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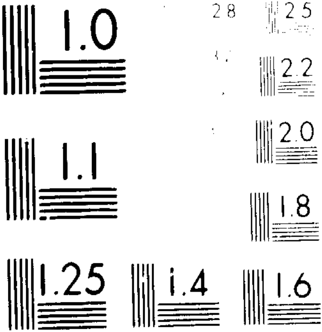
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DP/ID/SER.A/242
5 May 1980
English

ASSISTANCE TO THE CEMENT FACTORIES COMPANY.

SI/JOR/78/805

JORDAN

Techn :al report: Planning for improvement and better utilization of the existing installations*

Prepared for the Government of Jordan
by the United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

Based on the work of William J. Beckton, expert in cement process control

United Nations Industrial Development Organization
Vienna

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Annexes

SUMMARY.

There are four kilns in production at the Jordan Cement Factories Company, (J.C.F.C), in two distinct production lines. Kilns No.1, 2, and 3, the semi-dry process with Lepol grate preheaters, form one production line using the same raw mill feed, and Kiln No. 4 forms the second production line. This kiln is a dry process unit with a four stage gas suspension preheater.

Although the daily total clinker production from the kilns exceeds the rated capacities by approximately 17%, total annual capacity has shown a decrease over the last three years of between 60,000 and 90,000 tons compared to 1974, as shown in the following table:-

Annual Clinker Production 1974 - 1979 (Tons)

Year to March 31st	Kiln 1	Kiln II	Kiln III	Kiln IV	TOTAL
1974	108655	126951	136210	211717	583533
1975	105638	127046	113676	209207	555567
1976	107826	137875	142529	193845	582075
1977	93012	116529	124515	172916	506972
1978	N/A*	N/A*	N/A*	N/A*	494634
1979	88776	118192	124680	193294	524942

* Not available.

Thus there are good possibilities of restoring production at least to the 1974 level with the existing installations.

The main drawbacks preventing full usage of the production machinery are, firstly, the wide swings of variation in the chemical and physical composition of the materials at each stage of the production process. These variations are mainly due to the difficulties of control

because of the adverse design characteristics of the cement plant. The expert has made recommendations for minimizing these fluctuations.

Controlling these variations to acceptable limits would result in the following advantages to cement manufacture:

1. Increased production of the Raw Mills. Lower specific power consumption, (K.w.h. per ton).

2. A more consistent raw mill feed to the kilns. Variations in titration of the kiln feed should be $\pm$ 0.15 instead of 1.5 which is experienced at present.

3. Smoother running of the kilns and therefore longer continuous operation, increased annual output and longer wear of kiln brick linings.

4. Better quality clinker. Less free lime and more consistent chemical and physical composition. Better burning efficiency - lower specific fuel consumption (K.cal/K.gm).

5. Increase production of the cement mills because of improved grindability of the clinker and therefore lower specific power consumption.

6. Overall reduction in production costs per ton of cement.

7. Improvement in cement quality. More consistent chemical and physical characteristics.

The second major drawback to full production is the absence of a planned routine maintenance programme. The result is, frequent minor breakdowns which could have been avoided. Thus, although the daily production of the kilns exceeds the rated capacity, the total annual production is lower than necessary.

Thirdly, dust pollution has now reached a stage where it interferes with both maintenance and production control, apart from creating very unpleasant working conditions for the factory personnel. J.C.F. C. requested a special report on pollution, with recommendations for minimising or even eliminating the condition.

The new raw mix advocated by the Consultants employed by J.C.F.C., using smaller quantities of the marl component and thus lenthening the life of the raw material deposits, should produce a higher quality cement. The **expert** is in full agreement with this.

Quarry equipment is adequate up to 1983.

The main bottlenecks can be identified as follows:

- Inadequate separation of the four basic raw material components.
- The almost impossible control of quantity and quality of milled materials with the present system of rotary feed tables.
- The unsatisfactory method of blending pozzolanic material in the cement mills which causes low production and high specific power consumption.
- The unsatisfactory performance of Kiln No.4.

INTRODUCTION:

The Jordan Cement Factories Company Limited (J. C. F. C.), is extending its production facilities to meet market demands. Production from the existing two production lines (4 rotary kilns), is approximately 525,000 tons per annum and cement sales, augmented by the addition of 15% pozzolanic material totalled approximately 565,000 tons in 1978/1979.

A third production line, incorporating a fifth kiln of rated capacity 2000 tons/day and auxiliary machinery is under construction and is due to come on stream in August/September this year, (1979), bringing the total production capacity to 3700 tons/day. The Company is planning to extend its production capacity still further by the erection of a fourth production line in 1982/1983, kiln No.6, with a rated capacity of 2000 tons/day. Potential production is therefore 5700 tons per day.

Eventually production facilities will be co-ordinated by linking up the new plants with the existing installation, but meanwhile J.C.F.C. consider that the existing plant capacity is not being used at optimum level. The Company therefore sought assistance from U.I.D.O. in this connection.

Further background information is given in the Job Description, annex I.

FINDINGS:

There are two distinct production lines in the existing plant. After passing through the crusher, the raw material is divided and conveyed to two separate raw material storage compounds with overhead cranes. From one storage compound raw meal is prepared for Kilns I, II, and III, forming one production line, and the other storage compound supplies raw meal through a separate raw mill and homogenisation system to kiln No.IV. Each production line has a separate clinker storage hall, but the two lines are then linked together by transporting clinker from one storage hall to the other by trucks, where the clinkers are mixed by overhead crane before passing on to the cement mills. The flow sheet (annex II), illustrates the process.

