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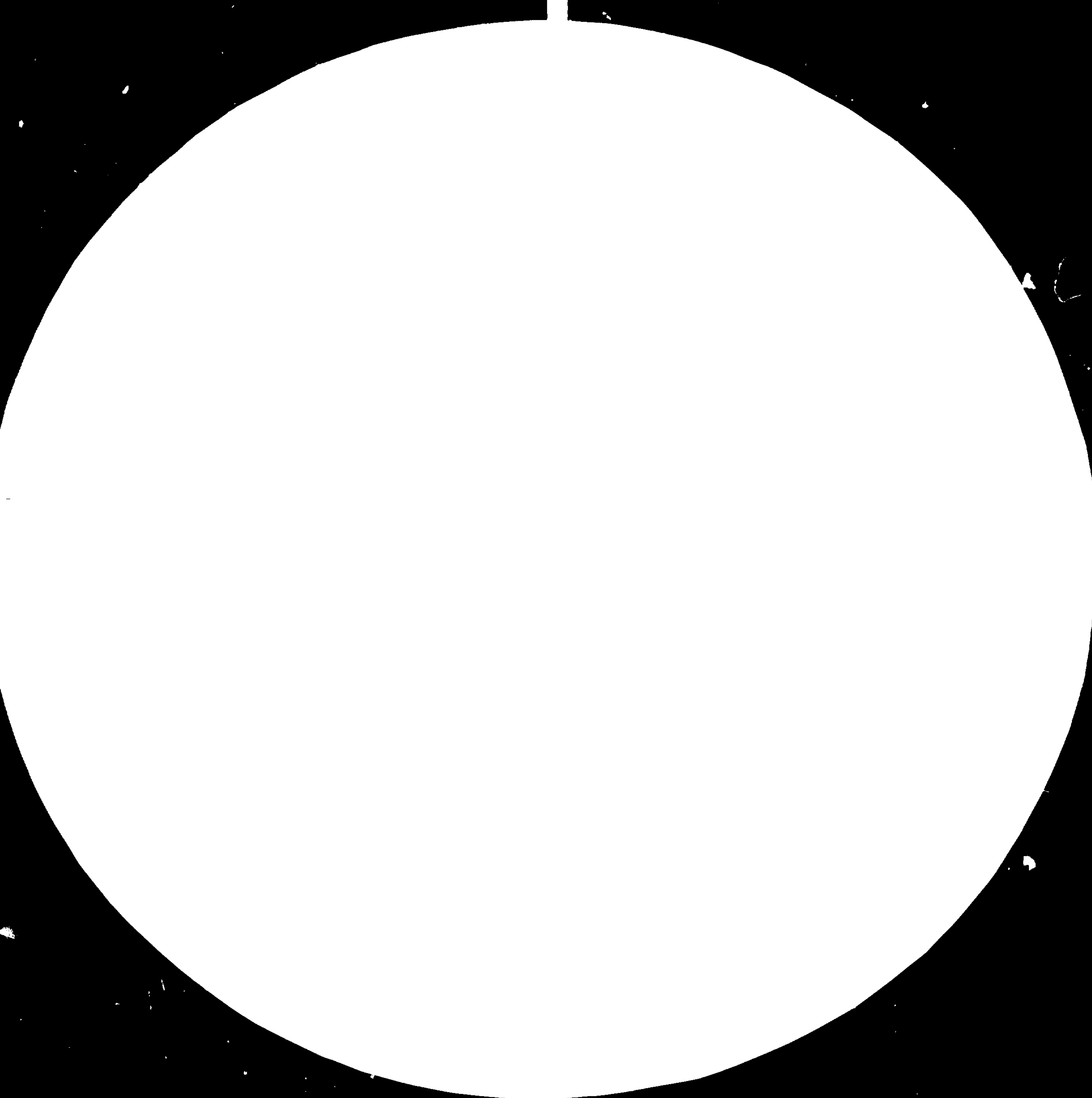

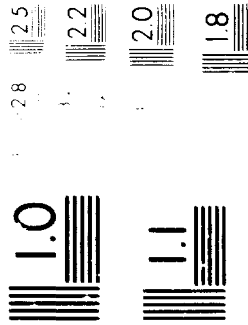


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9 March 1981
English

STRENGTHENING OF ENGINEERING DESIGN AND DEVELOPMENT OF CEMENT INDUSTRY

SI/IND/78/801

INDIA

Terminal report

Prepared for the Government of India by the
United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Mehmet A. Basman, cement consultant

United Nations Industrial Development Organization
Vienna

V.81-22646

Explanatory notes

References to tonnes (t) are to metric tons.

