal pressure drop of about 125 mbar, but if necessary up to 200 mbar. This is achieved by two or three piston blowers of the Roots type 7, one of which is being speed-controlled in order to adjust the necessary combustion air to the kiln output.

GENERAL OPERATION

Vertical kilns do not work with excess air. The exit gas temperature which is normally about 100 C. controls the kiln feed. Temperature is monitored along the kiln shell through the lining for safety reasons as well as for adjustments. Clinker quality is exclusively controlled on the chemical side and by grinding fineness. Successful operation is ensured by maintaining constant conditions of all external influences.



Mini-Cement Plants based on Shaft Kilns*

I. Background Information

As the investment cost in the cement industry is normally very high, it is important to determine the most economical and suitable size for small-scale factories in order to make savings through standardization. This seems to be in the range of a production of 60,000-120,000 t/a from two conventional shaft kilns.

For the conventional shaft kiln, low volatile fossil fuel, with less than 20% volatile matter will have to be used. If not available the problem may be solved by charring high volatile fuel; the volatile gases emitted could be burned and used for drying of raw materials. Such a system has worked successfully since 1965 at the Gippsland Cement Plant in Taralgou, Vic Australia. The plant is using charred brown coal briquettes as fuel for the 2 shaft kilns.

For the above-mentioned shaft kiln system, it is necessary to produce pellets or nodules, which are small, one-half inch (12 mm) diameter balls, of uniform quality and high strength, consisting of ground raw materials and 12-18% water. If formation of nodules of sufficient strength and heat resistance is not possible, a rotary kiln process is mandatory.

A small-scale cement plant producing 120,000 t/a would be the ideal size. The cost of machinery for the shaft kilns incorporating cooler would amount to approximately 4-6% of the total investment cost, whereas that of a rotary kiln plant would be approximately 8-10%. The advantages of a shaft kiln installation would be:

(a) Substantial savings in space;
(b) Simple construction with no heavy castings;
(c) Few problems with starting and stopping;
(d) High degree of reliability due to the durability of refractory bricks;
(e) The kiln and the cooler is an integrated unit;
(f) Low-alkali clinker could be produced;
(g) A high degree of do-it-yourself construction could be developed which is important in order to bring down the total investment cost.

* Source: Small Scale Cement Technology. UNIDO/IOD. 43/Rev. 1 16 January 1981

There are various processes for feeding the fuel to the shaft kiln. The most simple, and perhaps the most common is to feed the fuel (anthracite or petrol coke, coke breeze, blast-furnace coke or similar), separately in sizes of 1.5-2.5 mm, directly to the pan pellertizer together with the raw mix. Other processes such as black meal, shell (black meal with white meal coating), and coke slurry should be considered depending on the type of fuel, especially if high content of ash occurs.

Small-scale shaft kiln cement plants may meet with opposition from large-scale cement producers as a network of shaft kilns in some areas could create competition for their markets.

On the other hand it should not be forgotten that the rotary kiln technology is very reliable and that a small rotary kiln plant despite high costs help to familiarize operators with a technology that sooner or later may be applied in the expansion of the plant when the cement market has been developed with the first cement plant installation.

The quality of the cement depend on the quality of the Portland clinker produced. Therefore continuous and regular operation is important. Efficient operation of a shaft kiln require a good distribution of air in the burning zone. This can be facilitated with a good discharge grate. It has been proved that the so-called step grate works satisfactorily with low maintenance costs.

Highly-developed equipment for the preparation of raw material also helps to produce good quality low alkali clinker in a shaft kiln (semi-dry process). Pre-blending of the limestone is highly recommended whether a rotary kiln or a shaft kiln is considered.

II. CAPITAL INVESTMENT FOR NEW CEMENT PLANTS

Investment efficiency (production capacity per unit invested) is extremely important for all factories because it is difficult to find the necessary financial support unless the feasibility of the project is proven beyond doubt.

Once financing is secured, the fixed costs required for amortization will influence the price of the final product. Here the shaft kiln technology still appear to have an edge over the rotary kiln technology.

Manufacturers of rotary kiln plants with preheaters and calciners prefer not to use kilns of a capacity below 800 tons per day (t/D). The reason are :

(a) Cyclones are small and jamming might reduce the efficiency of the plant;

(b) In case of frequent stops, because of blocking of cyclones, fuel consumption might come out higher than anticipated.

(c) By-pass installations might be necessary in order to control the quality and additional investments might make the factory proposed less feasible.

(d) Bricklayers are reluctant to make repairs in the preheater and calciner because there is very little working space.

Never-the-less it is technically possible to produce small reliable dry process cement plants also without preheaters, the important points for a promotor is to have accurate information about investment and operating costs and compare different solutions before a final decision is taken.

III. ROTARY KILN WITH PREHEATER AND CALCINER

The present trend of building up large-scale cement plants will certainly continue.

The "run factor" for a rotary kiln mainly depends on its diameter. With diameters up to 5 m, the amount of refractory bricks used is still at an acceptable level of 0.5-0.8 kg/ton clinker.

Operations and maintenance experience have shown that conventional high-economy dry-process kilns with a four-stage suspension preheater are most reliable in the size range of 1,250-2,000 t/d, corresponding to a kiln diameter of 4.15-4.75 m or less if precalziner technique is applied.

It should however not be forgotten that small scale rotary kilns, as they were seen up to the fifties, still are technically possible to build. The only obstacle is that they are relatively expensive (investment costs per ton capacity) to build today.

Therefore some companies have started to examine the possibilities for simplifying the technique of small rotary kiln plants with present days know-how in order to be able to offer economic solutions to promotors of small cement factories.

IV. COMPACT SHAFT KILN CEMENT PLANTS

Many developing countries, particularly the least developed countries, have not developed their cement industry sufficiently. In many cases they have difficulties in identifying a balanced approach which will yield the necessary financial support.

The cement demand is often too little and to thinly spread over a large area to justify a medium or a large scale plant and .reasing transport costs also works against centralized production.

When therefore both production and transportation costs are analysed, the conclusion is often that decentralized production in small scale plants is advantageous.

Also the Socio-economic factor in creating employment centers in rural areas should not be underestimated.

Conventional Shaft Kilns.

The shaft kiln technology has been used for nearly a century, but especially in the early 1960s the layout and design of a shaft kiln plants reached a very high level. This however coincided with the introduction of the dry-process four-stage suspension preheater kiln that made it possible to avoid drastically increasing cement prices by the use of big and economical production units. The shaft kiln then started to loose popularity, particularly as transport costs were still relatively low.

There are however still cases where a shaft kiln is the best and the most economic solution. Quality wise clinker produced by a shaft kiln can be as good as clinker produced by a rotary kiln provided the same care is taken in the preparation of the raw material. In order to produce good shaft kiln clinker the following conditions will have to be fulfilled:

(a) Plasticity of the raw materials particularly the clay in order to make pellets of sufficiently high strength also at elevated temperatures. Without this, it is impossible to operate a shaft kiln.

(b) A kiln diameter exceeding 3 m is inadvisable. Air distribution may become irregular and result in an unstable operation.

A common and effective kiln size is 180-200 t/d. Such a kiln would have an inside effective diameter of 2.4 m and a total height of approximately 8 m. Smaller kilns work even better because of improved air distribution inside kiln cross section.

The vertical shaft kiln is very simple. The upper part of the shaft (approximately 15-20% of the total height) is conical to correct for shrinkage of the nodules through drying, calcining and sintering. The rest of the shaft is cylindrical and this part serves as a collar and heat exchanger as the heat from the clinker preheats the air moving in counter flow from the bottom of the cooler up to the burning zone in the kiln.

The raw mix and solid fuel fed to the kiln are agglomerated in a nodulizer where 12-14% of water is added, and nodules of one half-inch diameter (12 mm) are produced. These nodules are fed to the top of the kiln and distributed equally over the material surface by means of an rotating chute.

The feeding to the kiln is regulated according to the flue gas temperature, which should be kept at 80-90°C. The material flow should be regulated to move downward with a velocity of approximately 1.5 m/h. At the bottom, the kiln is equipped with a grate of different designs. Clinker is discharged through hydraulically-operated air-lock discharge gates/or through other discharge systems.

Combustion air is blown in counterflow to the kiln and the pressure needed is about 1200-2000 mm WG; this is best obtained with a Roots blower.

Current air pollution regulations call for an electrostatic precipitator for the dedusting of the flue gas. Dust production of a shaft kiln is very low, about 2% of the clinker production, but it looks worse due to evaporated water. The low temperature of flue gas makes it necessary to preheat the gas before the filter to about 90° - 100° C, which is the most suitable temperature for an electrostatic precipitator, 30-35° above the due point of the kiln gases.

V. FINDINGS AND RECOMMENDATIONS

Findings and recommendations should be considered as indicative as it is impossible to make general recommendations covering the entire world. However, it is hoped that they will be useful to promotors and Governments examining the availability of technology for small scale cement production in remote areas as well as in the least developed countries.

How to reduce capital investment

The total investment cost is divided among the following items:

	Fraction of total investment costs (%)
Mechanical and Electrical equipment	45-55
Civil Works	25-30
Transport (cif - fob)	3 - 5
Erection	12-15
Miscellaneous	4 - 5

The above-mentioned figures show where savings can be made. Civil works account for very high percentage of the cost. Considerable savings can be made here, for instance by reducing storage capacities, However, such savings depend to a large extent upon local conditions, and advice should be sought from an experienced consultant.

The following recommendations are made for the erection of mechanical and electrical equipment:

1. A perfect layout will be necessary
2. Intensive PERT (programme, evaluation and review technique) planning.
3. Intensive standardization should be made
4. The site should be provided with a well-equipped workshop especially for steel-plate work and welding.

5. Machinery manufacture and erection should be combined if possible.
6. All steel-plate work up to, say, a 25-mm thickness should be done at the site, if possible.
7. The latest welding techniques should be applied.
8. Considerable time can be saved by co-ordinating the civil work and the erection of mechanical and electrical equipment.

Implementation time.

In a plant, for example, of 120,000 t/a capacity, the civil works may involve about 8-10,000 m^3 of concrete and about 1,800 tons of mechanical and electrical equipment. The erection of civil works and the mechanical and electrical equipment would amount to approximately 120,000 and 140,000 man-hours respectively. Even on extremely difficult sites it should not take more than 10 to 13 months to erect a compact cement plant.

Economic size of plant

Shaft kiln plants producing 120,000 or 180,000 t/a would be the most economic size. For larger capacities normally the rotary kiln technology would be preferred. Particularly if low volatile coal is not available, but also the availability of good plastic clay is important to secure strong and heat resistant nodules for the shaft kiln process.

In order to give some more information about the relatively unknown shaft kiln process the following process or equipment details are given.

Nodulizer (pan pelletizer)

The production of suitable nodules (mechanically strong and heat resistant) is indispensable for a shaft kiln or any other kiln working on semi-dry process. The nodulizer for production of nodules was introduced in 1950 by the cement industry. Millions of tons of nodules have been produced by means of the nodulizer, especially after introduction of the semi-dry Lepol kiln. It is due to the development of the nodulizer and preblending and homogenization technique that the shaft kilns can produce clinker of high quality.

Irrespective of how the fuel is added in a black meal, shell or coal slurry process, the final nodules should consist of raw meal ground to a fineness of 10-15 percent retained on 4,900 meshes/cm^2 and less than 1,0 percent on 900 meshes/cm^2 in order to keep the free lime content below 3%. Nodule size should be kept at 10-16 mm diameter for a shaft kiln with a diameter of 2.4.

The water content depends on the raw materials (plasticity) and should be in the range of 12-18%. (wet base)

Burning Process.

Burning processes for shaft kilns are as follows :

Conventional

Black meal (Intergrate fuel process)

Shell

Coal Slurry

In the conventional process, which is the simplest, the fuel, for instance, coke, petrol coke crushed down to size 1.5-2 mm, is fed directly to the nodulizer together with the raw meal. The size of the fuel is important. Small sizes decrease and large sizes increase the height of the burning zone and thus the active cooling zone which will be respectively increased and decreased. A short burning zone results in a good thermal efficiency.

Black meal, shell and coal slurry processes require more equipment than the conventional one. These processes should only be considered in order to ensure uniform and good quality of the clinker if the fuel has a high-ash content or high reactivity. Determination of fuel content in the black meal every 2 hours as well as good mixing of the raw mix is essential for the conventional and for the coal slurry process.

Discharge grate.

Good air distribution is very important in a shaft kiln and a discharge grate is required to cope with irregular clinker formation. (lumps)

Some shaft kilns are equipped with a step grate which has proven its reliability satisfactorily for more than 20 years by securing a continuous discharge of Portland clinker up to 200 t/d.

The advantages of the step grate are :

Simple and robust construction
Low wear due to very low revolutions of the discharge grate (5RPH)
Low maintenance cost

Another grate construction is the discharge crusher grid, also called the rocker grate.
It consists of six water-cooled heavy shafts on which casted toothed sections, similar to toothed roller crushers. The rocker grate is turned every two years to distribute the wear evenly. The distance between the shaft centres allows for the passage of clinker between the toothed sections.

When the shafts are in motion by rocking from one side to another and back again they crush oversize lumps and discharge clinker as well as it secures a good air distribution even when clinker aggregation occur. The rocking movements are performed hydraulically and are activated from both sides. (Manstedt grate)

Other grates are the Wiege-rost (steinbüchl-grate) and
The Flat-grate (Grueber-grate)

Enerv Conservation in Cement Production*

The cement industry has important energy implications for the developing countries as production of cement is a heavy energy consuming technological process. However, only after the dramatic increase in the prices for oil in the 1970s, energy-related problems have become of primary concern for the industry since the share of the enery input exceeded 40 per cent of the production cost and energy became a major production factor.

Some of the main issues related to the use and conservation of energy in cement production are summarized below:

A camparison between data from developed and developing countries shows a great difference in specific consumption of energy in the production of portland cement, which is the principal product of the cement industry. This indicates the existence of broad possibilities for energy saving in the cement industry which can be realized through technological modifications, operational improvements and housekeeping measures.

Since about 90 per cent of the energy consumption in the production of cement goes to the process of burning the cement clinker the basic opportunities and the highest potential for energy saving relate to this part of the production chain.

The utilization of the suspension preheater-rotary kiln systems with the dry method of raw mix preparation leads to a significant reduction of specific energy consumption compared to the dry kiln systems without preheaters and wet process kiln systems (up to 40-50 per cent). This advantage has been one of the main reasons for the wide application of this type of technology in the cement industry in many countries. The majority of cement kilns which have been put into operation and planned for construction in the world during the last decade employ the dry method of cement production and use suspension preheater-kiln systems.

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* See "Use and Conservation of Energy in Cement Industry", UNIDO/IS/540, 12 July 1985.

The most advanced dry process kiln systems include precalciners along with suspension preheaters. The use of precalciners ensures not only further reduction of specific energy consumption but what is more important provides a possibility to use low grade fuels and various combustible industrial and other residues.

However, the cost of conversion of the existing wet process kilns to dry or semi-dry process kilns generally amounts to around 60 per cent of the cost of a new unit and is therefore not always feasible or affordable. Besides, at some locations the wetness of raw materials may make the use of wet process kilns necessary. In such cases a reduction of specific energy consumption can be achieved by preliminary dehydration of the raw mix, by utilizing different thinners, etc.

Prospective trends for reduction of the specific energy consumption related to the technology used in the production of cement include: calcination of clinker in a fluidized bed kiln; changing the mineralogy of cement by using mineralizers; low-temperature technology of clinker making with the use of calcium chloride; improvement of the existing grinding tube mills and application of roller mills as well as grinding aids to reduce consumption of electric power when grinding the clinker.

Considerable energy savings can be realized by using secondary energy for heating purposes, drying the raw materials, generating electric power etc.