Raw materials and Quarry Operation

The four raw material components required for the correct composition of the raw mix are: limestone (95 - 98% $CaCO_3$), marl (50-80 $CaCO_3$ iron scale (95% Fe_2O_3), and sand (95% SiO_2). The iron scale is imported, but is only used to the extent of about 2% in the selected raw mixture. The other three components are all to be found in the quarry which is adjacent to the factory.

Estimated reserves are 80 million tons, which is sufficient for 25 - 30 years plant operation taking into account the two extensions. There are further large deposits in the surrounding area. The following annual quantities are expected to be extracted from the quarries.

1979 - 844,000 tons - supplying existing plant.
1980 - 83 - 1,837,000 tons, supplying existing plant and one extension.
1984 - 2,825,000 tons, supplying existing plant and two extensions.

The necessary machinery and transport vehicles to handle the above quantities of raw materials are gradually being built up by the Cement Company, and a complete list of machines at present in use is given in annex III. These machines should be adequate to do the job up to the year 1983, but before the second extension No.6 kiln is completed, quarry equipment will have to be reviewed and the number of loaders and the truck fleet will have to be increased accordingly.

Some of the present equipment is in rather bad condition due to lack of maintenance, and it will be necessary to tighten up maintenance proceedures to maintain continuity of operation.

Raw Mix Composition

Before the expert's arrival in Jordan, a Consultancy Company was engaged by J.C.F.C. for the exploitation of the raw material deposits, and this company carried out a comprehensive exploration of the existing deposits, with many core drillings, and developed a bench plan for the economic operation of the quarry.

It had been considered by the J.C.F.C. that the present raw mix in use tended to use too much marl in proportion to the limestone and that, in future operation, marl would be a limiting factor for future production, but analysis of each bench has shown that marl consumption can be as high as 30% for the next twenty years. However, the alumina content in the marl is rather high, and a more suitable raw mix would use less marl in order to reduce the tricalcium aluminate (C,A) component in the clinker. A high percentage of C_3A in the clinker adversely affects cement quality.

The Consultants suggested a new raw mix which would increase the silica modulues (Ms) and raise the lime saturation favtor (L.S.F.) by fixing the alumina content at 5.20%. This raw mix would reduce the consumption of marl thus give longer life to the quarries, and at the same time improve the quality of the cement.

A comparison of the chemical composition of the clinker produced by the raw mix at present in use, and the new raw mix proposed by the Consultant is shown below.

The current raw mix components are calculated from the average clinker analysis for the month of December 1978, (annex IV), which is typical for the analysis throughout the year.

	RAW MIX IN CURRENT USE %	PROPOSED NEW RAW MIX %
$CaCO_3$	75.60	76.71
SiO_2	14.21	14.10
Al_2O_3	4.91	3.38
Fe_2O_3	2.04	2.26
Clinker components after calcining		
CaO	64.58	66.10
SiO_2	21.60	21.68
Al_2O_3	7.46	5.20
Fe_2O_3	3.10	3.47
Ratios		
L.S.F.	91.2	96.0
Ms	2.1	2.50
M_A	2.4	1.50
Percentage Theoretical mineral composition in the clinker		
C_3S	43.5	63.0
C_2S	29.0	14.0
C_3A	15.0	8.0
C_4AF	9.0	11.0

It can be seen that these changes in the Raw Mix would raise the L.S.F. and the M_s, and would reduce the undesirable C_3A in the mineral composition and increase the C_3S content.

quality than that produced at present, having a higher strength, more resistance to sulphate waters and sea water, and a lower heat of hydration.

Crushing Plant

There is one hammer mill crusher in operation for limestone and marl producing crushed raw material for both production lines. The rated capacity is 400 tons/hour, but the limestone and marl consists of soft rock which is easily crushed and the actual production greatly exceeds 400 tons/hour. A roughly proportioned mixture of iron scale and sand are introduced on to the rubber belt conveyor to the storage halls without passing through the crusher.

Raw Material Storage

No provision has been made in the design of both the storage compounds for keeping the different components separated so that, inevitably, the components are subjected to quite a degree of mixing before transferring to the raw mill hopper. This arrangement makes it very difficult to control the correct quantities to the raw mill hopper and is one of the main causes of fluctuations in composition of the raw meal.

Frequent breakdowns of the overhead cranes combined with unusually small raw mill feed hoppers cause bottlenecks in raw meal production.

Production line No. 1

Raw Mills

There are two raw mills in operation for this production line, numbered II and III. Mill No. I has not been used for some years and is now obsolete. The mills are fitted with separate oil heaters for drying the raw material. The milled product is controlled by titration to 77.0% $CaCO_3$ and a fineness of 8% residue on 4900 mash sieve. The mills have three feed hoppers and proportioning is controlled by rotary feed tables. Actual hour to hour titrations show variations between 80.0 and 74 and finenesses as high as 16%.

Production from raw mills II and III is slightly less than the total consumption of kilns I, II and III, it is therefor necessary to use ground material from mill No. IV, (No.2 production line), to make up the deficiency.

Homogenisation

There are seven blending silos of 350 tons capacity each and three raw meal storage silos, of 1500 tons capacity each, for No. I production line. The homogenisation system is the quadrant blending method, aerating the four separate quadrants in the base of the silos, in sequence, by compre sed air. The two compressors, capacity 53 m^3/min., are in poor condition, and will be augments by two new compressers of larger capacity, 62^3/min, to increase the blending effect. The automatic sequence aeration mechanism has not been operating on all seven blending silos for some years, the result is inefficient homogenisation.

The titration of the milled raw meal entering the blending silos has a variation range of 6.0, and after homogenisation the titration varies between 77.8 and 76.5, a variation range of 1.3, which is generally considered to be much too high for steady kiln operation. The acceptable variation should be a maximum of $\pm$ 0.20 with a $\pm$ 0.15 as a possibility. With the quadrant sequence aeration system it is normal to expect the variation range of the fully blended product to be one tenth of the variation range of the incoming mixture.