The following abbreviations have been used in this document:

ACC	Associated Cement Companies
CRI	Cement Research Institute
R and D	research and development
VSK	vertical-shaft kiln

ABSTRACT

The project "Strengthening of engineering design and development of cement industry" (SI/IND/78/801) is a reinstatement of an earlier approved SIS project (SI/IND/74/887) which was cancelled. The immediate objective of the present project, which was approved by the United Nations Industrial Development Organization (UNIDO) in November 1978, is to strengthen the technical capacity of the Cement Research Institute (CRI) of India in the evaluation of design ideas as well as in the actual design and dimensioning of new machines and equipment and in establishing a plan for the distribution of machines and equipment in accordance with production targets and required capacity. Finally, advice and assistance in the standardization of cement plants and machinery was to be given.

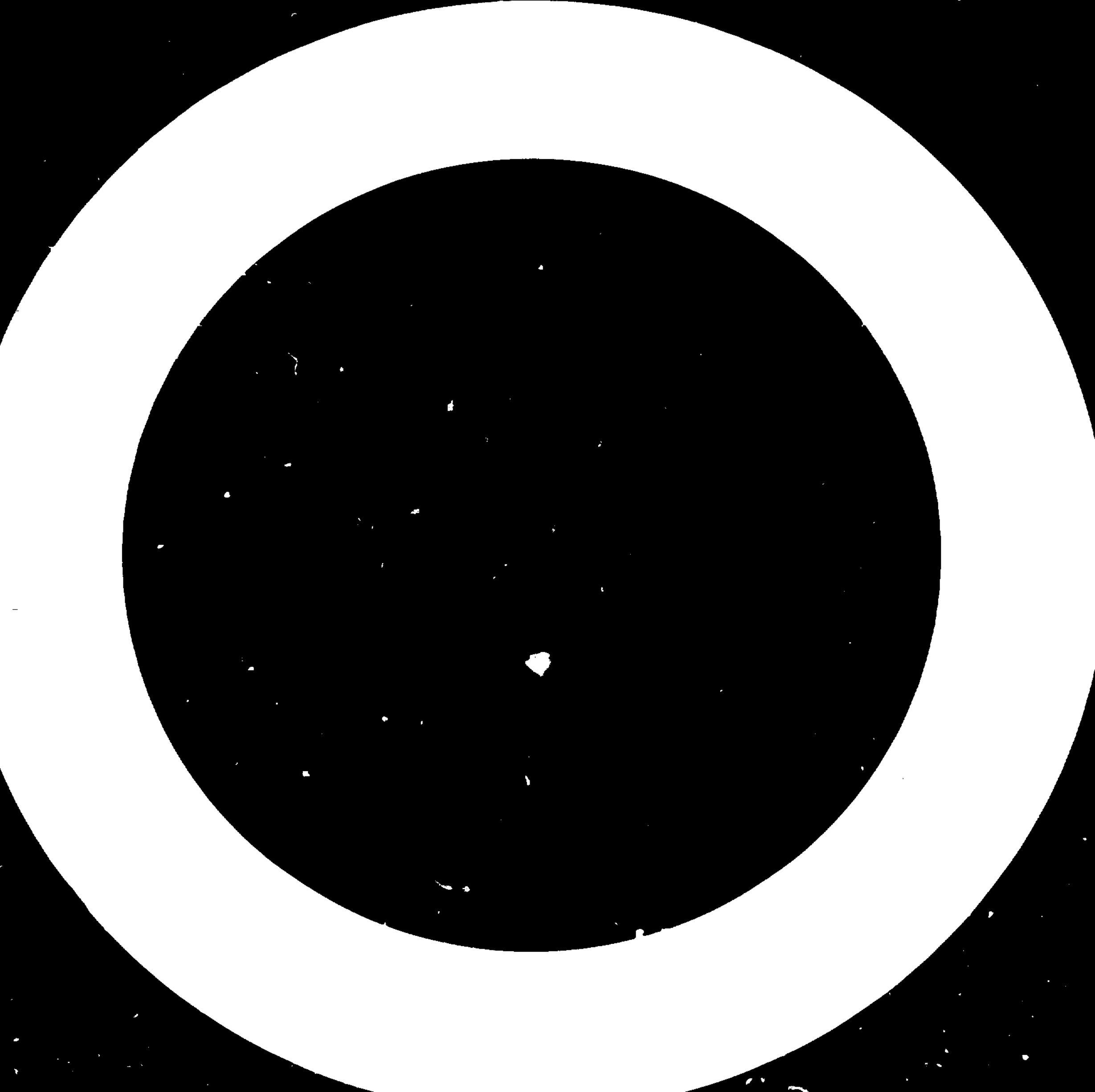
On 14 January 1981 UNIDO fielded a cement consultant to carry out the above-mentioned tasks. This mission of six weeks ended on 19 February 1981. The expert participated in CRI's research and development activities dealing with cement production units. In Tiruchirapalli, he visited CRI's vertical shaft kiln (VSK) pilot plant as well as the Dalmiapuram Cement Plant where shaft kilns are being erected. Followed visits to the Ammasandra cement plant in Bangalore, which has equipped one of its dry-process kilns with a CRI designed precalciner, and the Associated Cement Companies' central research station and headquarters in Bombay.