Besides the possiblities mentioned above for improvement of energy utilization of cement plants which require capital investments there also exists a considerable potential for energy saving through improved housekeeping measures at no or little cost. These include improved fuel handling and preparation, improved combustion and draft control as well as improved housekeeping in respect of electric power utilization.

An analysis of the developments which have taken place in the cement industry of different countries also reveals the following two important trends related to the use and conservation of energy in this industry:

a) Production of blended cements with the use of various pozzolana materials including fly ash and slag is now considered by many countries as a way to reduce energy consumption in the cement industry;

b) In many countries coal is regaining its position as a basic fuel used in cement plants. Some countries have almost accomplished the process of switching their cement plants from fuel oil to coal. A great deal of attention is given to the use of different low grade fuels and combustible residues in clinker burning. This has become possible with the introduction of precalciners.

CEMENT INDUSTRY PROFILE*

This Industry Profile is one of a series. Each Profile gives basic information on a small or medium-sized plant in a specific industry. It discusses succinctly the features of the industry and its marketing problems, shows the approximate amount of capital needed to establish a plant of specified capacity, and gives an estimate of the annual costs, by categories, of running the plant at full capacity. It also provides a plant lay-out and supplementary reference information on technical journals, articles, books, patents and the like.

Potential investors can, by examining the Profiles for the industries in which they are interested, take the initial step in the process of deciding whether to embark on particular projects. In some cases the next steps may be simple, in others they may be complicated, requiring full-scale feasibility studies by experts. But whatever the situation, it should be remembered that the Profiles are not a substitute for the specific studies, whether simple or elaborate, that should precede the actual establishment of new plants. The Profiles indicate the major factors to be considered in making such studies and provide a systematic guide for making cost estimates applicable to local conditions. Conditions in different areas vary and may affect the optimum plant size, the type of plant and equipment, the kinds of materials used, utilization of power, organization of transport, etc. Local costs may also vary for raw materials, labor, plant and equipment. Thus, specific studies may provide somewhat different estimates from those shown in the relevant Industry Profile. But the Industry Profiles provide an order of magnitude of costs, point the way to making proper assessments of actual situations, and help to precipitate investment decisions.

* Source: U.S. Department of Commerce, Clearinghouse for Federal Scientific and Technical Information, 410.14, Springfield Virginia 22151, 1976.

CEMENT: Standard Industrial Classification 3241

A. PRODUCT DESCRIPTION

Portland cement, manufactured in a rotary kiln. Various alternative combinations of raw materials may be used. Choice of them will depend on local availability. Other types of cement, e.g. masonry cement, may be made with the equipment described.

B. GENERAL EVALUATION

The growing use of cement as a construction material, the widespread presence of raw materials that can be used to make it, and the advantage of local production of a bulk commodity of this kind from the point of view of keeping down transport costs, recommend the cement industry as suitable for many developing areas. Against the advantages enumerated must be placed the fact that any cement plant, even the relatively very small one described, which is about the minimum practicable size, necessitates a very substantial capital investment, and also demands a fair amount of skilled labor. In spite of this drawback, developing areas usually give high priority to the establishment of cement plants, and often they have proved to be profitable ventures.

C. MARKET ASPECTS

1. USERS. Construction and public works contractors, railroads, various industries.

2. SALES CHANNELS AND METHODS. Sales are commonly made direct to large users, as well as to distributors for re-sale in small lots.

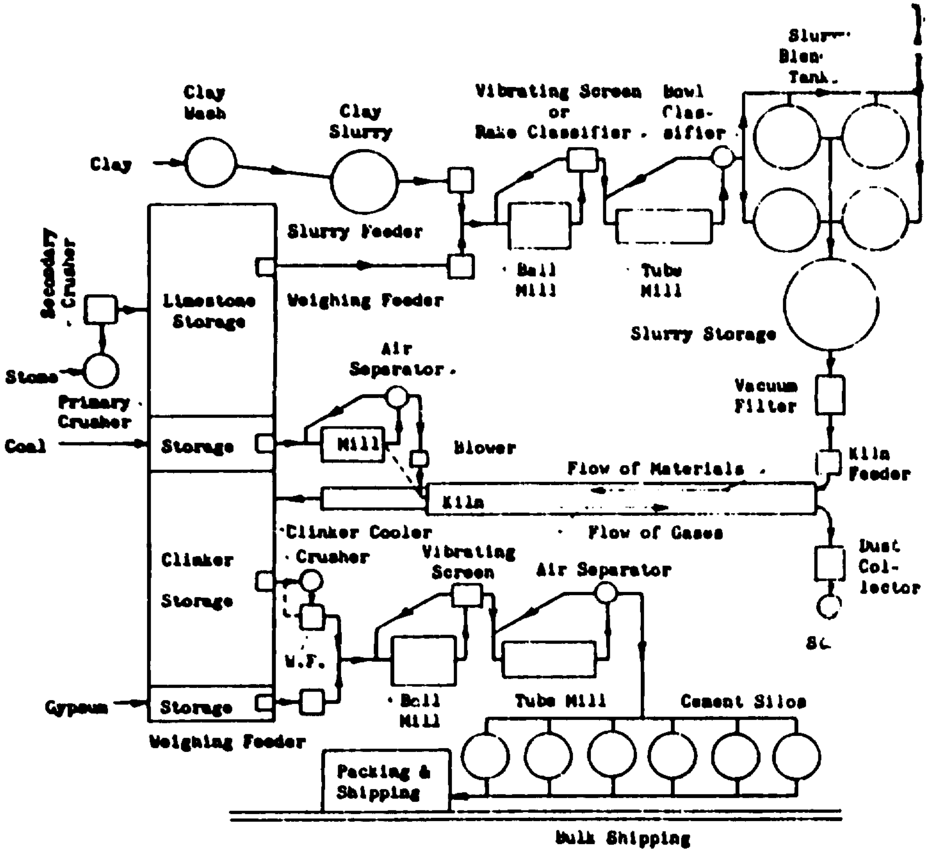
3. GEOGRAPHICAL EXTENT OF MARKET. a. Domestic. Generally cement is not shipped very far from the point of manufacture, owing to heavy transport costs. In the United States cement plants are scattered all over the country, and the market radius on the average probably does not exceed 100 miles. In some countries, however, cheap transport by barge over inland waterways, or by coastal ships, may permit sales at much greater distances. b. Export. Where cement plants are located at ports and can load directly into ocean vessels, sales to distant countries are possible.

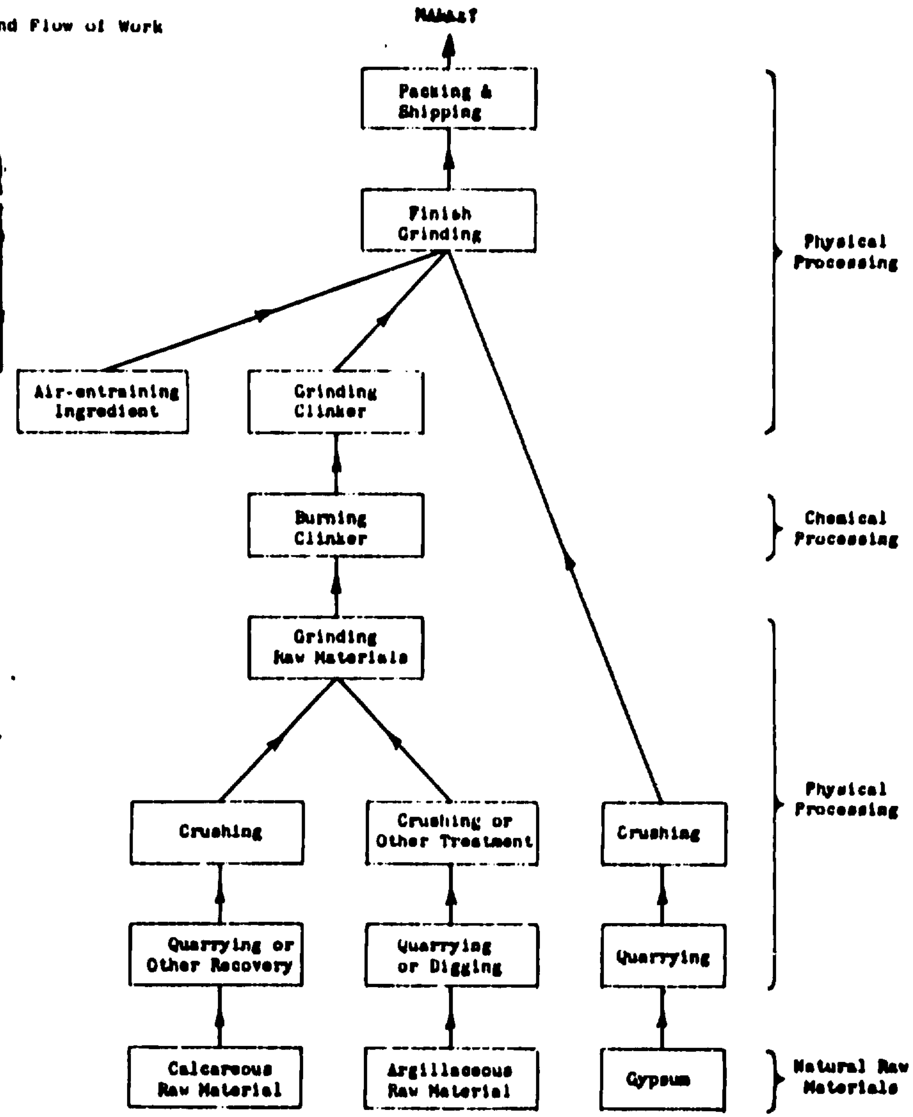
4. COMPETITION. a. Domestic Market. Competition from imports is likely to fluctuate in intensity. Surplus capacity sometimes develops rather suddenly and unexpectedly in this industry, and producers are sometimes prepared to sell abroad at low prices in order to maintain operations. Competition from alternative materials will depend largely on comparative costs, and this will vary greatly from area to area. b. Export Market. This plant would be too small to compete in general export business. Some regional sales might occasionally be possible.

5. MARKET NEEDED FOR PLANT DESCRIBED. Demand for cement will depend on the extent of new construction of various kinds that is under way, types of buildings in common use, cost of alternative materials, etc. A fairly modern and progressive urban area with a population of the order of a million people should generally develop sufficient demand for cement to support a plant of this size.

CEMENT: S.I.C. 3241

Plant Layout and Flow of Work





D. PRODUCTION REQUIREMENTS

ANNUAL CAPACITY - THREE-SHIFT OPERATION: 35,000 Tons

1. CAPITAL REQUIREMENTS

a. FIXED CAPITAL

		Cost
Land. Including deposits of clay & limestone - 80 acres.		$ --
Building. Total floor space area 50,000 sq. ft., including production, storage, power & office.		300,000
Equipment, Furniture & Fixtures.		
Prodn. tools & equipmt.	$1,200,000	
Other tools & equipmt.	50,000	
Furniture & fixtures	2,000	1,252,000
Total (excl. Land)		$1,552,000

Principal Items. Air drills & compressor, diesel shovels & dump cars. diesel locomotive & railroad siding, crusher, hammer mill, conveyor & elevator, rough mill & slurry tanks, air compressor, kiln & feed tank, rotary clinker cooler, clinker conveyor & silos, finish mill elevator & conveyor, packaging equipment, laboratory equipment, pumping equipment, water storage, maintenance equipment, power plant.

b. WORKING CAPITAL

	No. of Days	
Direct Materials, Direct Labor, Mfg. Overhead(a)	60	$ 71,300
Admin. Costs(b), Contingencies, Sales Costs(c)	30	6,300
Training Costs		25,400
Total Working Capital		$ 103,000

c. TOTAL CAPITAL (EXCL. LAND) $1,655,000

2. MATERIALS AND SUPPLIES

a. Direct Materials	Annual Requirements	Annual Cost
Limestone	52,000 tons)	Cost in
Clay	11,500 tons)	land
		) depletion
Gypsum	1,600 tons	11,000
Bags		18,000
Total		$ 29,000

b. Supplies	
Lubricants & hand tools	$ 700
Refractories, brick, clay & cement	18,000
Maintenance & repair parts	6,000
Office supplies	300
Total	$ 25,000

3. POWER, FUEL AND WATER

	Annual Cost
a. Electric Power. Connected load about 900 hp. Plant produces own power.	
b. Fuel. About 36,000 barrels of Bunker C oil annually.	$ 72,000
c. Water. About 10.8 mn. gals. annually.	$ 2,500

4. TRANSPORTATION

a. Own Transport Equipment. None necessary.

b. External Transport Facilities. Total in & out shipments about 4,000 tons a month. Railroad siding & good highway necessary.

5. MANPOWER

	Number	Annual Cost
a. Direct Labor		
Skilled	10	$ 60,000
Semi-skilled	20	100,000
Unskilled	20	80,000
Total	50	$240,000
b. Indirect Labor		
Manager & supervisors	3	$ 26,000
Chemist	1	9,000
Office	2	9,000
Other	3	15,000
Total	9	$ 59,000

c. Training Needs. Manager & supervisors should be fully experienced. With aid of 6 skilled workers, they should be able to do all labor training. Plant should reach full production in 2 months.

6. TOTAL ANNUAL COSTS AND SALES REVENUE

a. Annual Costs	
Direct Materials	$ 29,000
Direct Labor	240,000
Manufacturing Overhead(a)	158,500
Admin. Costs(b), Contingencies	50,000
Sales Costs(c), Bad Debts	30,000
Depreciation on Fixed Capital & Land Depletion	145,200
Total	$652,700

b. Annual Sales Revenue $875,000

NOTES. (a) Includes Supplies, Fuel, Water, Indirect Labor. (b) Includes Interest, Insurance, Legal & Audit Charges. (c) Includes Sales Commissions, Freight Out, Travel.

EQUIPMENT FOR CEMENT PRODUCING PLANTS*

Major equipment of cement producing plants serves to carry out such process operations as crushing, comminuting and homogenizing of raw materials, drying of raw compound and its preparing in heat-exchangers, the roasting of hard-burnt brick (clinker) in the kiln, cooling and hard-burnt brick grinding; storage, packing and shipment of cement.

Two principal methods of cement production, namely wet and dry, may be distinguished depending on the way of raw compound preparation. If a wet method of production is used the raw compound shall be prepared in aqueous medium, obtaining a liquid slurry roasted after that in rotary kilns. When it is a dry method of production the raw materials shall be comminuted, homogenized and roasted in a dry state.

1. Crushing equipment

At cement plants the crushers of different types are used in material crushing process. For the crushing of strong and grinding materials jaw and spindle breakers are to be used. The rotor, hammer, jaw-roll and roll breakers shall be used for the crushing of soft and low-abrasive materials.

Basic information on some breakers made in the USSR is given in Tables 1.1, 1.2, 1.3, 1.4 and 1.5.