Kilns I, II and III

The three kilns operating in Production Line No.1 are all designed on the semi-dry principle with rotating pan modulisers and moving grate preheater kiln feeds.

Kiln capacities and characteristics are as follows:

Kiln No.	Type	Rated Capacity Tons/day	Actual Capacity Tons/day	Specific Fuel Consumption K.cal/Mgm.
I	Semi-dry Lepol grate pre-heater system	200	350	1000
II	"	300	400	970
III	"	300	400	1000

Although daily production exceeds the rated capacity by 43% approximately, total annual production is low due to many shut-downs for minor repairs. Thus, no long continuous runds are achieved, resulting in high specific fuel consumption. Kilns of this type should be able to operate at 900 Kcals/kgm. or less.

Principle causes of reduced annual output are:

- Unsteady kiln operation due to excessive variation in the composition of the kiln feed. Low litre weights, below 1100 grams, and high free lime 4.0% and more are experienced for long periods, necessitating reducing the kiln output to regain sintering temperature.

- Operation difficulties due to faulty control instruments. The oxygen analysis on all three kilns have been out of commission for several years.

- Frequent shut downs for repairs which could have been avoided by planned preventive maintenance.

All three kilns receive the same feed from the three raw meal silos. Clinker is discharged, through grate coolers, to a common conveyor to the clinker crane storage compound.

Annex IV gives he clinker analysis for a typical month. of production which illustrates the wide variations in the chemical composition.

Production Line No. 2

Law mill No. 4

This production line consists of a completely integrated cement plant with separate raw mill (no. IV), two homogenising silos and two raw meal silos. The kiln is the dry process type with 4 - stage gas suspension preheaters (Doppol), and the hot exhaust gases are used to dry the raw material passing through the mill. The moist gases then pass through two cyclones to remove the coarser particles, and finally to the electrostatic precipitator.

No provision is made in the design of the plant to enable the kiln gases to by-pass the raw mill and pass straight to the electrostatic precipitator, and because of the permanent fixture of the kiln exhaust ducts to the raw mill, the kiln cannot run without the mill operating and the mill cannot operate unless the kiln is running. This is a most unsatisfactory arrangement, as a long uninterrupted run of the kiln is practically impossible.

Raw Mill Statistics

Mill No.	Type	Rated Capacity Tons/hr.	Average Production Tons/hr.	Average Fineness Residue on 4900 mesh Sieve.	Average Power Consumption K.w.h/Ton.
IV.	Closed circuit	65	60.5	15.0%	20.0

The mill has three feed hoppers and is controlled to a titration of 77.0% $CaCO_3$ and 15.0% fineness. The coarser raw meal being more suitable for the Doppol preheater system. Rotary feed tables are fitted which, as in the other mills, makes it difficult to avoid the wide variations in the composition of the raw meal.

Homogenisation

There are two mixing siles, capacity 750 tons each, placed above two raw meal storage silos, capacity 2000 tons each. The same troubles are experienced in achieving constant raw meal as in Preduction line No.1. The aeration sequence distribution system does not work and the compressors have become inefficient with insufficient maintenance.

Kiln No.4

Kiln No.	Type	Rated Capacity Tons/day.	Average Production Tons/day	Heat Economy K.cal/k.gms.
IV.	Dry Process 4 stage gas suspension pre-heater	700	650	890

As in the other kilns, the oxygen analyser instrument has not been in operation for a long time, and the raw mill feed to the kiln is irregular because the weigh feeder is frequently out of commission. The result is that the exhaust fan is operated at maximum speed to avoid the formation of the explosive carbon monoxide (CO) in the kiln exhaust gases. There is a continuous discharge of dust from the electrostatic precipitator, probably caused by the large inputs of excess air which would increase the valosity of total gases through the precipitator, beyond its capacity. To achieve efficient operation, gas valosity through an electrostatic precipitator should not exceed one metre per second.

Clinker Storage

The clinker production from Kilns 1, 2 and 3, are conveyed to a covered crane store and the clinker from No.4 kiln to a separate open store without an overhead crane. Clinker is then transferred from the open store to the covered store by trucks. The mixed clinker is then transferred to the cement mill hoppers.

Due to market pressures, the total clinker stock is only about 5 or 6 days kiln production. Two weeks kiln production is normally the minimum, to allow for cooling and to ensure good mixing of the clinker before transferring to the cement mills.

Cement Mills (clinker grinding)

There are four cement mills in operation. Three are open circuit mills and one uses the closed cirsuit system. Descriptions of mill characteristics are as follows:

Mill No.	Type	Rated Capacity Tons/hr.	Average Production Tons/hr.	Production Percentage of rated Capacity
1	Open Circuit	20	12.9	64.5
2	Open Circuit	30	20.8	69.3
3	Open Circuit	30	21.6	72.0
4	Closed Circuit	45	39.3	87.5

Pozzolanic material is used as an additive to the clinker to increase the cement production and reduce production cost per ton of cement.

The pozzolan is stored in the clinker storage compound and is added to the clinker hopper by the overhead crane and interground with the clinker. It is proportioned by adding the required number of grabs by the crane, which is not a very satisfactory method of mixing. One of the problems is the comparatively large piece size of the pozzolan, a high proportion being 20 cms. or more in diameter. These tend to accumulate in the first chamber of the mills. Pieces as large as 2 cms. have been found at the diaphram between the first and second chambers, thus tending to restrict the free passage of clinker particles and causing reduced production.

Because of its property of combining with alkalios, pozzolan is a useful means of preventing expansion and as the free lime in the clinker is often as high as 4% it has a beneficial effect on the cement. In this case, however, some means of reducing the size of the pozzolan appears to be essential to increase the output of the mills.