The conclusions regarding CRI's research and development activities dealing with cement production units and CRI's role in the development of the Indian cement industry are as follows:

(a) CRI has fulfilled its tasks in the development and implementation of small size vertical-shaft kilns and dry-process kiln precalciners;

(b) CRI's new research and development projects deal with rotary pilot plants, mini rotary dry-process kilns, refractory materials and filtering fabrics, and are all of national interest as well as being beneficial to the development of the Indian cement industry.

(c) CRI's productivity enhancement programme is being satisfactorily implemented.



CONTENTS

Annexes

INTRODUCTION

The project "Strengthening of engineering design and development of cement industry" (SI/IND/78/801) is a reinstatement of an earlier approved SIS project (SI/IND/74/887) which was cancelled. The immediate objective of the present project, which was approved by the United Nations Industrial Development Organization (UNIDO) in November 1978, is to strengthen the technical capacity of the Cement Research Institute (CRI) of India in the evaluation of design ideas as well as in the actual design and dimensioning of new machines and equipment and in establishing a plan for the distribution of machines and equipment in accordance with production targets and required capacity. Finally, advice and assistance in the standardization of cement plants and machinery was to be given.

On 14 January 1981, UNIDO fielded a cement consultant to carry out the above-mentioned tasks. This job description is given in annex I. The mission of six weeks was projected for October-November 1980, but was shifted to January-February 1981 in order to enable the expert to participate in the All India Cement Seminar organized by CRI and held 19-21 January 1981 at New Delhi.

The expert's work programme was prepared by CRI, in accordance with the mission targets, and comprised:

A visit to the CRI Ballabgarh Laboratories

Participation in the All India Cement Seminar

Participation in CRI research and development activity

A visit to the CRI vertical-shaft kiln pilot plant and the Dalmia Cement Dalmiapuram plant at Trichy

A visit to the Mysore Cements Ammasandra plant at Bangalore

A visit to the Associated Cement Companies Central Research Station Laboratories and headquarters at Bombay

RECOMMENDATIONS

1. To be better informed regarding developments in the world cement industry, CRI should organize periodic visits to Indian cement plants and cement manufacturing equipment suppliers and should arrange personnel exchange programmes with research and development centres and plants of other countries.

2. In connection with the afore-mentioned personnel exchange programmes, CRI should seek external technical assistance.

3. Regarding the mini cement plant project being encouraged by the Government of India, CRI should augment the capacities of its vertical-shaft kiln, either independently, or, preferably, in collaboration with an outside agency having experience with larger capacity shaft kilns.

4. CRI should adapt the already developed mini rotary kiln technology to Indian standards and conditions, in collaboration with the outside agency and should assist Indian entrepreneurs in the appraisal of their mini dry-process rotary kiln project.

5. CRI should emphasize its Productivity Enhancement Programme.

I. EXPERT'S ACTIVITIES

A. Visit to the CRI Ballabgarh Laboratories

An office in the Ballabgarh Laboratories was provided for the expert by CRI, and a visit of the Laboratories was organized by the Institute in order to acquaint the expert with CRI activities and facilities.

The Laboratories are about 30 km from New Delhi. It is a multi-disciplinary centre where CRI research and development (R and D) programmes are carried out. They cover the entire spectrum of activities from the exploration of raw material to the final utilization of cements. Equipment ranges from the simplest to the most sophisticated modern chemical and physical laboratory apparatus, as well as small-scale production machines for carrying out semi-industrial scale tests, including one rotary kiln of 2.5 t/d production capacity.

B. Participation in the All India Cement Seminar

From 19 to 21 January 1981 the expert participated in the All India Cement Seminar, organized by CRI every five years. The main topics of the Seminar concerned:

(a) New large-scale cement plants;

(b) Raw-material exploration and evaluation; plant dimensions, layout and system designing; and plant machinery and equipment selection;

(c) The manufacture of blended cements utilizing additive raw materials including industrial wastes, and new manufacturing processes and technology;

(d) Packing and utilization comprising packing and transportation and rational utilization in construction.

By request of CRI, the expert gave a lecture on the conversions of wet process kilns to dry process. The lecture was followed by review and discussions of the results obtained from conversions carried out in Turkey. A summary of this lecture is given in annex III.

C. Participation in CRI R and D activities

The expert participated in the CRI R and D activities connected with his mission. These are given, together with their objectives and the expert's findings and conclusions in annex IV.