* Source: Academy of Science of the USSR, Feb. 1979
Re: Q - 3887-1979

Table 1.1. Jaw breakers

Mark	Size of charging hole, mm	Capacity, cu.m/hr
С-182В	250x400	6
СМ-166А	250x900	35
СМ-741	400x900	48
СМ-16Д	600x900	200
СМД-58Б	900x1200	160
СМД-59А	1200x1500	280
СМД-60А	1500x2100	550

Table 1.2. Spindle breakers

Mark	Cone diameter	The largest size of starting material, mm	Capacity, cu.m/hr
СМ-561А	600	60	32
СМ-560А	900	100	62
ККД-500/75	1280	400	150
ККД-1200/150	1900	1000	680
ККД-1500/180	2520	1200	1300
КСД-1200Гр	1200	150	105
КСД-1200Т	1200	100	85
КСД-1750 Гр	1750	200	300
КСД-1750Т	1750	160	180
КСД-2200Гр	2200	300	580
КСД-2200Т	2200	250	340
КМД-1200Гр	1200	80	110
КМД-1200Т	1200	40	130
КМД-1750Гр	1750	100	120
КМД-1750Т	1750	70	80
КМД-2200Гр	2200	110	220
КМД-2200Т	2200	80	150

Table 1.3. Roll breakers

Mark	Roll dimensions, mm (diameter x length)	The largest size of starting materials, mm	Capacity, cu.m/hr
СМ-12	600 x 400	85	25
Г80x50	800 x 500	40	15
Г100x55	1000 x 550	75	45
Г150x60	1500 x 600	75	76
ДДЗЭ 15x12	1500x 1200	900	150
ДДЗ 700	1250x1000	900	700

Table 1.4. Hammer breakers

Mark	Rotor diameter, mm	The largest size of starting materials, mm	Capacity, cu.t/hr
С-218М	600	150	15
СМ-431	800	250	14
СМ-19А	1000	300	54
СМ-170Б	1300	400	200
ДМРИЭ 14,5x13-1000	1450	80	250
ДМ 17x14.5	1700	600	500

Table 1.5. Rotor breakers

Mark	Rotor diameter, mm	The largest size of starting materials, mm	Capacity cu.m/hr
СМД-85	800	400	50
СМД-75	1000	300	150
СМД-86	1250	600	125
СМД-94	1250	375	200
СМД-95	1600	800	200

2. Equipment for material grinding

In a cement production industry the tube ball and rod mills are mostly used for the grinding of raw materials, clinker and additions. Basic information on some mills made in the USSR is given in Table 2.1.

Table 2.1. Tube mills

Mark	Drum dimensions, mm		Capacity, t/hr
	diameter	length	
СММ-205	1948	10520	21[1], 13[2]
СММ-206	2660	13020	55[1], 35[3]
СММ-201	3200	8500	36-105[4]
СММ-203,6	3200	15000	76[2]
СММ-202	3200	15000	160[1], 50[2]
СММ-208	4000	13500	154

1)for dry material

2)for clinker

3)for cement

4)for raw material

The clay mixers for the preparation of a slurry consisting of soft raw material such as clay, chalk, marl are used.

The clay mixer of type СМЦ-426 has a mixing basin diameter of 12 m, capacity for clay is 40 t/hr, for clay and chalk compound 60 t/hr.

3. Equipment for the homogenizing and averaging of a raw compound and for feeding it into the kiln

In order to obtain a raw compound of required chemical composition and keep the homogeneity of this compound during a long period of time the homogenizing and averaging of a raw compound in vertical and horizontal slurry basins shall be carried out. The horizontal slurry basins shall be equipped with mixers to prevent slurry settling. Basic information on mixers is given in Table 3.1.

Table 3.1. Mixers

Mark	Basin dimensions, m	
	diameter	depth
СМЦ-421	25	5.4
СМЦ-422	35	6.6
СМЦ-423	35	6.95
СМЦ-424	35	10.1
СМЦ-445	35	9.96

A raw compound is to be delivered from the horizontal slurry basins into slurry feeders, which feed the raw compound into the kiln. Basic information on slurry feeders is given in Table 3.2,

Table 3.2. Feeders

Mark	Delivery, cu.m/hr
СМЦ-78	33-65
СМЦ-77	50-100
СМЦ-76	75-150
СМ-500	12.5-25
СМ-501	25-50

4. Kilns for clinker roasting

At cement producing plants the hard-burnt brick (clinker) is almost roasted extremely in rotary kilns. The kilns for clinker roasting by the wet method are provided with internal heat-exchangers. The kilns for clinker roasting by the dry method are usually shorter than those ones for wet method and provided with cyclon-type heat exchangers laid behind the kilns.

Basic information on kilns is given in Table 4.

Table 4. Rotery kilns

Mark	Casing dimensions, m		Capacity, t/hr
	diameter	length	
Ø3 x 60	3	60	15
Ø3,6x75	3.6	75	10
Ø3,6x110	3.6	110	10
Ø4,5x170	4.5	170	22
СМЦ-452	4	150	35
СМЦ-402	5	185	75
СМЦ-404	7	230	146
СМЦ-74	6.4	95	146
СМЦ-406	5	75	75
СМЦ-405	4	60	40

5. Coolers

For the cooling of cement clinker, coming from the rotary kiln the grate coolers are to be used. Basic information on coolers is given in Table 5.

Table 5. Grate coolers

Mark	Grate dimensions, mm		Capacity, t/hr
	length	width	
СМЦ-408	16600	2520	35
СМЦ-409	16600	3360	50
СМЦ-410	16600	5040	75

6. Ancillary equipment

Among the ancillary equipment of cement plants are dust cleaning devices (cyclones, bag-type and electric filters), equipment for proportioning and transportation of materials (feeders, measuring hoppers, conveyers, elevators, air-operated transport), equipment for packing and shipment of cement. For the efficient operation of a cement producing plant the vital importance is in the automatic control system for the process equipment. Information on ancillary equipment as well as the additional information on principal process equipment and cement plant automatic control systems may be found in the references given below.

Proposal and feasibility study for a 25 t/d mini cement plant *

†*R. Bruce** and *M. K. Garg**

Portland cement is used in building activities to the virtual exclusion of lime mortar or natural cement because the latter fail to meet present-day building requirements, and they cannot be improved in such a way as to ensure the advantages of low cost, simplicity of use and adaptability to remote rural areas. The large-scale production of Portland cement appears, therefore, to be the only choice left for the planners. The question is whether to use large plants located near the limestone deposits, involving heavy transport costs to consumer markets, requiring substantial capital, and taking considerable time to reach required production levels; or to use decentralized mini cement plants that would:

Utilize local deposits of calcareous materials

Require much lower capital investment

Come on-stream more quickly

Create rural employment

Sharply reduce transport and packaging charges

Technology of Portland cement

The production of Portland cement involves the following steps:

Mixing of raw material under rigid analytical control

Fine grinding of the mix (either wet or dry)

Firing (calcining) the mix to a temperature of 1,400–1,450°C

Fine grinding of the fired clinker with addition of a small amount of gypsum

The minimum efficient capacity of the rotary kiln is estimated at 300 t/d, and capacities of 3,000 t/d and above are preferred because they have the following advantages:

Lower radiation heat losses in the kiln area

Lower capital investment per tonne produced

Savings in personnel costs

A general reduction in overhead costs (spare parts, lubrication and maintenance)

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*On behalf of the Appropriate Technology Development Association (ATDA), Lucknow, Uttar Pradesh, India.

* Source: UNIDO- ID/232/12, January 1981

Despite the economic advantages of such large-scale plants, they have not been coming on-stream in India at the rate required to fill the gap reflected in the following statistics:

Period	*Installed capacity*	*Production*
	(millions of tonnes)	
1977–1978	21.9	19.2
1982–1983 (projected)	35	30

Vertical-shaft kilns, on the other hand, can be operated with a capacity as low as 1 t/d and have a maximum capacity of about 200 t/d. The techno-economic feasibility of setting up mini vertical-shaft cement plants, particularly in locations far removed from cement production centres, is therefore under consideration.

Details of development work done in India

With the successful utilization of vertical-shaft kiln technology for cement production in a number of countries, particularly in Europe and China, it may be asked why this technology has not yet been applied in India. This idea was taken up as early as 1949, and quite substantial development work has been carried out, but as yet no commercial production has begun. The reasons may be summarized as follows:

(a) In Europe vertical-shaft kiln technology has been developed on the basis of a kiln design with a capacity of 180–200 t/d. Four to six kilns of the above capacity are installed in one unit. The unit thus becomes not a mini cement plant but a large-scale cement plant. The only difference is that in place of a rotary kiln a number of vertical-shaft kilns are used. This model and design of kiln could not be used for decentralized mini cement technology required under Indian conditions;

(b) The vertical-shaft kiln used in China has a capacity of 25–30 t/d, which is also the requirement in India. But the quality of cement produced in China with such kilns is not the same as that of Portland cement and cannot meet Indian standard specifications. In China, the development and use of technology and the consumption of its products are all the responsibility of bodies which can exercise quality control, absorb non-commercial production costs, and operate small-scale plants even when they do not produce cement fully meeting Portland cement specifications;

Conditions in India are different. Government agencies are disinclined to promote any technique about which there is the slightest doubt. Private entrepreneurs and business organizations will not accept new technologies developed by government research agencies without some form of guarantee and technical assistance, which has never been offered in the case of mini cement plants. Furthermore, the majority of consumers are not prepared to accept a lower quality product, even at a lower price, when Portland cement is available.

Over the past 20 years efforts have been made to establish mini cement plants in India despite the problems presented by the above-mentioned conditions. Various projects have involved the Deccan Cement Company, the Defence Department, the Indian Cement Research Institute, the Jorhat Regional Research Laboratory at Assam, the Planning Research and Action Institute (PRAI) of the Uttar Pradesh state government at Lucknow, the National Research Development Corporation, and the Tamil Nadu state government. But none of these project plants managed to produce cement up to Portland cement specifications. In the case of the PRAI project plan at Mohanlalganj, the expansion ratio of the cement produced was rather high, making its use for structural and load-bearing purposes of doubtful safety.

The Intermediate Technology Development Group (ITDG), London, became interested in the efforts made in Mohanlalganj to develop appropriate technology for a mini cement plant. One of the authors (R. Bruce), an associate of ITDG, was therefore sent to India to make a detailed report on the Mohanlalganj cement plant.

On the basis of economic and production data from the Mohanlalganj plant, and data supplied by the Cement Corporation of India on the 1,200 t/d rotary kiln plants currently being installed in India, it was concluded that a 25 t/d vertical-shaft plant could successfully compete with the large plants, providing it consistently produced standard Portland cement. To achieve this, it would be necessary to seek expert technical advice.

It was further recommended that to achieve the widespread use of this technology in India, it would be necessary for a non-government agency to build and operate a new 25 t/d plant in co-operation with a business establishment or autonomous development agency. Its design should be based on that of the Mohanlalganj plant, which seems to be the most sophisticated available model. However, technical experts will be needed to establish plant specifications, to make design changes where necessary, and to provide on-the-spot assistance in India during the first year of the plant's operation. Such expert services should remove any remaining doubts about the feasibility of the technology and create the atmosphere of confidence required to attract investors.

In May 1977, ITDG arranged for the other author (M. K. Garg) to visit Kenya and Europe with complete plans and specifications of the Mohanlalganj pilot plant, which were examined by independent experts in the Federal Republic of Germany.

It was found that the high free-lime content of the cement produced at Mohanlalganj, which was the cause of the high expansion ratio, was largely the result of failure to reach and maintain a high enough temperature (1,400–1,450°C) in the kiln. Various simple procedures were recommended to solve the problem:

(a) The "mixed meal" rather than the inter-grinding process should be used;

(b) The forced air flow in the Mohanlalganj plant was 1.5 times what it should be. It should be reduced and a control system designed to vary the air flow and to be easily operated by the kiln operator should be installed;

(c) The feeding of nodules should be controlled according to gas temperature at the base of the chimney, which should be kept around 60°C, and in no case allowed to exceed 80°C. The average in the Mohanlalganj plant was around 150°C;

(d) The flue-gas temperature can be further regulated by installing infinitely variable gearing for the grate, thus enabling the kiln operator to control the rate of clinker discharge easily and quickly, and to keep the burning zone stable at the correct level;

(e) The make-up of the raw mix, particularly the heat input, should be carefully controlled. For this purpose, the heat content of the fuel must be tested and the constituents adjusted accordingly, which was not done in the Mohanlalganj plant.

The proposed project

Based on the Mohanlalganj experience, the Appropriate Technology Development Association (ATDA), Lucknow, proposes to build a 25 t/d plant with assistance from the Intermediate Technology Development Group, London, experts from private cement producers in the Federal Republic of Germany and Kenya, Appropriate Technology International in the United States of America, the Government of India, the Ministry of Economic Co-operation of the Federal Republic of Germany, and its executive wing, the German Agency for Technical Co-operation, and private Indian interests.

The project is to be carried out in two phases:

Phase I Examination of existing data and preparation of drawings and specifications by experts from the Federal Republic of Germany

Phase II Purchase of land and construction of buildings and plant; testing and demonstration under operational conditions by the ATDA with the advice and guidance of experts from the Federal Republic of Germany

Total capital requirements are as follows:

	(Dollars)
To commission experts from the Federal Republic of Germany to examine data, prepare a new set of drawings and specifications and provide advice and guidance to ATDA in erecting and commissioning the plant	78 400
To cover 50 per cent of the capital cost of the land, building, and machinery required for the plant, the balance of the funds being provided by Indian interests	163 660
For overall control and management of the project, including the initial costs of operating the plant for one year while testing, demonstrating and documenting its viability	54 880
Total	296 940

A feasibility study of the proposed plant is given in the annex.

Annex

Feasibility study of the proposed plant

Capital investment	*(Dollars)*	*(Dollars)*
Land and buildings		
Land	6 250	
Buildings	37 500	
	43 750	43 750
Machinery (ready to run)		
Jaw crusher (capacity, 4 t/h)	1 875	
Hammer mill (760 mm)	2 500	
Weighing equipment (raw mix)	2 500	
Mixer, concrete type (capacity, 2½ t/h)	2 500	
Ball mill (raw mix), air conveying gravity separator (capacity, 2 t/h)	43 750	
Homogenizer, continuous circulation fluidizer	3 750	
Nodulizer and silo	5 000	
Vertical shaft kiln and Rootes blower, instrument panel, variable speed grate, drive discharge gates, staging etc.	75 000	
Ball mill (cement	43 750	
Elevators and conveyors	12 500	
Raw materials silos	6 250	
Cement silos	6 250	
Installation and erection	15 625	
Laboratory building with test equipment	12 500	
Miscellaneous	35 000	
	268 750	268 750
Working capital		62 500
	Total	375 000

Gross income

Production

Capacity 30 t/d

Actual production, 25 t/d,
320 days per year: 8,000 t/a

Sale price

Market price (1977) per tonne of Portland cement, transported and sold in 50-kg bags: $56

Less taxes $18

Net price $38

The plant will market cement straight from the silo (unbagged) and customers will supply their own transport. The margin allowed by the Government for packing and transport is $10 per tonne. The price net to the plant is, therefore, expected to be about $28 per tonne.

Gross income expected per year is therefore:
8,000 t at $28: $224,000

Running costs are estimated on the basis of 1977 prices and quantities from data on the Mohanlalganj plant. Costs are calculated in dollars per tonne of cement.

Raw materials

Limestone	0.90 t at $6	$5.40
Kankar	0.65 t at $2	$1.30
Correctives	0.05 t at $3	$0.15
Gypsum	0.05 t at $15	$0.75
		$7.60

Fuel

The Mohanlalganj plant regularly achieved a fuel consumption of 0.18 t per tonne of cement. The fuel is mainly coke breeze with some coal added. The heat input averaged 3,962 kJ/kg of clinker in the 175 t/d vertical-shaft kilns used in the Federal Republic of Germany and 4,795 kJ/kg clinker in the 1,200 t/d wet-process rotary kiln of the Cement Corporation of India.

Coke breeze	0.15 t at $9.38	$1.40
Coal	0.03 at t $18.75	$0.56
		$1.96

Electrical energy

The Mohanlalganj plant consumed an average of 150 kWh/t as compared to 140 kWh/t for the 1,200 t/d rotary plants of the Cement Corporation of India.