Another constraint to production is the mill temperatures, which sometimes reach 160°C, normal running temperatures should not exceed 120°C. The high temperatures could be partly the result of using fresh hot clinker. Sometimes the mills have to be stopped to allow for cooling.

Still another restriction to cannot mill output is the heavy coating which occurs on the steel balls. This coating reduces the impact effect, and the grinding efficiency. The probable cause of the ball coating is the creation of static electricity by grinding two different materials, the fine particles of one becoming positively charged and the other negatively charged. The opposite charges attract each other and become agglomerated on the steel balls. This could also add to the elevated temperatures experienced in the mills.

A grinding aid such as ethyl glycol or triethanolamine, which are in common use, should effectively prevent ball coating.

Process Control

The complete programme of chemical and physical control tests in the laboratory is set out in annex V.

It will be seen that very little sampling and analysis is carried out at the quarry. It is essential to obtain the chemical composition of the incoming raw materials as near as possible to the source, in order to adjust the proportioning at the crusher and through the raw mills. This should be regarded as the first step in reducing the variation in chemical composition of the raw meal.

The remaining sampling frequency and chemical analysis appears to be carried out fairly accurately by comparison with a standard sample of cement which is kept in the laboratory.

It would be in the interests of the laboratory to keep composite daily or weekly samples of cement and clinker in sealed contrainers for six months, and labelled with the date of manufacture. These samples can then be referred to should any dispute with customers arise. This is common practice in many cement factories. The laboratory should also send occasional samples to internationally known public laboratories to check on the accuracy of their analytical work.

The Standard Manual of analysis in the laboratory is very brief, with the minimum of information on analytical detail. The writer was able to supply the laboratory with detailed chemical analytical procedures, which explained the theoretical principles of analysis as well as the practical methods, sources of error and the ways and means of correction.

Factory Organization

The proposed Organisation chart which has not yet been made official, illustrates the responsibilities allocated to the managerial, supervisory and specialist positions. There still seems to be some key personnel missing. In the writer's opinion, the Cement Company should appoint a Chief Engineer, a person with high academic qualifications, as well as wide experience in the cement industry, or other industry handling heavy machinery. A person of this stature would be in keeping with a factory of this size, which is growing rapidly and which will eventually be using the most modern technology. His main function would be to lay down a programme of continuous co-ordination and co-operation with the junior engineers and production staff, and create and maintain a planned maintenance schedule in great detail for every production department.

Equal in status is the Production Manager, who would be responsible for the quantity and quality of the materials produced. In order to carry out his duties satisfactorily, the laboratories would come under his control, so that he can define the sampling and analytical requirements according to the demands of the production process.

Job descriptions of all senior and junior staff should be clearly defined and recorded, to avoid unnecessary overlapping of responsibilities and authority.

Plant Records

The present system of recording statistical data, such as laboratory analysis and production records, in large books seems to the writer to be cimbersome and does not lend itself to easy reference. It is strongly recommended that a card index system be introduced. A daily average record could be extracted from the various books and only relevant data transferred to the cards. A separate card would record the daily averages of plant performance, such as the crusher, raw mills, kilns, cement mills, laboratory analysis, for one month, Monthly averages and yearly totals can then be easily calculated. The cards should be just large enough to fit a standard filing cabinet.

This system indicates at a glance any trends away from optimum operating conditions, and enables the process staff to take immediate steps to rectify the situation which might otherwise be overlooked. It also provides a visual historical record of plant performance which could prove very useful in the future. It is also recommended that a special clerk should be employed to keep the records up to date.

RECOMMENDATIONS

As stated, the main cause of low annual clinker production, inconsistent cement quality, poor mill performance, and thus high production costs is the fluctuation of chemical and physical composition of materials at all stages of manufacture.

In order to bring these variations under control, the following recommendations are made :

1. Increase the laboratory control of the quarry by more frequent analysis of the borehole drillings, particularly in the marl section. Establish long stockpiles on the quarry floor for pre-blending.

2. Change the Raw Mix at present in use to the Raw Mix described on **page 11**, by increasing the L.S.F. to 96.0 and the M_s to 2.50. This will produce a better quality cement and lengthen the life time of the quarry.

3. To separate the four raw material components build four walled compartments in both raw material storage compounds.

4. Install four feed hoppers for the raw mills, one for each component.

5. Replace the rotary feed tables on the raw mills by weigh-feeders, or volumetric feeders which can be calibrated. This conversion would ensure optimum mill control of production and accurate proportioning of raw materials to produce a consistent raw meal.

6. Control the fineness of the raw meal from all three raw mills to the same consistency, say 12% residue on 4900 sieve. This could be achieved when the weigh feeders are installed.

7. Restore the automatic aeration sequence mechanism of the homogenising silos to full working order: and maintain an adequate stock of spare parts for replacements in the event of further breakdowns.

8. Install the two new increased capacity air compressors for the homogenising silos.

9. Aim for incoming raw meal to the homogenising silos to have a minimum variation range of 2%. This should be possible when recommendations Nos. 2, 3, 4, and 5 are carried out. Homogenised raw meal should then have a variation range of 0.2%.

10. To level out the variations of the kiln feed still further, raw meal should be milled to at least two of the mixing silos at the same time, and two, or if possible, three, mixing silos after aeration should be transferred to the same storage silo. Finally, two silos should be fed to the kilns at the same time.

11. Restore all kiln instruments to full working order, particularly the oxygen analysers, as kiln control is impossible without these essential instruments. Make sure that stocks of the necessary spare parts are always kept at satisfactory levels.

12. Establish a daily routine inspection by the instrument engineer to make sure that all instruments are operating perfectly.