D. Visit to the CRI vertical-shaft kiln pilot plant

On 3 February 1981, the expert visited the CRI vertical-shaft kiln at Trichy, 40 km from the city of Tiruchirapalli. This plant has a production capacity of 20 t/d of clinker; its technical characteristics are given in annex 7. It was previously owned by the State of Tamil Nadu for use in conducting industrial-scale tests of mini cement plants, but because of deficiencies and operational difficulties, it was transferred to CRI in 1974 with the task of developing a vertical-shaft kiln (VSK) technology technically and economically suitable for the country's remote and less developed regions.

CRI has achieved a VSK technology in which:

(a) Investment cost per tonne of clinker per annum is relatively low when compared with rotary kiln costs;

(b) Operation and maintenance are very simple;

(c) Skilled and unskilled manpower requirements are limited;

(d) Plants are not sensitive to electrical power shut-downs and raw material shortages. They can stand stoppages of up to two days without product deterioration and without requiring refiring.

E. Visit to the Dalmia Cement Dalmiapuram Plant

The expert also visited the Dalmia Cement Dalmiapuram plant, located 5 km from the CRI pilot plant, on the 3 February 1981.

The Dalmia cement plant comprises one semi-dry process kiln of 250 t/d production capacity, comissioned in 1939, and two wet-process kilns of 500 t/d production capacity each, comissioned in 1954 and 1959.

The plant's layout and equipment are balanced. The plant operation is smooth and a regular over-production of 20% is obtained from the plant's kilns. No particular bottle-neck exists in the plant process flow.

From time to time, this plant, like other Indian plants, faces shortages of coal and shut-downs of electrical power, but the plant disposes of a stand-by powerhouse which keeps at least the kilns running during power shut-downs.

The plant produced 515,000 t of cement in 1979, which corresponds to a plant capacity utilization of 110%.

The company plans to add three vertical shaft kilns of 200 t/d production capacity each to its plant. The first kiln is under construction and the two others will be put in operation the following years.

The choice of three small-capacity vertical shaft kilns, which have relatively high fuel consumption compared to dry-process kilns, for the extension project may at first seem unusual. However, it was consciously made in order to provide experience in the preparation and operation of mini cement plants.

The company collaborates with an Australian consultant to promote vertical-shaft kilns in India, in keeping with Indian Government policy which encourages and provides incentives to mini cement plants up to 200 t/d production capacity.

To protect the environment, the company is equipping its two wet-process kilns with electroprecipitators. However, it does not anticipate converting its high fuel consumption wet-process kilns to dry-process kilns.

A company study showed that the conversion of the plant's existing old wet-process kilns was not economical, because of profit losses during conversion and the high cost of reconditioning the old kilns.

The company plans adding two new dry-process kilns while decommissioning the wet-process kilns and connecting the new electroprecipators to the new units.

F. Visit to the Mysore Cements Ammasandra Plant

On 4 and 5 February 1981, the expert visited the Mysore Cements Ammasandra plant, about 200 km from Bangalore. The plant consisted of:

(a) One dry-process short kiln equipped with a four-stage cyclone pre-heater designed and manufactured by a firm in the Federal Republic of Germany and commissioned in 1962. Its design production capacity is 300 t clinker per day;

(b) One dry-process kiln, similar to the first, manufactured by an Indian company and commissioned in 1966;

(c) One dry-process short kiln equipped with a four-stage cyclone pre-heater designed and manufactured by the supplier of the first kiln. Its designed production capacity is 600 t of clinker per day;

(d) One dry-process kiln similar to the first with slight modifications of the kiln shell diameters, manufactured by the company itself and commissioned in 1978. Its production capacity is 300 t of clinker per day.

The plant quarries are about 18 km from the plant. The quarry limestone is hard and heteregeneous. It is brought to the plant by cable car.

The plant's layout is very compact. Practically no bottle-neck exists in material flow. However, because of selective quarrying, the plant sometimes faces raw material shortages. The plant prevents these shortages by maintaining buffer stocks in its quarries and in the plant itself. The plant also produces cement additives from iron slags.

The plant produced 394,000 t of cement in 1979, including cement with additives, a plant efficiency of 77%.

The main factors deteriorating plant efficiency are:

(a) Coal shortages and electrical shut-downs, something common to all of the Indian cement industry;

(b) High ash content of the coal, which reduces production in the kilns, which were designed for oil burning (this explains the modification of the plant's fourth kiln);

(c) Cooling water shortages: since the region is poor in water resources, this prevents continuous electroprecipitator operations. They function without high tension as dust collection chambers so the plant's dust emmissions are very high.

These factos deteriorate the plant's production efficiency and also increase the plant's specific fuel consumption and the raw material-clinker ratio, which reach, respectively, 1,000 kcal (4 MJ)per kilogramme of clinker and 1.62.

The company works in close collaboration with CRI. The first CRI-designed pre-calciner was installed in the second dry-process kiln of the plant. The results obtained from it are very satisfactory. Kiln production has been increased by 30 per cent. Further increases are expected after the full implementation of CRI recommendations. With the collaboration of a supplier from the Federal Republic of Germany, the company is also implementing a new cement plant project of 500,000 t/a capacity in Dameh, Madhya Pradesh.