150 kWh at $0.025: $3.75

Labour (daily)

	Shifts	*Persons*	*Wage ($)*	*Total ($)*
Grinding and weighing	1	5	0.75	3.75
Mixer and ball mill	3	3	1.25	3.75
Nodulizer and homogenizer	3	3	1.50	4.50
Kiln operator	3	3	2.50	7.50
Clinker and cement mill	3	6	1.00	6.00
Silos	3	3	1.00	3.00
Packaging	1	1	1.00	1.00
Extras	3	6	1.00	6.00
Total		30		35.50

Cost per tonne: $1.40

Labour (monthly)

	Number	*Salary ($)*	*Total ($)*
Manager	1	188	188
Mechanical engineer	1	150	150
Supervisors	3	100	300
Chemist	1	125	125
Workshop machinist	1	75	75
Laboratory assistants	3	50	150
Electrician	1	62	62
Assistant mechanic	1	50	50
Accountant	1	88	88
Cashier	1	50	50
Clerk	1	50	50
Stenographer	1	75	75
Typist	1	50	50

Cost per tonne: $2.25
Total labour: $3.65 per tonne

Overhead

Overhead (including office expenses and contingencies) is calculated at 20 per cent total labour costs, or $0.75 per tonne.

Stores and repairs	Cost (dollars p.a.)
Buildings, at 2%	750
Machinery, at 4%	11 000
	11 750

Cost per tonne: $1.45

Summary of running costs

	($/t)
Raw materials	7.60
Fuel	1.96
Electrical energy	3.75
Labour	3.65
Overhead	0.75
Stores and repairs	1.45
Total	19.16
Safe estimate	19.50

Gross annual surplus	*(Dollars)*
Gross sales	224 000
Running costs	156 000
Gross annual surplus	68 000

This represents a gross return of over 20 per cent on capital invested, which is roughly what the Cement Corporation of India expects to earn on a large plant.

	(Dollars)
Deduct depreciation: Buildings, at 5%	1 875
Machinery, at 10%	26 875
	28 750

Net return: $68,000 – $28,750 = $39,250
Return on capital: 10.5 per cent

MINI CEMENT PLANT FOR BANGLADESH

THE PROJECT

The establishment of mini cement plant is aimed at providing 9000 tons of cement per year. There is scope for establishing more than one mini cement plant in Bangladesh.

At present, local production of cement covers about 30% of total consumption of cement, in the country, About 70% of total cement requirements is met by import.

The project is important to Bangladesh as an import substitute exercise.

The project will have an installed capacity of 9000 tons of cement per year.

Production schedule is based on three eight hour shifts working for 330 days a year.

Proposed mini cement plant will be equipped with rotary kiln which can work with either the wet or the dry process according to the type of plant in view.

Mini cement plant will be based on natural gas firing, for which special burners are required.

MARKET

Cement consumption has grown much during last five years in Bangladesh, and for the period 1982-83 reached the level of 307,000 tons. Difference between annual consumption of cement and its local production has been covered by import, which reached the level of almost 780,000 tons for the period 1982-83. To cover this gap and reduce or eliminate import, large scale cement plant ought to be built up. Alternatively several mini cement plants similar to that proposed in the project could be built up.

RAW MATERIALS

List of raw materials required for manufacture of 9000 tons of cement per year is as follows :

- Limestone	11,700 tons per year
- Clay	2,700 tons per year
- Gypsum	360 tons per year
- Gunny (jute) bags	180,000 nos per year

* Prepared by UNIDO team and submitted for promotion in 1984
Ref: project profile BGD/072/V/1984-07

4. Prices used for raw material calculation are as follows :

- Limestone $ 8.7 / ton

(price of local limestone ore stands at Tk. 300/ton i.e. US $ 12/ton. Price of imported limestone ore from India stands at about I.Rs 69/ton. The ratio of limestone ore used in the existing cement plant in sylhet is : ½ from local resources and ½ imported from India; a similar structure of limestone ore supply is assumed for the proposed mini cement plant. The price of limestone calculated as an average therefore stands at US $ 8.7/ton.)

- Clay US $ 4/ton.

(Existing cement plant in Sylhet uses its own clay deposit close to the factory and no figure on clay price is available. Therefore taking into consideration cost of fuel, labour, maintenance & depreciation of handling and transport equipment, cost of clay was calculated at US $ 4/ton. It is assumed that proposed mini cement plant also will use its own clay deposit close to the plant.)

- Gypsum US $ 52/ton

(The price is equal to wholesale price of imported gypsum. In future when phosphogypsum will be processed for cement manufacture, imported gypsum will be replaced by local one.)

- Gunny (jute) bag US $ 0.2/bag.

(The price of locally produced gunny bags is about Tk. 5 per bag i.e. US $ 0.2/bag.)

5. UTILITIES

The plant (wet process) requires natural gas, electricity & water to the extent of US $ 119,500 per year.

	Quantity	Price	Average cost
Natural gas	720,000 Nm^3	US $ 0.041 per Nm^3	US $ 29,500
Electricity & power	1,260 MWH	US $ 70 per MWH	US $ 88,200
Water (90% recycled)	22,500 Nm^3	US $ 0.08 per Nm^3	US $ 1,800

6. MANPOWER

The manpower requirements are estimated as follows:

	Number	Average cost (US $ p.a.)
Manager	1	3000
Supervisors	3	1500
Skilled workers	17	800
Unskilled workers	15	500
Accountant	1	1500
Office workers	3	500
Chowkidars	3	400

6.. The requirement will be met from local sources.

The supervisors and five skilled workers would need technical training.

7. <u>SITE AND INFRASTRUCTURE</u>

The proposed plant will be located in Sylhet district close to local limestone deposits and to alternative supply sources of imported limestone from India by ropeway, and to the existing cement plant there. The area has reasonably good communication facilities including roads, railways and rivers.

No provision is made for housing of the workers as they will be drawn from local resources.

Apart from Sylhet district, other locations can also be taken into consideration. For example locating one mini cement plant in Bogra close to local limestone deposit is desirable, Limestone output from that deposit is too small at present to supply large-scale cement plant, but appears to be enough for two or three mini cement plants. Limestone output in Bogra is constantly being diminished, and therefore existance and volume of the deposit has to be estimated before any decision to locate a mini cement plant there is made. Mini cement plants ought to be located near the lime and clay deposits or alternatively near to the main consumer areas. In either case transportation costs would be reduced.

8. <u>INVESTMENT COST</u>

The total investment cost of mini cement plant is estimated to be US $ 948,000.

	Local currency	Foreign currency	Total
Land (3.5 acres)	28	—	28
Buildings	86	—	86
Machinery & Equipment (C & F, duty, clearance)	40	533	573
Erection & supervision	100	21	121
Preoperational Expenses	24	—	24
Working Capital	35	—	35
Interest during construction	61	—	61
TOTAL :	394	554	948

9. SOURCES OF FINANCE

The project is expected to be financed as follows :

(US $ 1,000)

	Local currency	Foreign currency	Total
Equity	303	—	303
Loan	91	554	645
TOTAL :	394	554	948

10. IMPLEMENTATION PROGRAMME

The project will take two years for implementation, training and trial production.

The plant is expected to operate at 60% capacity in the first year, 80% capacity in the second and 100% in the third year and thereafter.

11. PROFITABILITY

The following profitability estimates are made assuming that the plant will operate at 100% capacity in the 3rd year after commissioning :

(US $ 1,000)

Sales		706
Manufacturing costs		
Raw materials	168	
Utilities	130	
Labour	32	
Overheads & maintenance	46	
Depreciation	33	
Selling & distribution Administration	6	
		417
Profit before interest & taxes		289
Interest		98
Profit before taxes		191
Profit before taxes as a percentage of turnover		27%

Profit before taxes as a percentage of investment	20%
Profit before taxes as a percentage of equity	63%
Rate of Return	30%

Payback period 5 years including 2 years of construction.

Breakeven point 23% of capacity.
(In case the plant will use only local limestone ore, Breakeven point will stand at 26% capacity).

Tax holiday for 9 years as Sylhet is a priority development area.

12. ASSISTANCE SOUGHT

Technology;
Know-how ;
Equipment & machinery supply.

13. SOURCES

SBP "Industrial Chemical Handbook".

"Statistical Yearbook of Bangladesh".

Discussions with the Bangladesh Minerals Exploration Development Corporation, Dhaka.

14. EXCHANGE RATE

Rate : US $ 1 = Tk. 25

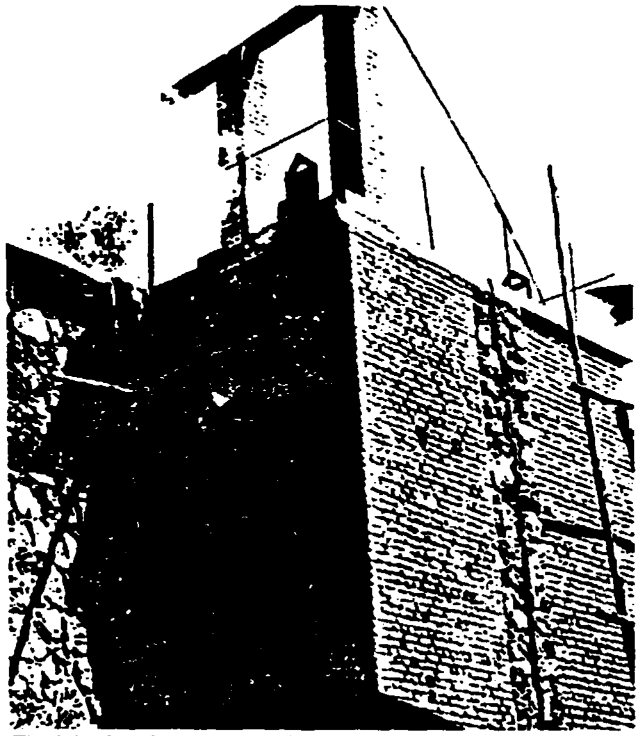
Date : 2.05.1984.

A Lime-pozzolana Cement Industry in Rwanda

J. Apers and M. Pletinck* describe a pilot plant in Rwanda which is producing a cementitious material based on local materials, using peat as a fuel, for almost half the price of imported Portland cement.

In 1982 Rwanda imported approximately 35,000 tonnes of ordinary Portland cement (OPC). Various attempts have been made to make Rwanda less dependent on the foreign cement producers. One possibility is the production of a binding material based on volcanic ash (a pozzolana) and limestone, both of which are locally available. A pozzolana is a material (usually siliceous) which, when mixed with lime, will harden to form a cement. Natural pozzolanas include various clays and laterite. Artificial pozzolanas can be made from broken bricks (called *surkhi* in India), rice husk ash and bagasse ash.

A small-scale pilot plant was recently constructed. The various stages of production are now being tested and the lime-pozzolana cement which has been produced is being intensively examined. The pilot plant was built as part of the PPCT project (Projct Pouzzolanes Chaux Tourbe) run by COOPIBO, an international volunteers organization, with technical assistance from the Post Graduate Centre — Human Settlements (PGCHS), a centre dealing with housing and building in developing countries, which is part of the Catholic University of Leuven, Belgium. The Ministry of Development Co-operation of Belgium finances the project.



The kiln that dries the pozzolana.

Objectives

The main objectives are to produce a cheap lime-pozzolana cement in a profitable way using a technology adapted to the local conditions. The potential consumers are mainly people from rural areas, and the production units are organized on a co-operative basis.

The lime-pozzolana factory

The basic raw materials are:

Pozzolana. Large quantities of volcanic ash can be found in the north-western part of Rwanda. On the basis of various criteria, such as pozzolanic activity, accessibility, quantity available, distance from the factory, and so on, a deposit was provisionally chosen. Further investigations have since been carried out to find a deposit of equal or better quality (the degree of pozzolanic activity and ease of grinding are especially important) situated closer to the factory (located in Ruhengeri).

The lime-pozzolana cement factory.

Limestone. Good quality limestone (travertine) can be found near Ruhengeri.

Peat. Because of the local wood shortage, peat was chosen as an energy source for burning the limestone and drying the pozzolana. A marsh near Ruhengeri was drained and the peat was taken from there.

In order to reduce as much as possible the transportation of materials between the different production phases, the entire pozzo-lime plant was built on a slope. But this choice meant that heavy retaining walls were needed. The factory consists basically of two different production lines.

The lime production line. The limestone is burned in a continously operating mixed feed vertical shaft kiln operating by natural draught (there is no fan, the lime kiln acts as chimney and draws its own air in). The burned lime is slaked with water in shallow concrete basins, sifted and stored in silos. The average production figures for the first six months of 1983 were as follows:

- capacity: about 55 tonnes per month
- 1.7 tonnes of peat are necessary to burn 1 tonne of limestone
- 2 tonnes of limestone are needed to produce 1 tonne of hydrated lime
- the lime contains sixty per cent calcium hydroxide.

Experiments to improve the efficiency and to increase the capacity are being continued.

The pozzolana production line. First the pozzolana is dried in vertical kilns, consisting of sets of horizontal plates, each covered with a layer of pozzolana. A mechanism allows the plates to be tilted so that the dried pozzolana slides downwards and can be removed. Then the pozzolana is ground in a vibrating ball-mill with a capacity of approximately one tonne per hour.

The resulting Blaine fineness is approximately 3,500 cm^2/g (measured with the Blaine apparatus).

The last phases consist of mixing the ground pozzolana with lime and a certain quantity of OPC (see later), packing and storing it. The various production stages (drying, grinding, etc.) are being examined and the lime-pozzolana cement produced is being intensively tested.

Some important research subjects

Measurement of the pozzolanic activity

Because testing must be carried out under local conditions in Rwanda, the test of the quality of the lime-pozzolana cement should be simple, fast, cheap, reliable, sufficiently accurate and repeatable.

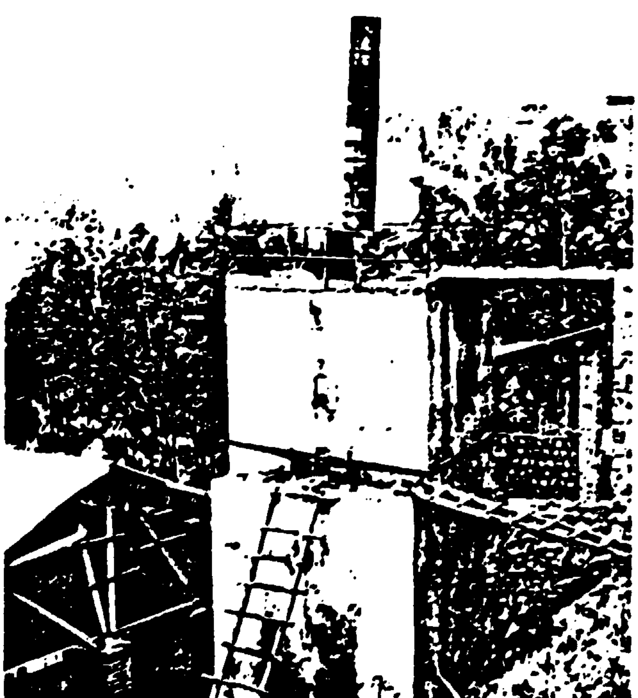
The methods proposed by various research centres can be divided into the following three groups:

- measurement of the quantity of the lime connected with pozzolana
- measurement of the quantity of active components of pozzolana (e.g. active silica)
- measurement of the compressive and tensile strength of pozzo-lime cement mortar.

No correlation has been found between the results of the various methods. As the compressive and tensile strength indicate the essential characteristics of the cement, namely to set, harden and bind together various materials, our research focused on the development of a test method according to the third principle. The Belgian standard for measuring the compressive strength of Portland cement was taken as a basis. This method was adapted in accordance with a detailed analysis of each test phase (mixing, compression, etc.), a statistical analysis of the test results and a comparative study of existing methods. This mechanical test takes twenty-eight days however. Attempts are being made to accelerate the entire testing process.

Acceleration of the lime-pozzolana reaction process

The strength of the binder increases very slowly. A number of investigations have been carried out to find out ways of accelerating the setting of the cement.