13. Arrange for all four kilns to deposit clinker in one storage hall with travelling crane, using one conveyor if possible. This would avoid the double handling as practiced at present and would provide better mixing of the clinker from Kiln No.4 with Kilns 1, 2 and 3.

14. To improve the performance of No. 2 production line, kiln No.4 and raw mill No.4 must be made to operate independently of each other.
A by-pass system must be installed to allow the kiln gases to pass direct to the electro-Static precipitator.

15. Try and maintain a clinker stockpile of at least two weeks kiln production before starting to mill, and arrange the stockpile in long heaps instead of conical heaps. This helps to cool and mix the clinker at the same time.

16. Replace the feed tables on the cement mills by weigh feeders or volumetric feeders.

17. Convert the cement mills to internal water spray cooling to reduce cement temperature.

18. Reduce the size of the pozzolan pieces to be equal to or less than the particle size of the clinker by (a) passing through a crusher and storing in a separate compound in the crane store or (b) by using No.1 cement mill, which contributes little to total cement production, exclusively for grinding pozzolan. The ground pozzolan could then be accurately proportioned continously with the clinker by a separate hopper and weigh feeder. This arrangement would improve cement mill production and produce a more consistent cement.

    Alternatively, arrange with the supplier to reduce the particle size to less than 25 mm. before delivering to the factory.

19. Recruit top level personnel as described under Factory Organization (page 18) as soon as possible.

20. Implement the Card Index system for plant records to facilitate process control. (Ref. page 19).

Further U.N.I.D.O. Assistance

There is great need for improving the maintenance in all departments of the existing installation. A specialist U.N.I.D.O. maintenance engineer, to provide assistance in this respect, is therefore recommended.

Annex I

JOB DESCRIPTION

(SI/JOR/78/805/11-01/32.1.A.)

POST TITLE:	Cement Process Control Expert
DURATION:	Two Months
DATE REQUIRED:	As soon as possible
DUTY STATION:	Amman with travel in the Country
PURPOSE OF THE PROJECT:	To assist and advise in planning and possibly in implementation of improvements in the cement industry.
DUTIES:	The expert will be assigned to the Government of Jordan to assist and advise The Jordan Cement Factories Company regarding maximum utilization of the existing installations. Particulary the expert will be expected to:

1. Examine the available raw materials and check whether the raw mix selected represent a resonable utilization of existing reserves.

2. Examine transport equipment and machines and report whether their production output corresponds with the rated capacity.

3. Examine the individual production lines and identify possible botlenecks and give proposals for their elimination.

4. Check the established procedures for process control and sampling from quarry to finished cement and advise on improvements whenever possible.

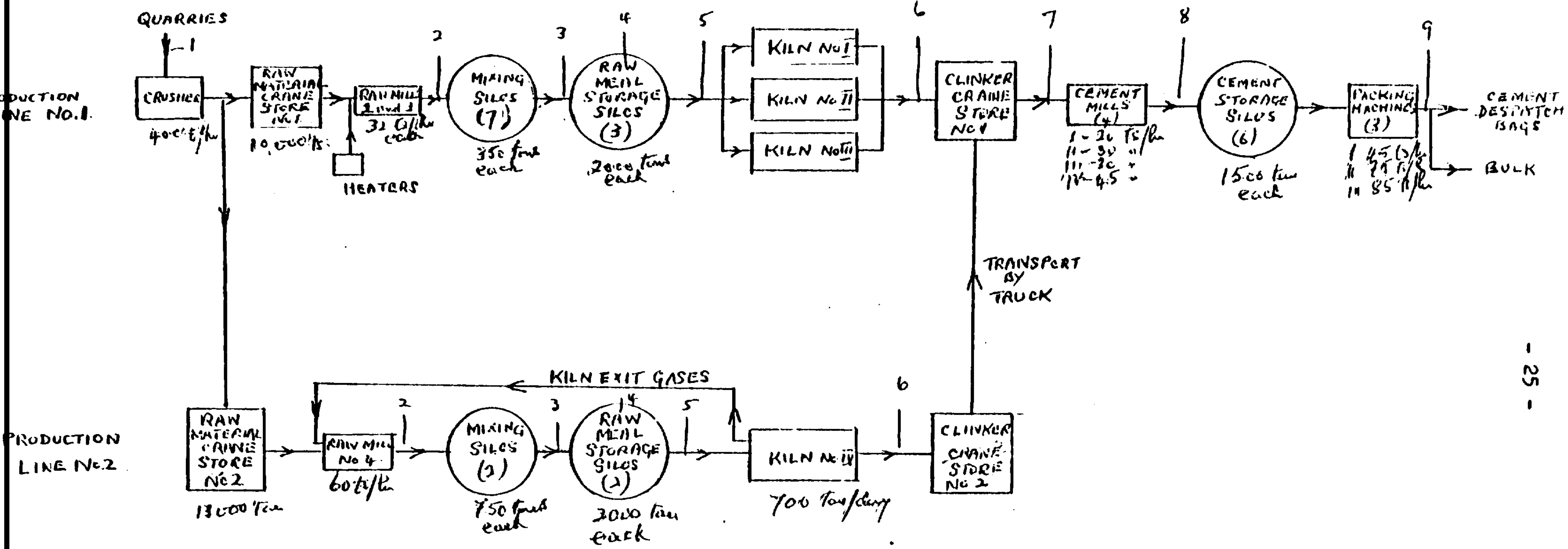
QUALIFICATIONS: Industrial Engineer with extensive experience in Cement Production and process Control in Cement Factories.