G. Visit to the Associated Cement Companies

The expert visited the Associated Cement Companies Central Research Station, in Thana, a suburb of Bombay, and its headquarters, in Bombay itself, on 5 February 1981.

The Associated Cement Companies (ACC) owns 17 cement plants spread all over India with a total production capacity of 7,024,000 t/a. Its 1979 production was 5,856,000 t, which corresponds approximatly to one third of the total cement production of India. Its plants' average production efficiency in 1978 was 93%.

Besides manufacturing cement, ACC also manufactures refractories, fertilizers, catalysts, heavy equipment etc. and acts as an industrial and management consultant. It also manufactures cement producing machines and equipment, electroprecipitators and refractory bricks. ACC collaborates with Mitsubishi in promoting a fluidized calciner for the Indian cement industry. ACC carries out all its R and D activities in the Central Research Station, which is adequately equipped and staffed.

During a visit to ACC headquarters, a special technical discussion was held with ACC production, maintenance and project engineers in which problems and trends in the cement industry were discussed and views exchanged. During the meeting the company's approach to the mini rotary dry-process cement plant was discussed. ACC is developing a project for a semi-dry, relatively long rotary kiln as a technically suitable and economically feasible small size rotary kiln for India.

II. FINDINGS AND CONCLUSIONS

A. General

The Indian cement industry is widespread and varied. It is staffed with skilled and experienced engineers and disposes of adequately equipped research and development centres with competent scientists, experienced consultants, and construction workshops tooled to manufacture most cement producing machines and equipment.

The variety and the dispersion of the groups involved in cement production in India leads to an isolation precluding co-ordination. There are often examples of repetition in research activity. There is a tendency to disregard other countries' experiences in the matter, due, perhaps, to regional alliances with other cement-producing units or suppliers of equipment or raw material. Thus the task of CRI in developing the cement industry of India is a difficult one.

In order to avoid such inefficiency and follow up the technological development in the cement industry, the contact of CRI with the Indian cement plants and cement producing machines and equipment manufacturers should be extended. Periodic plant and workshop visits for CRI scientists and engineers should be organized. The information received would aid in selecting R and D, training and standardization programmes.

B. CRI projects

This section adds detail and emphasis to the findings and recommendations of the expert on CRI projects summarized in annex IV.

Mini Cement Plant

In order to promote the country's remote and less developed areas, the Indian Government is encouraging, through substantial incentives, the establishment of small-scale or mini cement plants having a daily production capacity of up to 200 t of clinker.

The creation of mini cement plants depends on their techno-economic feasibility. The determinant criteria are the simplicity of the process, raw material supply, reliability, fuel consumption and efficiency. Currently, the vertical-shaft kilns and the rotary dry process are the favoured alternatives.

Vertical-shaft kilns

CRI has developed its own vertical-shaft kiln technology which has proven performance of 20 t clinker production per day, and augmentation to 50 t/d seems to be realized without any major difficulties. Ten CRI vertical-shaft projects are being implemented. Further augmentation may be possible after receiving the results from the augmented kilns which are under construction.

Rotary kilns

Although short dry-process rotary kilns equipped with four-stage cyclone pre-heaters are the most efficient kilns in terms of specific fuel consumption, they are sensitive to raw material composition fluctuation, require sophisticated devices and instrumentation, and their unit investment costs are high. The down-scaling of such kilns to 200 t/d while at the same time retaining the equipment necessary for the maintenance of smooth operations together with low specific fuel consumption, makes the process economically unfeasible. Therefore, many firms dealing with small dry rotary kilns, instead of down-scaling four-stage pre-heater kilns, have developed longer dry-process or semidry-process kilns having higher specific fueld consumptions.

CRI involvement in mini rotary kiln cement plant projects could be as follows:

(a) To develop a new mini rotary kiln technology. This would require considerable time and the results obtained might be very similar to those found in existing small rotary kilns;

(b) To collaborate with an agency that has already developed such a kiln and adapting it to the Indian cement industry's standards and conditions. The benefits of the project would be obtained in a relatively short time;