The lime kiln.

The peat marsh which fuels the factory.

Increase of curing temperature. An increase of 20°C (to 40°C) makes the setting process about five times faster. This method is only practical however for the production of pozzo-lime blocks or other prefabricated components.

Heating the pozzolana. The pozzolana can be heated during a certain period at a certain temperature. Test results show that:

— the heating period and the optimal temperature vary according to the kind of pozzolana used

— for certain kinds of pozzolana, the optimal temperature range is very restricted; this means that the kiln must have an extremely accurate heating system

— for some kinds of pozzolana, the temperature range between 70°C and 400°C should be avoided as it may lead to a reduction in the pozzolanic activity.

Further research is needed if this method is to be used.

Additives. The influence of gypsum, Portland cement (OPC), other salts such as sodium carbonate, and zeolites was examined.

Since sodium carbonate appeared to be the most interesting additive, both from a technical and an economic viewpoint, it was examined in more detail. Unfortunately although the laboratory results were promising, the practical test results (for plastering and masonry) were disappointing.

Another additive, OPC, is therefore also being examined in detail. The results of mixtures with a twenty per cent quantity of OPC are positive. One of the most important tasks now is to determine the minimum quantity to be added in order still to have a lime-pozzolana binder of sufficient quality.

Some economic data

The direct production cost of one tonne of pozzolana is about 6,000 Rwf (100 Rwf is about US$1). For one tonne of lime it is about 10,000 Rwf. One tonne of Portland cement costs 30,000 Rwf. A common mixture is composed of 20% OPC, 20% lime and 60% pozzolana.

The direct production cost of one tonne of pozzo-lime cement is approximately 14,000 Rwf (including 1,000 Rwf packing charges), i.e. 700 Rwf for 50 kg. When taking into account a selling price of 850 Rwf per bag, the industry starts to be profitable from a yearly production of about 3,000 tonnes onwards. ●

* *J. Apers and M. Pletinck are both members of the Post Graduate Centre — Human Settlements, at the Catholic University of Leuven, Kasteel Arenberg, B-3030 Leuven, Belgium.*

UNITED NATIONS NATIONS UNIES

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Project Questionnaire

on

Cement Industry*

Country:

Project Title:

Product:

Planned Capacity:

Project Number:............

ISIC:...................

Submission Date:...........

Project Sponsor/Promoter

Name:

Public Sector ☐

Private Sector ☐

Not Yet Identified ☐

We have:

a feasibility study ☐ dated

a detailed project profile ☐ dated

other studies ☐

studies under preparation ☐

Address:

Tel. No.________________

Telex: ________________

* This Questionnaire is to assist local project sponsors who seek foreign collaboration through UNIDO. It refers to cement production units in the planning or the development phase.

A. Description of the Project

1. Is this project a new enterprise or expansion/modernization of existing one?____

2. Plant capacity:

3. Describe cement technology and the production process which you plan to employ.

4. Type of plant:

5. Specify technological assistance, contracts sought if any, licenses and or know-how considered or negotiated.

6. If you intend to expand/modernize your existing industry, please state reasons.

7. Availability of raw materials and their types, percentages used in raw mix?

8. How large are the proven and exploitable reserves and how much it will serve the production of the project?

B. Manpower

Estimated local and foreign personnel requirements and average annual wages inclusive of all allowances and benefits.

	Local		Foreign	
Title	Number	Salary/Year Person	Number	Salary/Year Person
Management	____	____	____	____
Clerical	____	____	____	____
Technical Supervision	____	____	____	____
Skilled Labour	____	____	____	____
Unskilled	____	____	____	____
Other (Specify)	____	____	____	____
Total	____	____	____	____

What staff training will be needed?

What type of assistance will be needed from foreign staff?

C. Utilities and Energy	Quantity/ton of cement	Unit Price
Fuel, oil, etc.		
Gas		
Electricity		
Water		
Other		

Are there sufficient power resources and utilities available at the proposed site? Describe problems, if any.

D. Market

1. What is the annual demand for cement in your country?

2. How is the demand presently met (by local productio. or imports)?

3. At what rate is the local market expected to expand over the next few years?

4. What percentage of your production is intended for exportation with indication of major markets?

5. Will your product benefit from any trade agreement between your country and proposed export market?

6. What incentives are granted to the locally made products?

E. Site and Infrastructure

1. Where is the plant to be built or expanded?

2. Is the location away from towns?

3. Is the location near the raw material deposits?

4. Raw material has to be transported by ______ from about ______ km. away from plant. (Indicate distance from quarries to the plant)

5. How much land is required? (Sq. meters)

6. Cost per square meter in US $:

7. Specify existing facilities at site:
Transportation facilities connecting the factory to the markets, (road, rail, port), communication, housing, banking, environmental protection, water and utilities.

8. Is there any additional investment needed to provide or secure utilities supply?

9. Indicate any other relevant information.

Project Title: ______________________________

G. Investment cost and financing

1. Estimate of investment cost:

	Local currency component (in US$)	Foreign currency component (in US$)	Total (in US$)
Investment:			
Land			
Site Preparation			
Buildings/Civil Works			
Design/Engineering			
Machinery/Equipment			
Net Working Capital			
Pre-operational Expenses			
Other Contingencies			
Total Investment	________	________	________

2. Sources of Finance	Local sources (in US$	Foreign sources (in US$)	Total (in US$)
Equity			
Long-term Loans			
Suppliers Credits			
Short / medium term Loans			
Total	________	________	________

3. Foreign Contribution Desired:
   - equity participation
   - loan
   - technology (licensing, patents, etc.)
   - management
   - market access
   - services (engineering, product development, etc.)
   - training

H. Commercial Profitability at Capacity Operation

1. Total Sales

2. Production Costs

   Materials

   Production labour

   Utilities

   Maintenance

   Factory Overhead

   Administrative, Sales,
   Distribution Costs

   Depreciation/Interest

   TOTAL PRODUCTION COSTS:

3. Profit before taxes
4. Income taxes
5. NET PROFIT

I. Ratio Analysis

1. Return on total investment ....%
2. Return on equity ....%
3. Return on sales ....%
4. Pay-back ....years

   Pay-back period = $\frac{\text{total investment}}{\text{net profit + interest + depreciation}}$

5. Break even capacity of operation ....

   Source of information ____________________

   Exchange Rate (US $)

THE MINI-CEMENT PLANT*

based on simplicity in both layout and choice of equipment.

Design of the plant is geared to efficiency to ensure a consistent product according to BS, ASTM, or other standards, and to keep the downtime of the plant to a minimum. All non-productive equipment in the plant has been eliminated. In this way, investment is drastically reduced, facilitating easy financing.
The standard sizes of The Mini-Cement Plant vary from 40,000 TPY to 150,000 TPY, making it ideal for installation in remote areas. For a plant of this capacity, a small limestone deposit of 1.5 to 2 million tons can now be used, opening enormous possibilities in the choice of site.
Building time of the plant is short. This is due to the reduced use of concrete in the construction of the plant, and delivery of the greater part of the equipment pre-assembled to the site. This results in fast conversion of invested capital into production.
The plant is easy to operate due to the elimination of sophisticated electrical equipment, control devices and other non-productive installations. This leads to a minimum need for skilled personnel.
Finally, as the result of this simplicity, the maintenance requirements of the Fuller Mini Cement Plant have been greatly reduced.

* GATX-FULLER S.A., Quai de la Papee. 75583 Paris Cedex 12

Introduction*

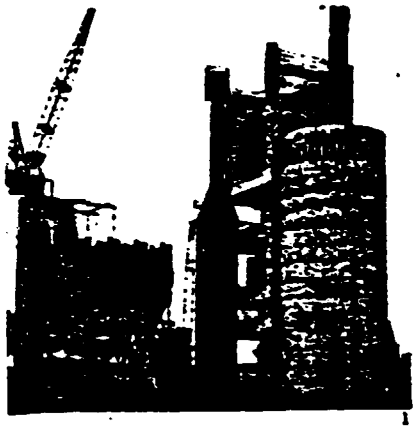
Cement is a vital commodity in man's development. However, all over the world there are areas that do not have sufficient raw material, big enough markets or transport facilities to support a conventional cement plant. For these areas BCND, a joint venture between Blue Circle Industries and Newell Dunford Engineering, has designed an economic, compact and self-contained Unit Cement Plant with a capacity of approximately 200 tonnes per day.

Blue Circle Industries has been, for over seventy years, in the forefront of investing in, building and managing cement plants throughout the world. It has, for many years, applied its highly developed techniques to the design and engineering of cement plants for clients outside the group.

Newell Dunford Engineering has been involved in the cement industry since the early twenties and has specialised in equipment production and has supplied kilns, mills, coolers, feeders and bucket elevators to BCI and other cement companies all over the world.

In association, these two experienced companies have designed a small scale cement plant using modern technology, Newell Dunford designing and supplying the machinery and Blue Circle the cement production expertise.

The Unit Cement Plant uses well proven, ruggedly constructed and largely standardised equipment on simple concrete foundations. It incorporates a dry process kiln and produces a satisfactory and consistent quality cement.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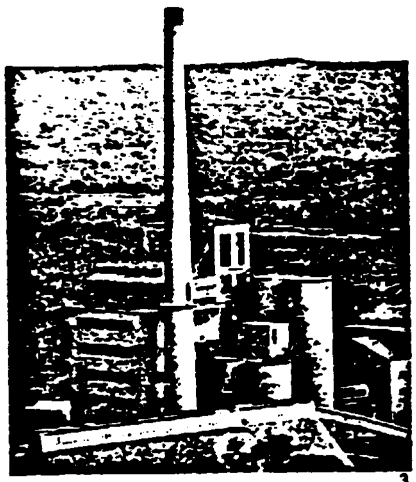
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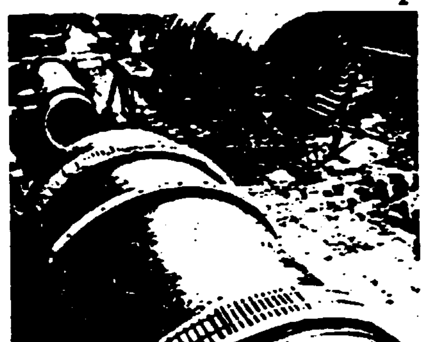
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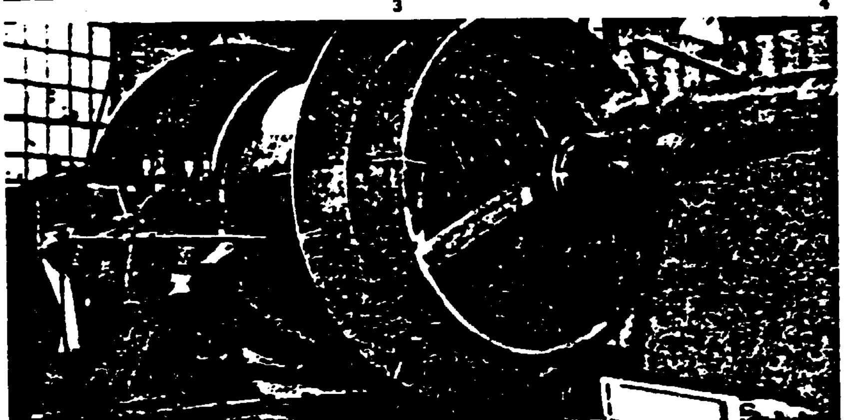
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1. Berrima, New South Wales, Australia – Blending silo and pre-heater building.
2. Pan Feeder.
3. Hope Works, Sheffield – General view.
4. Dryer Shells.
5. Spiral Trunnion Liner.
6. Hope Works, Sheffield – Pre-heater tower.

* Source: BCND
see page 97.

Design

BCND Unit Cement Plant designers have concentrated on simplicity.

As far as practicable the design has been standardised so that the manufacture, construction, operation and maintenance are as economic as possible.

The equipment is erected on simple concrete foundations and housed in sturdy steel-framed buildings, making it the ideal plant for processing small deposits of raw material. It can be dismantled and re-erected elsewhere with the minimum of expense.

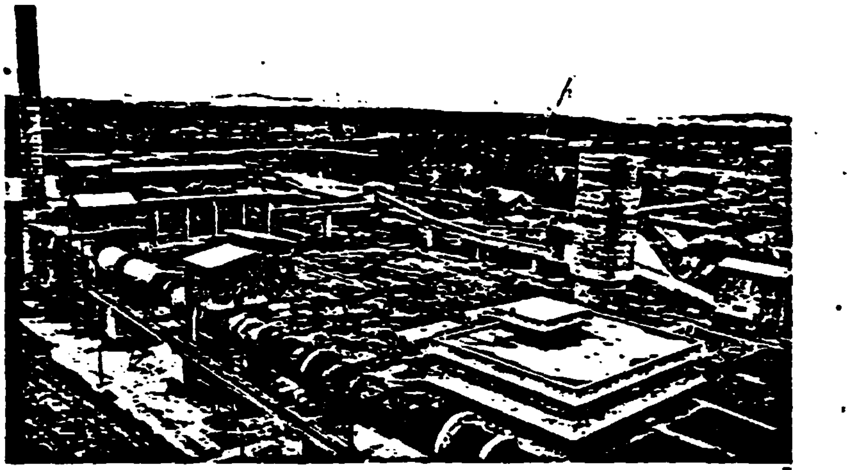
Features

BCND Unit Cement Plants have the following advantages:

1. Low capital cost
2. Economic processing of small deposits of raw material
3. Simple operation and maintenance
4. Low maintenance costs
5. Consistent quality cement
6. Minimum distribution costs
7. Well built, long lasting equipment with a high degree of standardisation.

Operation

After winning, the raw materials are crushed, screened, stored and then mixed to the correct chemical composition. If it is necessary to reduce the moisture content the mixture is fed into the optional rotary dryer prior to being ground in the mill and then blended in the raw meal blending silos. The blended material is clinkered in a rotary kiln fired by oil, gas or coal and then cooled in a rotary cooler which also preheats the combustion air for the kiln. The clinker is stored in silos and gypsum added while it is being conveyed to the cement mill where it is ground into the finished cement. Finally the cement is stored in silos before being automatically packed into bags.