LANGUAGE: English

BACKGROUND INFORMATION: The Jordan Cement Factories Company was established in 1951 with share capital assets of JD 4.5 million. As a result of subsequent expansion, the Company's capital has increased to JD 15 million in 1978. The Government was allotted 49.5% of the shares and the balance was offered for sale to the public. Currently, the Company employs 1200 persons. Plans are being made to expand its plant to increase the production capacity from 1700 tons to 3700 tons per day in 1980. The total estimated expansion capital cost is JD 10 million. Moreover, technical and economic studies are being made to determine the feasibility of establishing a new cement plant in the Southern region of Jordan. It is furthermore felt that existing plant capacity is not being used at optimum levels. The company seeks advice from UNIDO this connection.

Annex II

FLOW SHEET



Annex III

LIST OF QUARRY MACHINERY OPERATING IN JULY 1979

Excavators

1.0 and K R H 140 5 m^3 capacity bucket

1 Wesserhutte Excavator W 24

Wheel Loaders

4 Cat 980 mechanical shovels

2 Cat 988 " "

Bulldozers

2 Cat D8F bylldozer

1 Cat D6 "

Pump Trucks

14 N. A. N. Dump trucks 22215 - 15 tons capacity

5 Perlini Dump trucks DP 363 - 35 tons capacity

Rock Brills

2 HALCO Drill rigg C 73 HR, Halcotrack 150

Compressors

3 Hollman Com. 37 HP X Rotair

Road Graders

1 CAT 140 Grader

Annex IV

CLINKER ANALYSIS, DECEMBER 1978

DATE	L.O.I	SIO_2	AL_2O_3	Fe_2O_3	CaC	Mgo	SO_3	S.M.	H.M.	I.M.	L.S.F.	TOTAL
1	1.002	20.64	7.17	3.10	65.56	1.12	1.03	2.00	2.13	2.31	0.95	98.25
3	1.002	20.12	7.41	3.10	65.56	1.17	1.63	1.90	2.15	2.39	0.95	98.77
5	1.002	20.32	7.65	3.10	65.07	1.26	1.20	1.88	2.10	2.47	0.95	98.71
8	1.002	21.82	7.80	3.21	63.07	1.26	1.34	1.97	1.93	2.43	0.86	98.60
10	1.002	21.12	6.92	3.10	65.32	1.17	1.03	2.10	2.10	2.23	0.90	98.75
13	1.002	20.92	7.66	3.10	64.82	1.17	1.10	1.93	2.06	2.47	0.92	98.87
15	1.002	21.22	7.42	3.10	64.46	1.26	1.25	2.00	2.07	2.39	0.91	98.76
17	1.002	21.24	7.16	3.10	64.31	1.26	1.34	2.06	2.05	2.31	0.91	98.80
19	1.002	20.42	7.42	3.10	65.07	1.22	1.41	1.93	2.11	2.39	0.94	98.77
22	1.002	22.02	7.16	3.10	64.07	1.17	1.20	2.13	1.99	3.31	0.88	98.81
24	1.002	21.62	7.66	3.10	63.82	1.26	1.20	2.00	1.98	2.47	0.88	98.76
26	1.002	21.22	7.15	3.10	64.56	1.26	1.27	2.06	2.06	2.31	0.91	98.68
29	1.002	21.12	7.42	3.10	64.56	1.08	1.23	2.00	2.05	2.39	0.91	98.64
AVERAGE	1.002	21.60	7.46	3.10	64.58	1.18	1.20	2.04	2.13	2.41	0.91	

Annex V

PROGRAMME FOR ROUTINE TESTING

(Numbers of sampling positions are indicated in annex II)

POSITION	SAMPLES TAKEN FROM	TYPE OF SAMPLE	FREQUENCY OF SAMPLING	FREQUENCY OF TESTS CARRIED OUT ON AVERAGE SAMPLES.	TESTS TO BE CARRIED OUT											
					MOISTURE %	TITRATION	FINENESS % 5900 MESH	LITRE WEIGHT	BLAINE	COMPLETE ANALYSIS	CRSATS	FREE LIME	SO_3	EXPANSION	SETTING TIME	STRENGTHS.
1	QUARRY	LIMESTONE MARL SAND.	OCCASION-ALLY		X	X				X						
2	RAW MILLS OUTLET	RAW MEAL	$\frac{1}{2}$ HOUR	$\frac{1}{2}$ HOUR		X	X									
3	MIXING SILOS OUTLET	RAW MEAL	1 HOUR	HOURLY		X										
4	STORAGE SILOS	RAW MEAL	1 HOUR	DAILY		X	X			X WEEKLY						
5	KILN INLET	RAW MEAL KILN FOOD	1 HOUR	HOURLY		X	X									
6	KILN OUTLET	CLINKER	1 HOUR	HOURLY				X								
6	KILN OUTLET	CLINKER	1 HOUR	TWICE WEEKLY						X						
6	KILN OUTLET	EXHAUST GAS	OCCASIONALLY								X					
7	CEMENT MILLS	GYPSUM	OCCASIONALLY							X						
8	CEMENT MILLS OUTLET	CEMENT	1 HOUR	HOURLY										X	X	
8	CEMENT MILLS OUTLET	CEMENT	1 HOUR	DAILY					X				X			
8	CEMENT MILLS OUTLET	CEMENT	1 HOUR	WEEKLY					X	X		X OCCASIONnally	X	X	X	X
9	PACKING PLANT OUTLET	CEMENT	1 HOUR	WEEKLY					X	X			X	X	X	X

Annex VI

LIST OF PERSONS MET DURING MISSION

Mr. W. Asfour, Chairman of the Board of Directors

Mr. S. Sboul, Managing Director

Mr. Qusem Abu-Sheik, Assistant Managing Director

Mr. Khamash, Technical Manager

Mr. Dhaknous, Works Manager

Mr. Fayez Khdeir, Production Manager

Mr. Mahmoud Sbeih, Administration and Supplies Manager

Mr. Halaseh, Chief Chemist.