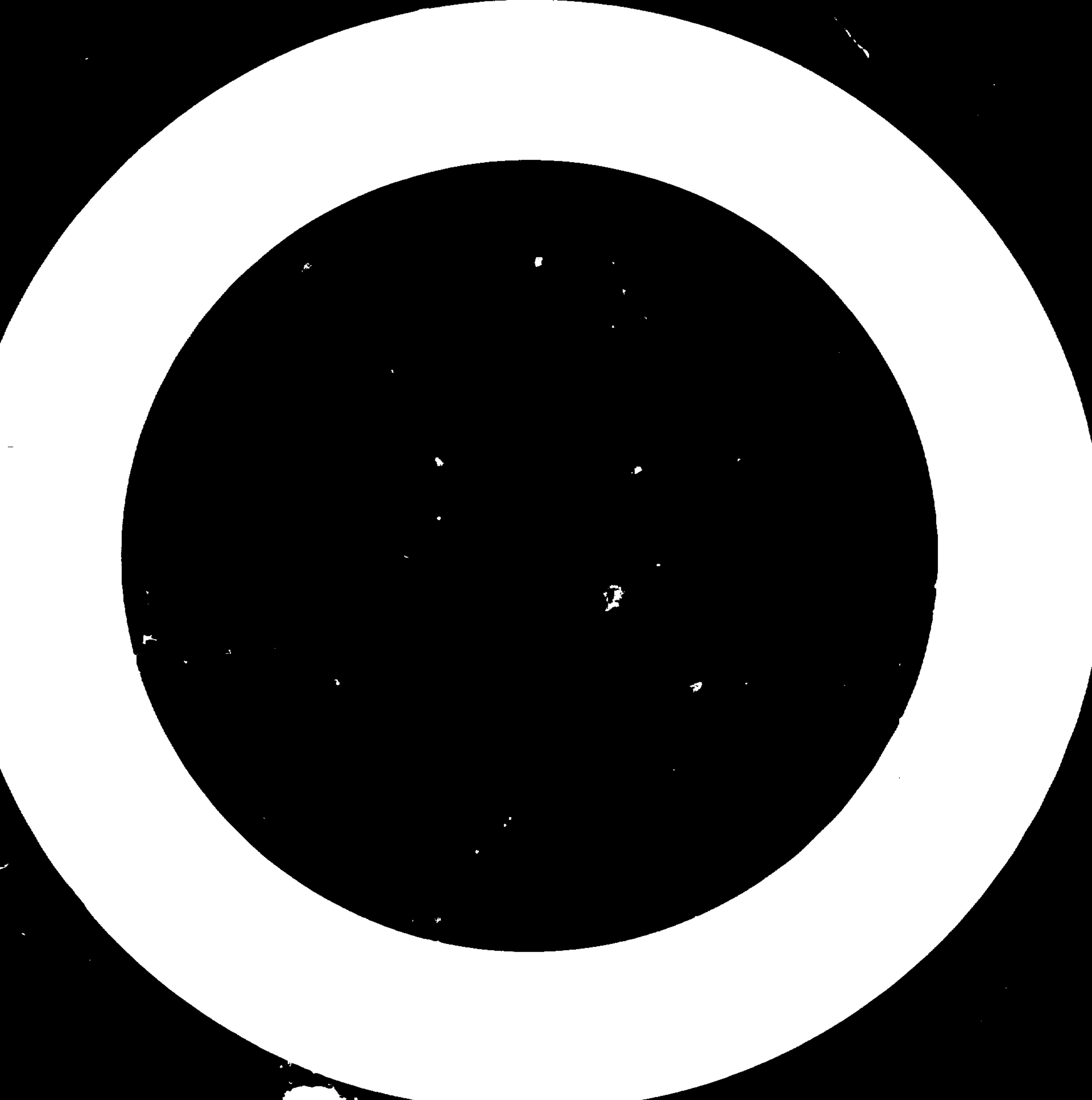
(c) To assist entrepreneurs in planning for mini cement plants equipped with rotary kilns in order to avoid unfortunate results.

At any rate, CRI should maintain contact with existing cement plants producing the country's smallest dry-process short rotary kilns in order to obtain data on the operation and design of rotary kilns equipped with four-stage cyclone pre-heaters.

The CRI Productivity Enhancement Programme

The CRI Productivity Enhancement Programme is one of the most important activities for the improvement of the cement industry of India.

It is well known that savings and production increases can be obtained through this Programme without substantial investment. Because of their isolationist tendencies, the plants, however, are reluctant to undertake such programmes. The success of such a programme depends mainly on mutual respect and confidence in the experiences of the parties involved. For building up such a collaboration ambiance, periodic plant visits become a prerequisite for the successful implementation of the Productivity Enhancement Programme.