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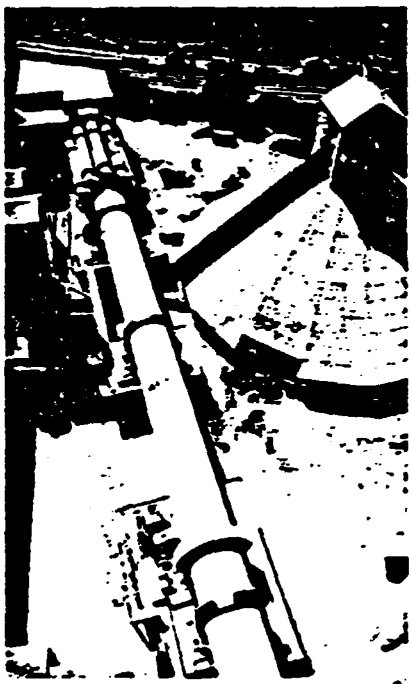

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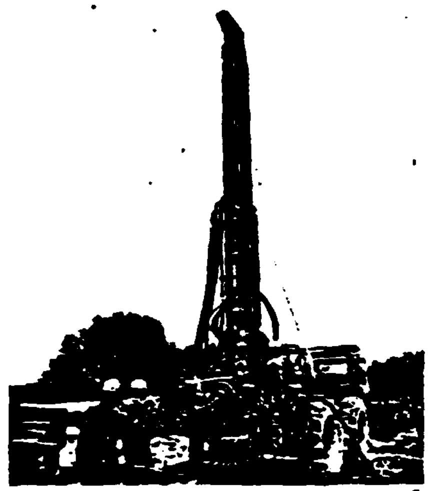

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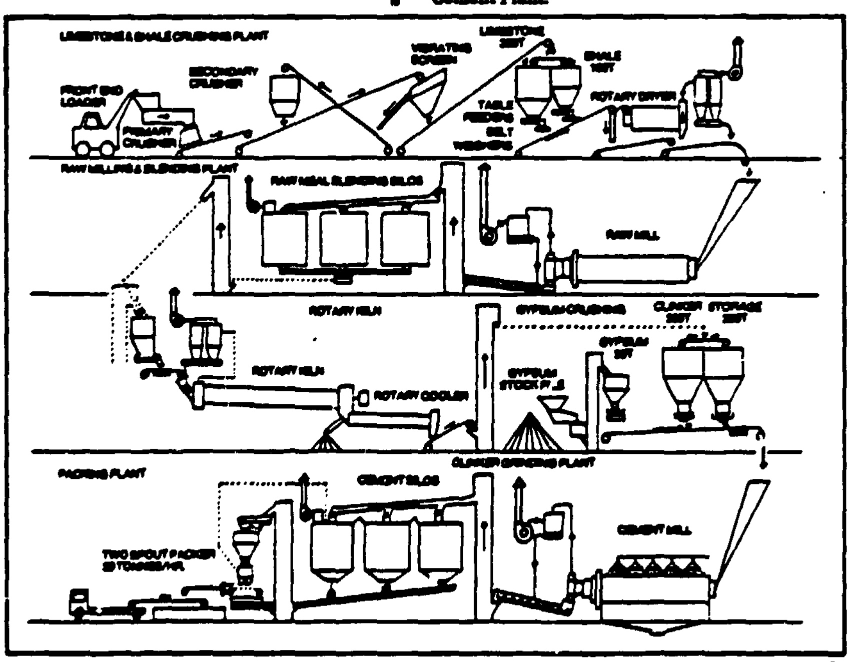
7. Berrima, New South Wales, Australia – View of the new dry process kiln.

8. Cement kiln supplied by Newell Dunford.

9. Blue Circle Geologists at Shoreham.

10. Flow Diagram of BCND Unit Cement Plant.

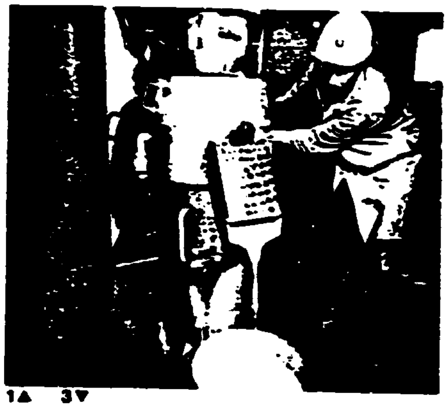


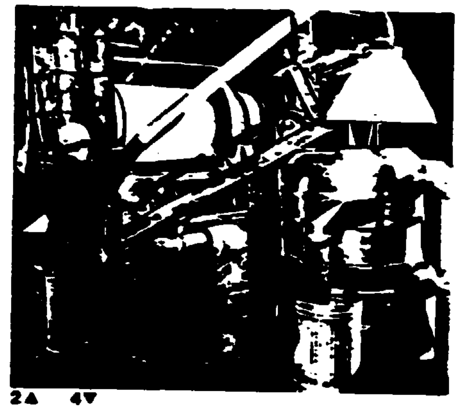
10

1 Ultrafine Grinding Mill
2 Rotary Louvred Dryer and Screen
3 Vibratory Mill
4 High Speed Mix~ Disperser

1 Broyeur a poudre ultafine
2 Secheur rotatif a volets et tamis
3 Broyeur vibrant
4 Melangeur diffuseur a haute vitesse

1 Ultrafein-Pulvermuhle
2 Drehjalousietrockner und Sieb
3 Vibrationsmuhle
4 Hochgeschwindigkeitsmischmaschine Disperser





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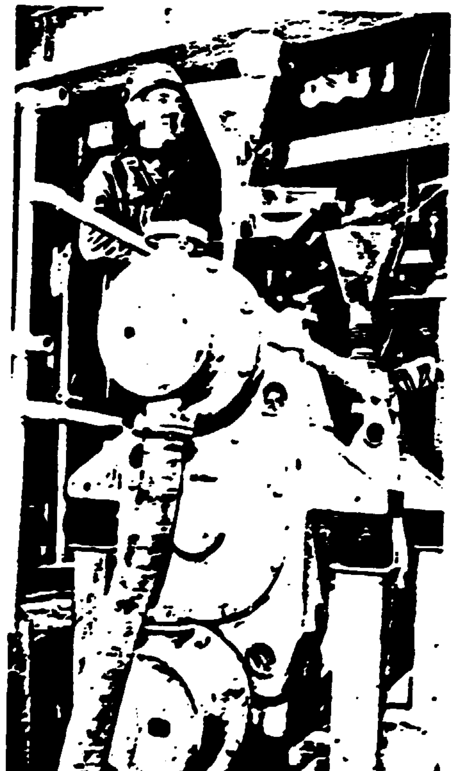
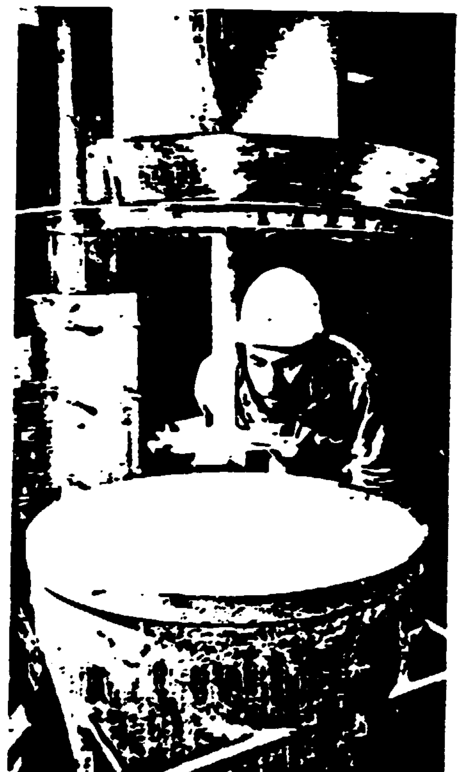


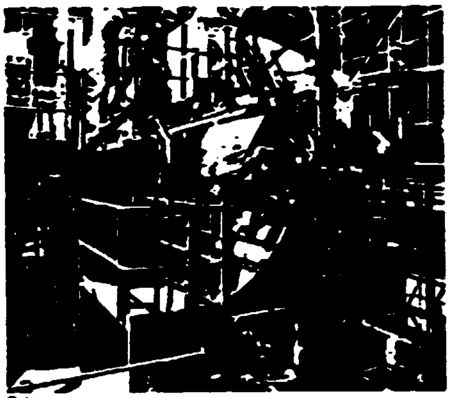


Source: **Product and process development at Barnstone**
Barnstone Nottinghamshire, England

1 Nodule Testing
2 Noduli[illegible] Dish
3 Medium Scale Kiln

1 Essais des granules
2 Granulateur
3 Four a echelle moyenne

1 Grana[illegible]enprufung
2 Granuliergefaß
3 Brennofen der Entwicklungsstufe



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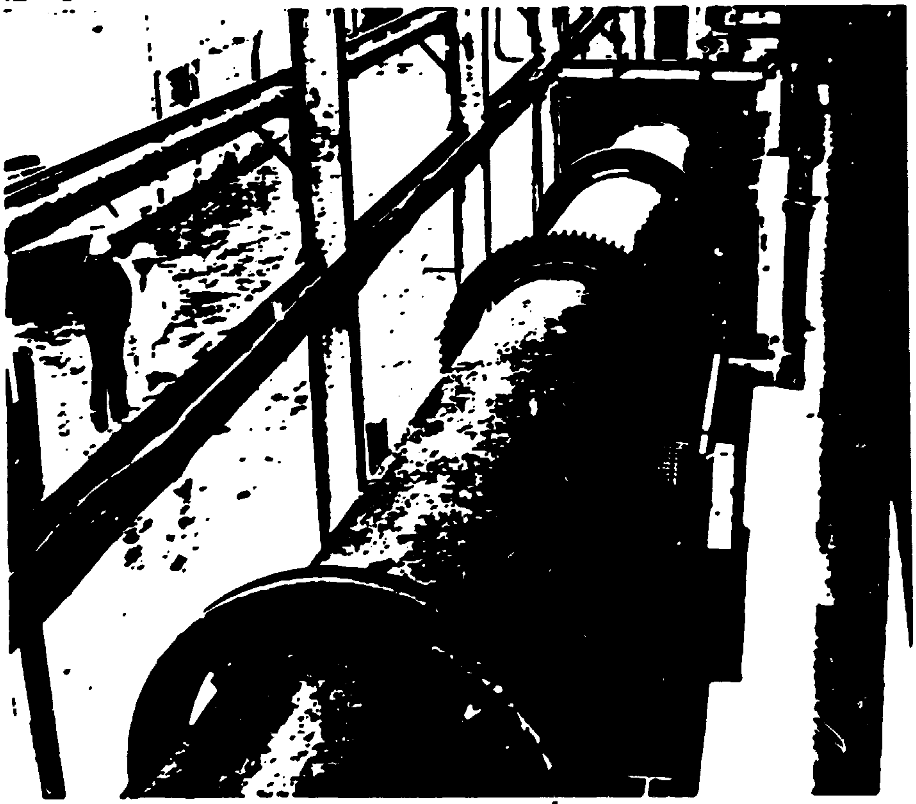
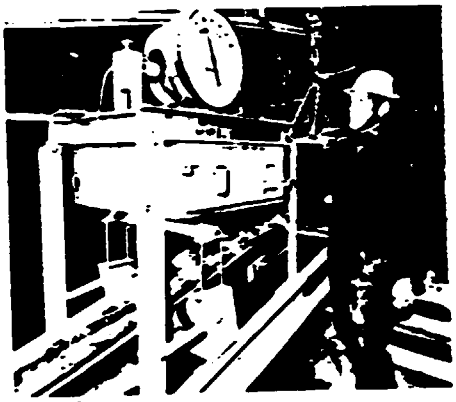
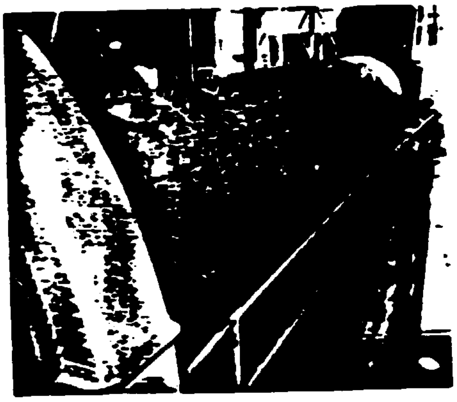


1 Raw Material Weigh-Belt
2 Wet Grinding Mill
3 Slurry Tank

1 Transporteur doseur de matieres premieres
2 Broyeur par voie humide
3 Reservoir a pâte

1 Rohstoff-Wiegeband
2 Naßmuhle
3 Schlammbehalter





1▲ 3▼ 2▲

INSTITUTIONS AND CONSULTING AGENCIES

Cementvazumaskiner AB
S-610 53 Enstaberga
Sweden

Termit Maskin AB
S-780 51 Dala-Järna
Sweden

Scandia Consult
International AB
Stockholm
Sweden

Cement Research Institute of India
M-10 New Delhi South Extension II
New Delhi 110 049
India

CEMBUREAU
The European Cement Association
2, rue Saint-Charles
F-75 740 Paris
France

American Concrete Institute
Box 4754
Redford Station
Detroit, Michigan 48219
U.S.A.

Forschungsinstitut der Zementindustrie
4000 Düsseldorf 30
Federal Republic of Germany

Societé Des Ciments Francais
Tour Générale Cédex 22
92088 Paris
France

Dansk Cement Central
P.O. Box 382
1504 Copenhagen
Denmark

Technion Research and Development
Foundation
Senate House, Technion City
Haifa
Israel

Standards Institute of Israel
42, University Street
Tel Aviv
Israel

Austroplan, Austrian Engineering Co. Ltd.
Vienna Austria , 15 Linke Wienzeile 234

Cement Making Machinery and Equipment*

ALC TOURNAI S.A., Chaussée d'Antoing 55, B.P. 5, B-7500 Tournai

Czechoslovakia

PRAGOINVEST, Českomoravská 23, Postfach 000, CS-180 56 Praha

Denmark

Smidth & Co. A/S, F.L., Vigerslev Alle 77, DK-2500 Copenhagen -Valby

Finland

METEX, Ruoholahdenkatu 4, P.O. Box 156, SF-00181 Helsinki -18

France

Constantin S.A., E., 105, rue Lafayette, F-75010 Paris
Creusot-Loire, 15, rue Pasquier, F-75008 Paris
Fives-Cail Babcock, 7, rue Montalivet, F-75383 Paris -Cedex 08
Venot-Pic, 7, rue Montalivet, F-75383 Paris -Cedex 08

German Democratic Republic

SKET EXPORT-IMPORT, Johannes-Dieckmann-Strasse 7-9, DDR-1080 Berlin

Germany, Federal Republic of-

KRUPP POLYSIUS AG
Graf-Galen-Str. 17, D-4720 Beckum 2
Tel. (02525) 711, Telex 89481

Loesche GmbH, Steinstraße 18, Postfach 5228, D-4000 Dusseldorf -1

Peters AG, Claudius, Kapstadtring 1, Postfach 002120, D-2000 Hamburg -60
PFEIFFER AG, GEBR., Barbarossastraße 50-64, D-6750 Kaiserslautern
KHD Humboldt Wedag AG, Wiersbergstraße, Postfach 910457, D-5000 Koln -91
Klöckner-Humboldt-Deutz AG, Deutz-Mühlheimer-Str. 111, Postfach 800509, D-5000 Koln -80, Deutz
Möller GmbH & Co. KG, G., Am Wasserturm, Postfach 568, D-4920 Lemgo

AUMUND-Fördererbau GmbH
Maschinenfabrik
Saalhoffer Str. 17, D-4134 Rheinberg 1
Tel. (02843) 72-0, Telex 812448
Förder- u. Hebetechnik -
Conveying systems and lifting engineering -
Technique des installations de transport et de levage -
Técnica de las instalaciones de transporte y elevadoras -
[illegible]

Italy

SOTI, Società Trasportatori Industriali S.p.A., Via Locatelli, 40, I-24011 Almè (BG)
Comprogetti, S.p.A., Via Broseta, 70/A, I-24100 Bergamo
Tosi, S.p.A., Franco, Piazza Monumento, 12, I-20025 Legnano (MI)
SICAL, Corso Venezia, 37, I-20121 Milano

Netherlands

Schugi B.V., Chroomstraat 20, NL-8211 AS Lelystad

Poland

POLIMEX-CEKOP GMBH, Czackiego 7/9, Postfach 815, PL-00-950 Warszawa

Portugal

Construções Técnicas, S.A.R.L., Avenida 24 de Julho, 24, Apartado 2241, P-1100 Lisboa -Códex
FENAL-COMETNA, Rua da Academia das Ciências, 5, Apartado 2402, P-1111 Lisboa -Códex

Romania

UZINEXPORTIMPORT, Bd. Republicii 32, P.O. Box 2, R-70433 Bukarest

Spain

Gruber, S.A., Hermanos, Apartado, 450, E- Bilbao
Urbasa, S.A., San Vicente, Edificio Albia, 6.° planta, Apartado, 945, E- Bilbao -1
Neyrpic Española, S.A., Avenida José Antonio, 191-217, Apartado, 103, de Barcelona, E- Cornella de Llobregat (Barcelona)
Compañía Española de Motores Deutz Otto Legitima, S.A., Avenida Pio XII, 100, E- Madrid -16
TAMESE, S.A., Camino Torre del Rio, s/n., Apartado, 208, E- Malaga
GATX-Fuller, S.A., Paseo de los Olmos, 14, 4.°, Bidebieta, 1, E- San Sebastián

Switzerland

Bühler AG, Gebr., CH-9240 Uzwil (SG)
Hischmann & Co., R., Muhlebachstrasse 23, CH-8008 Zürich

USSR

TECHNOSTROJEXPORT V/O, Ovchinnikovskaya Naberezhnaya 18/1, SU- 113324 Moskau
MACHINOEXPORT V/O, Mosfilmowskaja ul. 35, SU- 117330 Moskau

Great Britain and N.I.