Annex VII

REPORT ON AIR POLLUTION CONTROL AT THE JORDAN CEMENT FACTORIES COMPANY LTD.

Introduction:

The J.C.F. has requested the expert for a special report on pollution conditions in the existing Cement Factory and where possible to suggest methods of minimising or even eliminating the condition.

A permanent 100% cure does not, at first sight appear to be practical in the old part of the Factory. Kilns, 1, 2 and 3 are now over 20 yeats old and the pollution problem has been obviously worsening over the years. It is therefore proposed to examine the problem to find a partial solution, which can be carried out immediately, and then to investigate the possibilities of maintaining a comparitively clean enviroment in the factory area on a permanent basis in the future which may involve capital expenditure for additional equipment and mechanical modification to the existing machinery.

General Considerations:

The waste gases from the kilns and drying plants consist mainly of Carbon Dioxide, generated from the Calcium Carbonate in the raw materials, and water vapour. Very ocasionally Carbon Monoxide is generated, but to a very small extent, and of usually short duration. The waste gases are not harmful and therefore cannot be regarded as a form of pollution. Very dusty conditions prevail, however, in all production departments and large quantities of dust and rubbish have been allowed to accumulate for several years all over the Factory, inside and outside the buildings, thus creating a serious menance to machinery bearings and electrical equipment, not to mention very unpleasant working conditions for the staff and operating personnel. The dust consists of limestone, marl, clinker and cement and therefore, in itself, is not harmful, it can however cause eye soreness. It also constitutes a serious loss of material.

Observations:-

The main sources of dust creation in the Cement Factory are as follows:-

1. Crushing Plant:

Dust is caused by lorries tipping their loads into the hopper. Sometimes a small amount of material remains outside the hopper and this is allowed to accumulate and wind a passing vehicles tend to disperse the dust to other parts of the Factory.

2. Raw Material and Clinker Storage Compounds:

The travelling cranes cause considerable dust clouds when transferring material to the mill hoppers. These clouds of dust are dispersed by wind and are re distributed round the Factory. The Clinker fines constitute production losses which cannot be made up.

The short shutes from the Clinker conveyors from kilns No. 1 2 and 3 give a long free fall of Clinker and again the fine particles are blown away and lost to production.

3. Double Handling of Clinker:

Clinker from No. 4 kiln is discharged to a separate storage compound. It is then conveyed by front end loader to the storage compound for kiln 1, 2 and 3, a distance of some 100 m. The spillage from the front end loader and the clouds of dust from the discharging action of the loader causes Clinker dust to be re distributed to the Factory area.

4. Kiln Building:

The burners platform is comparitively free from dust, although by some effort on the part of the burners to instruct the labourers, it could be much cleaner. During kiln shut down periods, when work such as replacing bricks and other repairs have to be carried out, it is impossible to avoid dust and rubbish accumulating in the immediate area.

The floor under the burners platform where the Clinker coolers and Clinker Converyors are situated is very much worse and has been used more or less as a rubbish dump for a long period. Under kiln No. 1, the accumulation there is very great. The conveyers tunnel and cable troughs also contain Clinker spillage and dust accumulation.

5. Kiln No. 4, Raw Mill and Electro-Precipitator:

The exhaust gases from kiln No. 4 are at the moment, the worst source of dust generation in the Factory. The dust-laden exhaust gas, during the three weekly period under observation, has omitted dust continually in greater or lesser amounts. After discussion with the electrical engineer and the production Manager, the writer is assured that this is just a temporary phase in the operation, and that in the near future dust will be almost entirely eliminated from the exhaust gases.

At first sight it seems that the Electro precipitator is at fault, but further investigations show that it is the process control of the kiln and raw mill which is the real cause of dust creation. Mechanically and electrically the precipitator is working normally. The high tension voltage is 78000 volts, the rapping gear is functioning satisfactorily, the extraction conveyor is operating normally and the gas temperatures at the input and output of the raw mill are in accordance with specifications.

The oxygen analyser on kiln No. 4, as also in the case of the other three kilns, is not working which makes the operation of kiln No. 4 more difficult, and increases the incidence of CO in the kiln gases. When CO occurs, the electro-precipitator automatically cuts out and the dust is not removed from the waste gas, during that time. Hence a large amount of dust is discharged into the atmosphere which settles down over the whole factory area.

Another, and more frequent, reason for dust creation at this point is the irregular operation of the raw mill. The mill production is sometimes erratic, due to the mill hoppers being short of material, or the feed tables blocking up, or other operational difficulties, while the hot kiln gas flow is particularly constant. These irregular conditions upset the function of the electro precipitor resulting in the discharge of dust to the atmosphere.

The writer is assured that the electro precipitator receives thorough and regular maintenance by the mechanical and electrical engineering staff, and does operate well under stable running conditions of the raw mill and kiln.

6. Packing Plant and Dispatch Department:

This Department is one of the most serious source of dust and waste in the factory. All packing plants should be spotlessly clean. Any dust contamination here is cement dust, in other words the finished product, so that the amount of waste in this department far outweighs, in importance, the dangers of dust contamination.

It appears that very little attempt is made to clear the cement, caused by broken bags and leaking spouts, until the end of the day when loading is completed at 4 p.m. The floor is then cleared of cement by sweeping it into the spillage conveyor which returns it to the machine hoppers. Meanwhile cement dust is trampled about on the floor, much of it falling into the roadway to be spread over a wide are by the wheels of the lorries.

It seems that there are only two labourers available to do the job of cleaning up in addition to their main job of supplying empty bags to the packing machine operators.

7. Power Station, Mill Building and Workshops:

These Department have obviously been kept clean from the start of operation, but they are good examples of what can be done by day to day efforts on the part of the working staff to maintain clean surroundings. There is no reason why the kiln department and surrounding area should not be maintained to a similar standard of cleanliness although admittedly, it would be more difficult to do so.