Annex I

JOB DESCRIPTION

POST TITLE	Design Consultant for Equipment to the Cement Industry
DURATION	Two and a half months
DATE REQUIRED	As soon as possible
DUTY STATION	New Delhi with travel within the country
DUTIES	The expert will be attached to the Government of India and the Cement Research Institute to assist in introducing new ideas for the development of production units. Specifically, the expert is expected to: 1. Assist the Cement Res. [illegible] h Institute in evaluating design ideas and to participate in the design and dimensioning of new machines and equipment for the cement industry. 2. Assist in the planning and distribution of machine production in accordance with projected targets and capacities. 3. Advise on standardization of cement plants and machinery. The expert will also be expected to prepare a final report setting out the findings of his mission and his recommendations to the Government on further actions which might be taken.
QUALIFICATIONS	Mechanical engineer with experience in design and production of cement plants and equipment.
LANGUAGE	English

Annex II

OFFICIALS MET DURING THE MISSION

Cement Research Institute of India

S.I. Chopra, Acting Director General

R. Rama Shandran Group Manager (MCP/RIC)

J.P. Sakena, Group Manager (LEB/MAT)

M.V. Ranga Rao, Group Manager

D.V. Ramana Rao, Scientist

V.K. Jain, Scientist

V.K. Sitvastava, Scientist

V.K. Arora, Scientist

D.B.N. Rao, Scientist

J.P. Mittal, Scientist

S.K. Gueta, Scientist

R. Ganapathy, Scientist

T.K. Chatterjee, Scientist

S.C. Rastogi, Scientist

D.K. Singh, Scientist

S. Gopinath, Scientist

Kamal Kumar, Scientist

C.D. Elkunchwar, Scientist

Ashwani Pahuja, Scientist

Naresh Kumar, Scientist

CRI Pilot Plant, Trichy

L.K. Jankiraman, Unit Manager

I. Alexander, Laboratory Chief

V. Balasubramanian, Process and Quality Control Manager

Dalmia (Bharat) Cement Ltd., Trichy

C.S. Thirumalai, Financial Manager

R. Kandaswami, Chief Engineer

Mysore Cements Ltd., Ammasandra

N. L. Hamirwasia, President

R. Shreenivasan, Process and Quality Control Manager

H.L. Sethi, Works Manager

R. Moulik, Financial Manager

Associated Cement Companies Ltd (ACC), Bombay

P.S. Rangnekar, Director, R and D Station

A.K. Chatterjee, Cement Research Station Chief

M.S. Ramachandran Rao, Operation General Manager

F.E. Mistry, Production Manager

M.M. Prabhu, Chief Mining Engineer

I.C. Ahuja, Design Engineer

P.P. Rao, Senior Design Engineer

N.B. Engineer, Planning Chief

N.R. Hillcowalla, Chief Industrial Engineer

Annex III

SUMMARY OF THE LECTURE GIVEN AT THE ALL INDIA CEMENT SEMINAR

Conversion From Wet to Dry Process Technology in Cement Plants

During the last decade and especially after the sky-rocketing of fuel prices, the conversion of clinker kilns from wet to dry process has been carried out in many cement plants and studies are being carried out for many others.

This conversion provides substantial savings in fuel consumption, and is in line with the internationally adopted energy saving policy. However, although fuel is the most expensive element in the manufacture of cement, the economies realised through conversion from one technology to another are insufficient to cover rising fuel prices.

Conversion from one process to another becomes economically relevant only when fuel savings are combined with a substantial increase in productivity.

Therefore, before undertaking any conversion project, serious techno-economical feasibility studies should be carried out.

Raw material availability for covering the requirement of the plant's increased production capacity for a minimum of 15 years, and raw material suitability for dry-process technology should be ascertained.

Costs of equipment, civil works, the plant's process conversion, and the cost of the complete overhaul of the plant's equipment retained have to be accurately estimated.

The project implementation timing schedule, including existing equipment overhaul, kiln shut-down and commissioning periods should also be realistically prepared.

The conversion project investment cost and plant operation costs after conversion are estimated by taking into consideration the plant's loss of profit during the project implementation. Generally speaking, the techno-economic feasibility of the conversion from wet to dry process appears when:

(a) The raw material moisture contents are low, varying from 5% to 8%;

(b) The production capacities of the existing wet kilns are relatively high; 400 t/d production can be considered as a minimum;

(c) The wet-process production-line equipment is relatively new or is in very good condition.

Although many conversion possibilities exist, conversion from the wet- to dry- process kiln are mostly realized either by keeping the existing kiln, adding two-stage suspended pre-heater, or by shortening the existing kiln, adding a four-stage suspended pre-heater. In the second alternative, the addition of a pre-calciner can be anticipated.

The fuel saving obtained from the two alternatives are approximately 400 and 550 kcal (1,700 and 2,300 kJ) per kilogram of clinker produced, respectively.

The increases in production resulting from the two process conversions reach 40% and 50%, respectively.

The addition of a pre-calciner to the second alternative slightly reduces the fuel saving - around 50 kcal (210 kJ) per kilogram of clinker produced - but on the other hand it increases the production of the kiln by 100%.

The advantages of the first alternative are:

(a) It reduces the investment cost of the conversion;

(b) It causes small loss of production or profit during the conversion process. Succinctly, it facilitates the conversion process.

On the other hand, fuel savings and increases in production are less than in the second conversion alternative which, in the long run, is a more economical solution.

In both alternatives, the raw material grinding, and the clinker cooling section and transport system of the plant have to be completely redesigned. In practice, during the conversion the plant slurry mills are often converted to cement mills.