Unipulver Ltd., Newport Forge, Anstey Mill la., GB- Alton, Hants.
Polysius Ltd., The Brackens, P.O. Box 3, GB- Ascot, Berks.
Luke (S.S.) Ltd., R.F., Oncraft wks., Boughton la., GB- Clowne, Chesterfield, Derbyshire
Gresham Plant Sales Ltd., Taywood rd., Ruislip rd., GB- Northolt, Middx.
Babbitless Co (Great Britain) Ltd., Stonefield Way, GB- Ruislip, Middx.

Hungary

CHEMIMAS Engineering, Postfach 30, H-1475 Budapest
INDUSTRIALEXPORT, Postfach 574, H-1373 Budapest

Yugoslavia

ITAS, Reška cesta 13, YU-61330 Kočevje
INKOBROD, Damiste bb, YU-50260 Korčula
MAŠINSKA INDUSTRIJA NIŠ, SOUR, YU-18000 Niš
UNIS, Maršala Tita 24, YU-71000 Sarajevo
DJURO DJAKOVIĆ, Njegoševa 1, YU-55000 Slavonski Brod
DALMASTROJ, Sinaco 12, YU-58060 Split
FERIMPORT, Ilica 1, P.O. Box 1019, YU-41001 Zagreb
INGRA, Proleterskih brigada 62, P.O. Box 277, YU-41001 Zagreb
JADRANBROD, Savska cesta 41/XVI, YU-41000 Zagreb
IVO LOLA RIBAR-OOUR, Tome Bude 2, YU-11250 Zeleznik

Zementfabrikeinrichtungen und -maschinen
Cement making machinery and equipment
Installations et machines pour la fabrication de ciment
Instalaciones y máquinas para la fabricación de cemento
Attrezzature e macchine per la fabbricazione del cemento

Belgium

Malzone S.A., René de, Quai F. Timmermans 15, Sclessin, B-4200 Ougrée

AUSTRIA
Voest-Alpine AG
Pf.2, A-4010 Linz

* Source: Veuillez mentionner ABC 1983.

Machinery and equipment for the cement, lime, gypsum, trass, and chalk industries

(Planning, consultation, and construction of complete cement and lime works see 40/8)

430
Machinery and equipment for the cement industry

(Crushers and mills for the cement industry see 13A/1, 2, 2a, 2b, 7, 8, 21, 22, 40, 44; wind sifters see 13A/201 a.f.; furnaces see 3/156, 212, 248, 257)

BABBITLESS GmbH Deutschland Aufbereitungsanlagen, Postfach 12 21
7640 Kehl (Rhein)

FAUN Aktiengesellschaft Hauptverwaltung, Postfach 8
8560 Lauf a.d. Pegnitz
Off road haulers, wheeled loaders

HAZEMAG Dr. E. Andreas GmbH & Co.,
Postfach 34 47, 4400 Munster

KHD Humboldt Wedag AG, Postfach
91 04 57, 5000 Koln 91 (Kalk)

KKK-AG Kühnle, Kopp & Kausch,
Postfach 2 65, 6710 Frankenthal (Pfalz)
Axial and radial blowers only

Gebrüder Lödige Maschinenbaugesellschaft mbH, Postfach
20 50, 4790 Paderborn
Mixers

LOESCHE GmbH, Postfach 52 26
4000 Dusseldorf 1
Crude cement processing machines

Maschinenfabrik Gustav Eirich, Postfach
11 60, 6969 Hardheim
Pelletising and mixing plant
(3) – in front of Group 13

MATHIS SYSTEM TECHNIK GMBH,
Besler Kopf 1, 7844 Neuenburg
Mixing-tower installations, residue-free discharging pug-mill mixers

MÖLLERS Maschinenfabrik GmbH,
Postfach 14 39, 4720 Beckum

C.G. MOZER KG Maschinenfabrik,
Postfach 9 43, 7320 Goppingen
Drying drums

MVT-Maschinen- und Verfahrenstechnik Bernhard Bietten GmbH, Postfach 16 65
6630 Dillingen

O&K Zementanlagen und Aufbereitungstechnik, Postfach 10 25
4722 Ennigerloh

Gebr. Pfeiffer AG, Postfach 30 80
6750 Kaiserslautern
Mills for raw materials and cement

CARL SCHENCK AG, Postfach 40 18
6100 Darmstadt

Schneckenbau Munster GmbH,
Hansaring 134, 4402 Greven

F.L. Smidth & Co GmbH Maschinenfabrik Zementindustrie-Einrichtungen, Postfach
16 32, 2400 Lubeck

WESTFALIA LÜNEN, Industriestr. 1
4670 Lunen
Scraper conveyors, drag-bar conveyors

435
Machinery and equipment for the lime industry

(Crushers and mills for the lime industry see 13A/1, 2, 40, 55, wind sifters see 13A/201 a.f.; furnaces see 3/156, 212, 248, 257)

BABBITLESS GmbH Deutschland Aufbereitungsanlagen, Postfach 12 21
7640 Kehl (Rhein)

FAUN Aktiengesellschaft Hauptverwaltung, Postfach 8
8560 Lauf a.d. Pegnitz
Off road haulers, wheeled loaders

Michael Glatt Maschinenbau GmbH,
Industriestr. 2, 8423 Abensberg (Ndb)
Lime slaking installations

HAZEMAG Dr. E. Andreas GmbH & Co.,
Postfach 34 47, 4400 Munster

Industrieanlagen Auerbach-Füre GmbH,
Postfach 14 60, 4750 Unna
complete plants and single machines

KHD Humboldt Wedag AG, Postfach
91 04 57, 5000 Koln 91 (Kalk)

Maschinenfabrik Köppern GmbH & Co KG, Postfach 80 08 53, 4320 Hattingen
Briquetting plants, briquetting presses for hard coal, chemicals, ores, salt and other minerals
(3) – see page Group 15

MATHIS SYSTEM-TECHNIK GMBH,
Besler Kopf 1, 7844 Neuenburg
Mixing-tower installations, residue-free discharging pug-mill mixers

C.G. MOZER KG Maschinenfabrik,
Postfach 9 43, 7320 Goppingen
Rotary dryers

MVT-Maschinen- und Verfahrenstechnik Bernhard Bietten GmbH, Postfach 16 65
6630 Dillingen

O&K Zementanlagen und Aufbereitungstechnik, Postfach 10 25,
4722 Ennigerloh

Gebr. Pfeiffer AG, Postfach 30 80
6750 Kaiserslautern

VIBRA-TECHNIK Maschinenfabrik Adolf Claus GmbH & Co. KG, Postfach 25 01 25
5600 Wuppertal 2 (Barmen)
Discharging attachments for vertical kilns

WESTFALIA LÜNEN, Industriestr. 1
4670 Lunen
Crushers, scraper conveyors

440
Machinery and equipment for the gypsum industry

(Mills for the gypsum industry see 13A/40, 41, 55, wind sifters see 13A/201 a.f.; furnaces see 3/156, 212, 257)

BABBITLESS GmbH Deutschland Aufbereitungsanlagen, Postfach 12 21
7640 Kehl (Rhein)

BABCOCK-BSH AKTIENGESELLSCHAFT vorm. Büttner-Schilde-Haas AG, Postfach
2 66, 6430 Bad Hersfeld

FAUN Aktiengesellschaft Hauptverwaltung, Postfach 8
8560 Lauf a.d. Pegnitz
Off road haulers, wheeled loaders

Dr. Gerlach GmbH & Co., Postfach
10 22 44, 7170 Schwabisch Hall
Planning and construction of plaster-board works

GRENZEBACH Maschinenbau GmbH,
Postfach 11 56, 8854 Asbach-Baumenheim, Hamlar
Conveying lines for gypsum-board and gypsum-fibreboard plants

HAZEMAG Dr. E. Andreas GmbH & Co.,
Postfach 34 47, 4400 Munster

Industrieanlagen Auerbach-Füre GmbH,
Postfach 14 60, 4750 Unna
Single machines and complete plants

KNAUF ENGINEERING GMBH, Postfach
10, 8715 Iphofen
Machines for gypsum industry. Planning and construction of complete plants for calcined plasters, plasterboard, partition wallblocks, ceiling tiles of natural gypsum or phospho-gypsum

Königshütte GmbH & Co., Postfach 1 70
3422 Bad Lauterberg (Harz)

Gebrüder Lödige Maschinenbaugesellschaft mbH, Postfach
20 50, 4790 Paderborn
Mixers

Maschinenfabrik Gustav Eirich, Postfach
11 60, 6969 Hardheim
Plants for the preparation of mixed materials
(3) – in front of Group 13

MATHIS SYSTEM-TECHNIK GMBH,
Besler Kopf 1, 7844 Neuenburg
Mixing-tower installations, residue-free discharging pug-mill mixers

C.G. MOZER KG Maschinenfabrik,
Postfach 9 43, 7320 Goppingen
Drying drums

MVT-Maschinen- und Verfahrenstechnik Bernhard Bietten GmbH, Postfach 16 65
6630 Dillingen

O&K Zementanlagen und Aufbereitungstechnik, Postfach 10 25
4722 Ennigerloh

Gebr. Pfeiffer AG, Postfach 30 80
6750 Kaiserslautern

Westfälische Maschinenbau-Gesellschaft mbH, Postfach 21 29, 4750 Unna

WESTFALIA LÜNEN, Industriestr. 1
4670 Lunen
Crushers, winning equipment, scraper conveyors

445
Machinery and equipment for the trass industry

O&K Zementanlagen und Aufbereitungstechnik, Postfach 10 25
4722 Ennigerloh

Gebr. Pfeiffer AG, Postfach 30 80
6750 Kaiserslautern

450
Machinery and equipment for the chalk industry

HAZEMAG Dr. E. Andreas GmbH & Co.,
Postfach 34 47, 4400 Munster

C.G. MOZER KG Maschinenfabrik,
Postfach 9 43, 7320 Goppingen
Drying plants

O&K Zementanlagen und Aufbereitungstechnik, Postfach 10 25
4722 Ennigerloh

VDMA

WHO MAKES MACHINERY
1985

Look for products in the blue part.
find manufacturers in the white part.
locate contact partner in the yellow part.

Suppliers of Machinery and Equipment for Cement Plants

- VOEST - Alpine AG
  Pf. 2, A-4010 Linz
  Austria

- The Associated Cement Co. Ltd.
  P.O. Shahabad ACC (S.E.Rly.)
  (West Bengal), India

- Vickers Ltd., Engineering Group
  Cement Machinery Division
  Vickers Armstrong
  Barrow Engineering Works
  Barrow in Furness, Lancs
  United Kingdom

- F.L. Smidth and Co. A/S
  77, Vigerslev Alle
  Capenhagen - Valby
  Denmark

- Klockner - Humboldt - Deutz AG
  Postfach 440
  5. Köln - Deutz 1
  Federal Republic of Germany

- Verein Oesterreichischer Zementfabrikanten
  1030 Wien, Reisner Strasse 33
  Austria

- GATX-Fuller S.A.
  Quai de la Papee. 75583
  Paris Cedex 12
  France

- BCND Unit Cement Plants
  Portland House
  Stag Place, London SW1E 5BJ
  United Kingdom

- Cementvarumaskiner AB
  S-610 53 Enstaberga
  Sweden

- Termit Maskin AB
  S-780 51 Dala-Järna
  Sweden

- PRAGOINVEST, Ceskomoravska 23
  108 56 Praha 9-Vysocancy
  Czechoslovakia

- LOESCHE KG
  Postfach 5226
  D-4 Düsseldorf
  Federal Republic of Germany

Bibliography

INDUSTRIAL DEVELOPMENT ABSTRACTS

**

RECORD NUMBER: 007408
DOCUMENT DATE: 1976
CALL NUMBER:
PERSONAL AUTHOR: JANSSENS PF
CORP. AUTHOR: UNIDO
TITLE: CENTRE NATIONAL D'ETUDES INDUSTRIELLES (PHASE II), TUNISIE. RAPPORT TECHNIQUE: CIMENTERIE ALGERO-TUNISIENNE.
SOURCE: VIENNA, 1976. 43 P. DIAGRAM.
DOC. NUMBER: UNIDO-DP/ID/SER.A/58
ABSTRACT: /UNIDO PUB/. /EXPERT REPORT/ ON A /CEMENT INDUSTRY/ PROJECT IN /TUNISIA/ - COVERS (1) STUDY, ACTIVITIES, FINDINGS RELATING TO A /MULTINATIONAL PROJECT/ UNDER THE AUSPICES OF AN /ALGERIA/N-TUNISIAN /CEMENT/ INSTITUTION (CIMAT) (2) ASSISTANCE GIVEN IN EVALUATION OF /MACHINERY/ AND /EQUIPMENT/ TENDERS BY VARIOUS FIRMS (3) /RAW MATERIAL/S, /MINING/, /CALCIUM CARBONATE/, /GYPSUM/, /WATER SUPPLY/, /FUEL SUPPLY/, /POWER SUPPLY/, ETC. (4) /ORGANIZATIONAL ASPECTS/ OF CIMAT. /RECOMMENDATIONS/, /DIAGRAM/.
LANGUAGES: FREN

INDUSTRIAL DEVELOPMENT ABSTRACTS

**

RECORD NUMBER: 007426
DOCUMENT DATE: 1977
CALL NUMBER:
PERSONAL AUTHOR: VISVESVARAYA HC
CORP. AUTHOR: UNIDO
EXPERT GROUP MEETING ON THE UTILIZATION OF NATIONAL TECHNOLOGICAL INSTITUTIONS IN THE DEVELOPING COUNTRIES FOR INDUSTRIAL DEVELOPMENT, PORT OF SPAIN, TRINIDAD, 1977
TITLE: IMPROVED PACKAGING FOR CEMENT AND MINI CEMENT.
SOURCE: VIENNA, 1977. 24 P. GRAPH, DIAGRAM.
DOC. NUMBER: UNIDO-ID/WG.246/1
ABSTRACT: /UNIDO PUB/ ON /TECHNOLOGY TRANSFER/ FUNCTIONS OF /TECHNOLOGICAL INSTITUTE/S AND /RESEARCH CENTRE/S IN /DEVELOPING COUNTRIES/, WITH SPECIAL REFERENCE TO IMPROVED /PACKAGING/ FOR CEMENT AND TO DEVELOPMENT OF MINI /CEMENT INDUSTRY/ - COVERS (1) THE FUNCTION OF INDUSTRIAL /RESEARCH AND DEVELOPMENT/ (2) THE CONCEPT OF TECHNOLOGY TRANSFER (3) /ORGANIZATIONAL ASPECTS/ OF THE /CEMENT/ RESEARCH INSTITUTE OF /INDIA/ (CRI) (4) /CASE STUDY/S OF TWO TYPICAL /INDUSTRIAL PROJECT/S.
LANGUAGES: ENGL

** The documents are no longer in print. Many of them are available on microfiche. These may be ordered from the UN Sales Section, Room A-3315, New York, N.Y. 10017 or Palais des Nations, Geneva, Switzerland, quoting record No., title and doc. No.