8. Internal use of Company's Vehicles:

It is noted that works staff frequently use vehicles such as Land Rovers to travel short distances to inspect the various departments in the works. Possibly this is due to the unpleasant and sometime even dangerous, walking conditions at present prevailing. The movement of these vehicles, usually driven at excessive speeds, causes clouds of dust which is blown about by the wind making it very unpleasant for people walking in the vicinity.

When a cleaner factory environment is achieved, the use of cars, for this purpose, should be minimised.

Recommendations for immediate action:

1. For immediate action, the whole factory area should be cleaned up quickly. The writer considers that the complete clearance of the factory is such a big operation that it is beyond the scope of the present Company personnel. It is recommended therefore, that an outside contractor should be employed to carry out this task. There are many hundreds of tons of dust and rubbish which has been accumulating for many years and the contractor, after discussion with the management, should outline a plan of action, acceptable to the company, over a fixed period, say one month, to quarantee the complete removal of all dust and rubbish, inside and outside the buildings and the entire factory area.
be considered as a first priority.

2. After this first procedure has been carried out, no worker should be allowed to dump rubbish indiscriminately, or allow dust of any kind to accumulate. Everything should be cleaned up right away and removed from the Factory. A disused part of the quarry might be chosen for this purpose. This would need considerable organisation from the management and a directive from the Works Manager could be circulated and some form of discipline introduced. The responsibility for plant cleanliness could be given to the plant of shift foreman who, in turn, would be responsible to the Production Manager.

3. Alternatively, a small labour force of, say, twenty labourers could be employed specially for keeping the Factory clean. A foreman in charge of the labour force, and systematically patrolling the whole plant, could be made responsible to the Production Manager.

4. When a clean environment is achieved, the use of Factory vehicles for short journeys to visit works departments should become un-necessary. Meanwhile a strict 15 k.p.h. should be imposed. Speeds beyond this limit cause clouds of dust to be distributed by the wind, making walking about the factory compound very unpleasant. Not only would the speed limit keep dust by this cause to a minimum, but the Company would gain financially by prolonging the life of the vehicles and reduce maintenance costs.

Large notice boards indicating the speed limit should be placed at strategic points. For visiting vehicles a large notice board should be placed at the Factory entrance, and the gate keeper should be instructed to warn all incoming drivers to adhere to the regulated speed limit. The Factory roads should be sprayed with water, if available, at regular intervals, and roads leading to the quarry should have waste oil spread over them.

Wherever possible all internal roads should be hard surfaced, and crumbling surfaces repaired.

5. The Packing Plant is badly in need of re-organising. Operating staff should be instructed to sweep all cement spillages from broken bags, leaking spouts etc. to the spillage conveyors immediately. The people concerned should be made aware that the dust created in the packing plant is the most valuable and therefore should be treated with respect and not wasted. The packing machines appear to be in need of repair and priority should be given to this work. As already stated a packing plant should be spotlessly clean, and the writer sees no reason why it should not be achieved in this case. Possibly the employment of two more labourers would be advantageous.

6. Kiln No. 4 and Raw Mill.

The process control of this production line should receive priority. It is essential that the dust created by the exhaust gases should be brought under control as early as possible. The process workers concerned, the crane drivers and the millers, should be instructed to perform their duties accurately and, above all, consistently, to eliminate all irregularities in the performance of the raw mill. All instruments not functioning, in need of repair, or waiting for spare parts should be repaired as quickly as possible. For essential instruments such as the oxygen analyser, it is sometimes preferable to purchase a completely new instrument and use the old one for spare parts.

Unless the dust control from this particular plant is rectified, it will be a continuous source of contamination to the surrounding area.

7. Raw Material and Clinker Compounds.

It is very difficult to eliminate dust creation from these areas because of the open structure of the buildings, but it is recommended that the travelling crane drivers are instructed to be more careful in handling the material. Material should be lowered into the mill hoppers instead of dropping it in, and all efforts should be made to avoid doubling handling of materials.

Recommendations for future consideration.

The writer understands that the future policy of the Cement Company is to link up as far as possible the new plant, at present under construction, to the old plant. From the point of view of eliminating dust pollution, this is an excellent policy, and it is strongly recommended that it should be carried out to the fullest extent.

It is proposed to convey proportioned raw materials from the new plant via the sampling station and continuous blending compound to the raw mills of the old plant. The tables of the mill would be replaced by weigh feeders. This system would have two major beneficial results:-

1. It would make obsolete the travelling crane and open raw material storage system at present in use which creates dust pollution.

2. It would produce a much more homogeneous Raw Meal and more constant operating conditions for No. 4 kiln and raw mill, thus enabling the electro-precipitator to work better and stop the discharge of dust to the atmosphere.

Similarly, it is proposed that clinker from the four existing kilns would be conveyed to the new clinker storage silo and returned by covered conveyor to the cement mills in the old plant. This system would make obsolete the clinker storage area with the overhead travelling crane.

Thus, these two proposals would remove two of the major sources of dust pollution in the factory. It is strongly recommended, therefore, that the Company should proceed with these plans.

Conclusion.

1. Exhaust gases from the kilns do not, in themselves constitute a pollution problem.

2. Dust pollution is the major problem in the factory, but it is possible to achieve and maintain a comparatively dust free environment within a short time.

3. The recommended programme of dust control imposes great effort and self discipline on the Senior Staff and workers, but as the factory environment becomes cleaner, the work will become less arduous, and every one should enjoy the benefits.

4. To achieve a lasting solution to the dust problem, it will be necessary to educate the work force on cleanliness, and gradually instill a new atitude towards their work.

5. In the future, the proposed plans for technological ties with the new plant should finally reduce dust pollution to a minimum.