From this very short review of the conversion of cement kilns from the wet to the dry process, it may be seen that a general approach for conversion cannot be given and that any conversion project should be studied carefully, as a new cement plant establishment project, and the most convenient solution in respect to the plant target has to be selected.

Annex IV

SUMMARY OF ACTIVITIES AT CRI

Activity	Objectives	Findings	Comments and recommendations
Study of insufflation in wet process kilns (Recycling of dust collected in the smoke chamber by means of the coal-burning system)	To increase clinker quality, lengthen brick lining life and eliminate operation difficulties	*Quantity recycled not* measured Slurry composition not corrected Fluctuations in feed	1. Avoid insufflation; recycle the collected dust to slurry-mill hopper 2. (a) Install variable-speed volumetric feeder; (b) Adjust slurry composition in accordance with dust and coal-ash compositions; (c) Keep dust-to-slurry feed ratio constant.
Discussions about refractories in the cement industry	Exchange of views	Principle types are: Clinker bricks Alumina bricks Chrome-magnesite bricks Castable	
Conversion from wet to dry process	Fuel saving Production increases	Raw grinding section needs to be completely reviewed Kiln needs complete overhaul	Conversion should be carried out only when: (a) Raw materials have low moisture and alkali content; (b) Plant equipment is relatively new or in good condition; (c) Substantial over-production can be obtained.

Down-scaling short rotary kiln with four-stage suspended pre-heater	To be within Government Incentive Plan To maintain low specific fuel consumption
Discussions about addition of pre-calciner to existing dry process kiln	Exchange of views
Split location of coal grinding (while adding pre-calciner to dry process kiln)	To dry coal with kiln exhaust gases To grind with different fineness
Study of fabric filtering media	To test behaviour of cotton and woolen fabrics

System sophistication and instrumentation remain unchanged (Pre-homogenization, homogenization, electroprecipitator)	1. Avoid down-scaling, it seems to be economically not feasible
Very slight change of tower height	2. Develop a new dry process system
Specific fuel consumption increases because of greater specific heat loss by radiation	3. Retain developed system with higher specific fuel consumption 4. Optimize design for 200 t/d kiln
Substantial production increase expected	Low investment per unit for over-production obtained
Redesign of pre-heater and extension of electroprecipitator necessary	
May require less investment than extension of existing grinding section	Should be thoroughly investigated
	1. Establish a CRI fabric standard for ambient temperature operations 2. Anticipate further tests and standard for special conditions

Pilot rotary plant modification	To equip with a four-stage suspended pre-heater
Discussion about heat-exchange systems	Exchange of views
Discussion about	Exchange of views
Vertical shaft kiln	To learn of CRI experiences and upscaling method

Anticipated tower height seems to be increased Flexibility with modular construction components	1. Increase the height of the tower by 50% 2. Plan visits to already existing pilot plant
Type discussed: Cyclone exchanger Chain system Refractory brick or cast-steel scrapers	
Equipment specifications Commissioning performance Original operating instructions for equipment	1. Consider initial performance of equipment more thoroughly 2. Plan periodic visits to plant 3. Facilitate collaboration
Scaling up to 50 t/d causes no problems	1. As first step, scale up to 50 t/d 2. Upscale further if experience with 50 t/d warrants Collaborate with other firms or institutes on VSK

Annex VI

DATA ON CRI VERTICAL-SHAFT KILN PILOT PLANT AT TIRUCHIRAPALLI

Plant production capacity	20 t clinker per day
Raw materials	Limestone, 34 km from plant Clay, 20 km from plant Gypsum
Fuel	Breeze coke, calorific value 5,290 kcal/kg (22.1MJ/kg)
Equipment	Raw material and clinker storage building, 8 m x 22 m, with 3-t overhead crane Jaw crusher, 1.5 t/h Raymond roller mill, 4t/h, 14% in 170 mesh Vertical-shaft kiln, 20 t/d, diameter, 1.5 m (inside shell); height, 7.00 m (kiln itself); refractory, high and low alumina depending sections; specific fuel consumption, 1,100 kcal (4.6 MJ) per kg clinker Tube mill, 1.4 m x 6.0 m, compound type with three compartments and external water cooling Cement storage capacity 60 t Manual bagging (jute-bags) Plant specific electrical energy consumption 110 kWh per tonne of cement
Personnel	Total 86, as follows: Management 1 Unit manager 2 Chemical engineers 1 Administrative assistant 10 Administrative personnel, driver included 14 Plant Operation and Maintenance Four shifts of 8 workers, including: 1 fitter 1 electrician (also operates crane) 1 mechanic 1 turner in one shift 33

Raw-material crushing

Four shifts of 6 workers
24

Load-out

One shift of 9 workers

Laboratory

Four shifts of 1 sampler each
2 chemists
6