INDUSTRIAL DEVELOPMENT ABSTRACTS

**

RECORD NUMBER: 007504
DOCUMENT DATE: 1976
CALL NUMBER:
PERSONAL AUTHOR: DESCHAMPS JM
CORP. AUTHOR: UNIDO
TITLE: ASSAINISSEMENT ET REORGANISATION DE LA CIMENTERIE DE MALBAZA, NIGER. RAPPORT TECHNIQUE: RESULTATS DES SONDAGES.
SOURCE: VIENNA, 1976. 26 P. TABLES.
DOC. NUMBER: UNIDO-DP/ID/SER.A/77
ABSTRACT: /UNIDO PUB/. /EXPERT REPORT/ ON ASSISTANCE TO /CEMENT INDUSTRY/ IN /NIGER/, WITH SPECIAL REFERENCE TO EXPLORATION OF /LIMESTONE/ /MINERAL RESOURCES/ - (1) PRESENTS RESULTS OF TEST BORINGS FOR POSSIBLE /MINING/ TO OBTAIN /RAW MATERIAL/ FOR THE MALBAZA /CEMENT/ PLANT (2) COVERS (A) METHODS FOR CALCULATION OF EXTENT OF DEPOSITS; THE ESTIMATED RESERVES (B) /CHEMICAL ANALYSIS/ OF /CALCIUM CARBONATE/ (C) TECHNICAL ASPECTS OF EXPLOITATION AND /TRANSPORT/ OF MATERIALS FROM QUARRY. /RECOMMENDATIONS/, /STATISTICS/.
LANGUAGES: FREN

INDUSTRIAL DEVELOPMENT ABSTRACTS

**

RECORD NUMBER: 007724
DOCUMENT DATE: 1977
CALL NUMBER:
PERSONAL AUTHOR: LE BEL F
CORP. AUTHOR: UNIDO
TITLE: TURKEY. TECHNICAL REPORT: STUDY ON THE OPTIMIZATION OF CEMENT KILN AND MILL PRODUCTIVITY.
SOURCE: VIENNA, 1977. 33 P. DIAGRAMS.
DOC. NUMBER: UNIDO-DP/ID/SER.A/81
ABSTRACT: /UNIDO PUB/. /EXPERT REPORT/ ON ASSISTANCE TO /CEMENT INDUSTRY/ IN /TURKEY/ - COVERS (1) GEOLOGICAL STUDIES, /MINERAL RESOURCES/, /MINING/, TEST DRILLING (2) INDUSTRIAL PREPARATION OF /CLAY/ AND /SILICATE//RAW MATERIAL/S (3) /DATA RECORDING/ AND USE OF A /DATA BANK/ (4) ACTIVITIES RELATING TO /RESEARCH/ /LABORATORY/, /ROADS/ PROBLEMS, THERMAL BALANCE OF A /CEMENT/ /FURNACE/ (5) /TECHNICAL ASSISTANCE/. /DIAGRAM/S.
LANGUAGES: ENGL

INDUSTRIAL DEVELOPMENT ABSTRACTS

**

RECORD NUMBER: 008082
DOCUMENT DATE: 1978
CALL NUMBER:
PERSONAL AUTHOR: BOECK HC
CORP. AUTHOR: UNIDO
TITLE: EVALUATION D'UNE PROPOSITION POUR LE PROJET DE CIMENTERIE D'ONIGBOLO, BENIN. RAPPORT TECHNIQUE: EVALUATION TECHNIQUE.
PROJ. NUMBER: SI/BEN/77/802
SOURCE: VIENNA, 1978. 30 P.
DOC. NUMBER: UNIDO-DP/ID/SER.A/113
ABSTRACT: /UNIDO PUB/. /EXPERT REPORT/ REGARDING DEVELOPMENT OF /CEMENT INDUSTRY/ IN /BENIN/ - PRESENTS A /PROJECT EVALUATION/ OF A COMMERCIAL PROPOSAL FOR A NEW CEMENT PLANT, COVERING: /MINING/ OF /LIMESTONE/ /RAW MATERIAL/S; TECHNICAL ASPECTS OF PROCESSING; /MACHINERY/ AND /EQUIPMENT/; /TRANSPORT/, /STORAGE/, /MAINTENANCE AND REPAIR/, /FACTORY ORGANIZATION/, ETC. /RECOMMENDATIONS/.
LANGUAGES: FREN

INDUSTRIAL DEVELOPMENT ABSTRACTS

**

RECORD NUMBER: 008317
DOCUMENT DATE: 1978
CALL NUMBER:
CORP. AUTHOR: UNIDO
INTERNATIONAL FORUM ON APPROPRIATE INDUSTRIAL TECHNOLOGY, NEW DELHI AND ANAND, INDIA, 1978
TITLE: CASE STUDIES. (CEMENT INDUSTRY).
SOURCE: (IN 'STRATEGIES FOR DEVELOPMENT OF CEMENT AND ALLIED INDUSTRIES IN DEVELOPING COUNTRIES'. VIENNA, 1978. PP. 54-84). TABLES.
DOC. NUMBER: UN..JO-ID/WG.282/2
ABSTRACT: /UNIDO PUB/ ON /APPROPRIATE TECHNOLOGY/ FOR /CEMENT INDUSTRY/. PRESENTS /CASE STUDY/S REGARDING CEMENT PRODUCTION AND /PACKAGING/, AND /CONCRETE/ (BASED ON EXPERIENCE IN /INDIA/) - COVERS (1) MINI/CEMENT/ /FACTORY/S, INDIGENOUS PRECALCINATORS, RAPID /QUALITY CONTROL/ SYSTEMS (2) IMPROVED PACKING OF CEMENT (3) READY-MIX CONCRETE; DESIGN OF CONCRETE POLES FOR /RURAL AREA//ELECTRIC POWER DISTRIBUTION/ (4) DESIGN OF /BUILDING MATERIALS/ FOR LOW /COSTS/ /HOUSING/. REFERENCE: /CHOICE OF TECHNOLOGY/, /MACHINERY/, /EQUIPMENT/.
LANGUAGES: ENGL

INDUSTRIAL DEVELOPMENT ABSTRACTS

**

RECORD NUMBER: 008678
DOCUMENT DATE: 1978
CALL NUMBER:
PERSONAL AUTHOR: BRUCE R
GARG MK
CORP. AUTHOR: UNIDO
INTERNATIONAL FORUM ON APPROPRIATE INDUSTRIAL TECHNOLOGY, NEW DELHI AND ANAND, INDIA, 1978
TITLE: PROJECT PROPOSAL AND FEASIBILITY DATA FOR A 25 TON/DAY MINI-CEMENT PLANT. BACKGROUND PAPER.
SOURCE: VIENNA, 1978. 27 P. TABLES.
DOC. NUMBER: UNIDO-ID/232/12
UNIDO-ID/WG.282/33
ABSTRACT: /UNIDO PUB/ ON /APPROPRIATE TECHNOLOGY/ FOR SMALL-SCALE /CEMENT INDUSTRY/ - COVERS: /BUILDING MATERIALS/ IN USE FOR CEMENTING PURPOSES; /RAW MATERIAL/S REQUIRED; TECHNOLOGY OF /PORTLAND CEMENT/, DEVELOPMENT WORK AND EXPERIENCE IN /INDIA/; TECHNICAL ASPECTS OF THE MOHANLALGANJ /CEMENT/ PLANT; /CAPITAL COSTS/, /PRODUCTION COSTS/. ADDITIONAL REFERENCES: /CHOICE OF TECHNOLOGY/, VERTICAL SHAFT /KILN/S. /STATISTICS/.
LANGUAGES: ENGL

INDUSTRIAL DEVELOPMENT ABSTRACTS

**

RECORD NUMBER: 008906
DOCUMENT DATE: 1979
CALL NUMBER:
PERSONAL AUTHOR: BOECK HC
CORP. AUTHOR: UNIDO
TITLE: ASSISTANCE TO THE CEMENT INDUSTRY. ETHIOPIA. TECHNICAL REPORT: TENDER EVALUATION FOR NEW MUGHER CEMENT PLANT.
PROJ. NUMBER: SI/ETH/78/802
SOURCE: VIENNA, 1979. 26 P. DIAGRAM.
DOC. NUMBER: UNIDO-DP/ID/SER.A/180
ABSTRACT: /UNIDO PUB/. /EXPERT REPORT/ ON ASSISTANCE TO /CEMENT INDUSTRY/ IN /ETHIOPIA/ - COVERS TENDER /EVALUATION/ FOR A /CEMENT/ PLANT, WITH ATTENTION TO: ALTERNATIVES; /RAW MATERIAL/S OF /LIMESTONE/, /CLAY/, /SAND/, /GYPSUM/ AND PUMICE; /SITE ASSESSMENT/ AND /FACTORY LAYOUT/; TECHNICAL ASPECTS, /MINING/, /EQUIPMENT/, /TRANSPORT/, /STORAGE/, POWER AND WATER SUPPLY; /ECONOMIC ASPECTS/, /COSTS/, /INFRASTRUCTURE/. /MAPS/, /JOB DESCRIPTION/.
LANGUAGES: ENGL

INDUSTRIAL DEVELOPMENT ABSTRACTS

**

RECORD NUMBER: 009918
DOCUMENT DATE: 1980
CALL NUMBER:
PERSONAL AUTHOR: QIN ZHIGANG
JIANG ZHIGAN
CORP. AUTHOR: UNIDO
CONFERENCE: INTERREGIONAL SEMINAR ON CEMENT TECHNOLOGY, BEIJING, CHINA, 1980
TITLE: METHODS OF EVALUATION AND PROSPECTS OF UTILIZATION OF WASTE AND BONE COAL AS FUEL AND RAW MATERIALS IN THE CEMENT INDUSTRY.
SOURCE: VIENNA, 1980. 17 P. TABLES.
DOC. NUMBER: UNIDO-ID/WG.326/1
ABSTRACT: /UNIDO PUB/ ON USE OF WASTE AND BONE /COAL/ IN THE /CEMENT INDUSTRY/ (BASED ON EXPERIENCE IN /CHINA/) - COVERS (1) /MINING/ /WASTE UTILIZATION/ AND BONE COAL AS /RAW MATERIAL/ FOP /CEMENT/; USE OF SPOIL (/CARBON/ACEOUL ROCK); /CHEMICAL ANALYSIS/ OF SOME SPOILS, BONE COALS AND /CLAY/ (2) PRODUCTION OF ORDINARY /PORTLAND CEMENT/ (3) SPOIL AND BONE COAL AS /FUEL/ (4) /DEVELOPMENT POTENTIAL/ AND PROSPECTS. ADDITIONAL REFERENCE: /POLLUTION CONTROL/. /STATISTICS/.
LANGUAGES: ENGL

INDUSTRIAL DEVELOPMENT ABSTRACTS

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RECORD NUMBER: 009926
DOCUMENT DATE: 1980
CALL NUMBER:
CORP. AUTHOR: UNIDO
SICHUAN INSTITUTE OF CEMENT INDUSTRY, CHINA
CONFERENCE: INTERREGIONAL SEMINAR ON CEMENT TECHNOLOGY, BEIJING, CHINA, 1980
TITLE: TECHNIQUE AND ECONOMY FOR THE USE OF LIGNITE IN CEMENT ROTARY KILNS.
SOURCE: VIENNA, 1980. 26 P. TABLES, GRAPHS.
DOC. NUMBER: UNIDO-ID/WG.326/8
ABSTRACT: /UNIDO PUB/ ON /CEMENT INDUSTRY/ IN /CHINA/ WITH SPECIAL REFERENCE TO USE OF /LIGNITE/ IN ROTARY /KILN/S - COVERS (1) PROPERTIES AND /CHEMICAL ANALYSIS/ OF LIGNITE USED AT THE KAI YUAN CEMENT PLANT AS /FUEL/ FOR CLINKER BURNING; /MINING/ AND MINERALOGICAL ASPECTS (2) TECHNICAL ASPECTS OF BURNING /CEMENT/ CLINKER (3) THERMAL CONDITIONS (4) COMPARISON WITH USE OF BITUMINOUS /COAL/; /ECONOMIC ASPECTS/. ADDITIONAL REFERENCES: /HEATING/, /TEMPERATURE/, HEAT BALANCE. /STATISTICS/.
LANGUAGES: ENGL

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LANGUAGES: ENGL

INDUSTRIAL DEVELOPMENT ABSTRACTS

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RECORD NUMBER: 011104
DOCUMENT DATE: 1981
CALL NUMBER:
PERSONAL AUTHOR: BOECK HC
CORP. AUTHOR: UNIDO
TITLE: CAP-VERT. RAPPORT TECHNIQUE: MINICEMENTERIE D'UNE CAPACITE DE 600.000 TONNES PAR AN ET CONTRE-PROPOSITION.
PROJ. NUMBER: RP/CVI/80/001
SOURCE: Vienna, 1981. 26 p. tables, diagram.
DOC. NUMBER: UNIDO-DP/ID/SER.A/302
ABSTRACT: <UNIDO pub>. <Expert report> on assistance in planning for establishment of a small <cement industry> in <Cape Verde> - covers (1) technology of the cement industry; <capital costs>, <financial aspects>, commercial aspects (2) available <raw material>s; <pozzolana>, <gypsum>, <stone>; production and <domestic consumption>, possibility of <export>. <Recommendations>, tables, <diagram>.
LANGUAGES: FREN
COUNTRY CODE: 682
CLASSIFICATION: 33.20

INDUSTRIAL DEVELOPMENT ABSTRACTS

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RECORD NUMBER: 012242
DOCUMENT DATE: 1982
CALL NUMBER:
CORP. AUTHOR: UNIDO
CONFERENCE: INTERREGIONAL CEMENT TECHNOLOGY FORUM, BENGHAZI, LIBYA, 1982
TITLE: REPORT. (FORUM ON CEMENT TECHNOLOGY).
SOURCE: Vienna, 1983. 44 p.
DOC. NUMBER: UNIDO-UNIDO/IO.535
ABSTRACT: <UNIDO pub>. <Report> of a <meeting> on <choice of technology> for <cement industry> in <developing countries> - (1) covers organization of the forum; comments and observations (2) gives summaries of papers presented and discussions, with reference i.a. to <mining>, <factory establishment>, <grinding>, <limestone>, <kiln>s, <training centre>s, <pollution control>, <refractory materials>, <maintenance and repair>. <List of participants>, <list of documents>. Additional references: <alumina>, <packaging>, <silos>, <electronic data processing>.
LANGUAGES: ENGL
CLASSIFICATION: 33.20

INDUSTRIAL DEVELOPMENT ABSTRACTS

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RECORD NUMBER:	014815
DOCUMENT DATE:	1985
CALL NUMBER:	
CORP. AUTHOR:	UNIDO
CONFERENCE:	MINI CEMENT WORKSHOP FOR THE ASIA AND PACIFIC REGION, BEIJING AND TIANJIN, CHINA, 1984.
TITLE:	TECHNICAL REPORT: PROCEEDINGS OF THE MINI CEMENT WORKSHOP FOR THE ASIA AND PACIFIC REGION.
PROJ. NUMBER:	DP/RAS/83/014
SOURCE:	Vienna, 1985. 23 p.
DOC. NUMBER:	UNIDO-DP/ID/SER.A/617
ABSTRACT:	<UNIDO pub>. <Report> of a <meeting> on <development potential> of <cement industry> as a <small scale industry> in the <ESCAP> region - (1) covers background and organization of the workshop (2) gives summaries of fourteen country papers. <Recommendations>, <list of participants>, <list of documents>. Additional references: <choice of technology>, <training>, <regional cooperation>, <China>.
LANGUAGES:	ENGL
COUNTRY CODE:	920
CLASSIFICATION:	33.20