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SEMINAR ON
CLEANER PRODUCTION IN THE CEMENT INDUSTRY

Cairo, Egypt, 28-29 March 1993

REPORT*

* This document has not been edited.

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INTRODUCTION

Approximately eighty persons registered for the Seminar on Cleaner Production in the Cement Industry held at the Pullman Hotel, Cairo, Egypt, 28-29 March 1993. The seminar, jointly organized by UNIDO and the Suez Cement Company, concluded the Egyptian part of the UNIDO project Demonstration of Cleaner Production Techniques. The project was funded by the Norwegian Government.

How can industry in developing countries afford to avoid polluting the environment? An answer proposed by the UNIDO conference on Ecologically Sustainable Industrial Development, in 1991, is cleaner production, i.e., the best and most cost-effective environmental protection is not to generate wastes in the first place.

The project Demonstration of Cleaner Production Techniques was designed to prove the environmental and economic benefits of cleaner production in a practical way in Egypt's cement industry and Mexico's sugar industry. Aiming to show that significant pollution reductions can be achieved with very limited resources, the project used a strategy of identifying and rectifying raw material and product losses, to achieve both productivity gains and pollution reductions. The method used is described in the UNIDO/UNEP publication Audit and Reduction Manual for Industrial Emissions and Wastes.

This report describes the results achieved by the Suez Cement Company during the one-year cooperation with UNIDO, as reported in the seminar.

The seminar preceded a two-day workshop on operation and maintenance of baghouse and electrostatic filters staged by the World Environment Center and the Suez Cement Company. Most participants were present for both events.

CONCLUSIONS AND RECOMMENDATIONS

Eleven technical papers were presented during the two day seminar. Most of these papers were authored by the staff of the Suez Cement Company and reported on several pollution reductions and productivity gains achieved at the company's two plants at Quattamia and Suez. The most important results achieved in the project were:

- reduction from 15 to 3 tons per day of air emissions from the gravel bed filter at the cement kiln in Quattamia plant, i.e., 12 tons per day more clinker produced with the same energy and raw materials input;
- reduction of 20 tons per day of material being lost from the raw materials area of the Suez plant, and an apparent material loss reduction of 152 tons per day from this plant's cement kiln;
- advanced pilot plant trials on the possibilities of reusing the by-pass dust which is currently being dumped as a solid waste in the desert. The environmental and economic benefits of eliminating this loss are large since the by-pass dust amounts to 2-5% per day of total clinker production. This problem, caused by alkaline raw materials, is shared by all Egyptian cement plants, and many others throughout the world.

UNIDO did not supply more than limited technical advice towards the achievement of these results. The work was essentially carried out by the plant staff extending their daily duties. No capital investments were needed to obtain the above reported waste reductions which all provide a direct economic return to the company. Thus, the results confirm that industry can achieve significant pollution reductions with very limited resources, and that there are both economic and environmental reasons for them to do this.

In order to assist other industries in Egypt to reap the benefits of reducing wastes at the source and improve their environmental performance, the seminar recommended the establishment of an Egyptian Center for Cleaner Production. The first activity of such a center would be to catalyze and organize joint research of the by-pass dust problem. While initially concentrating on the cement sector, the Center would gradually expand to promote cleaner production in a range of industries by, for example, providing training in waste auditing, information on clean technologies and technical seminars.

It was also recommended that UNIDO conduct this type of waste minimization project for other industrial sectors, such as leather tanning, textile, chemicals and fertilizers.

I. ORGANIZATION OF THE MEETING

Some eighty participants registered for the Seminar on Cleaner Production in the Cement Industry. Most of them were cement plant chairmen and managers from Egypt and adjoining countries. Government organizations, engineering firms, UNIDO, and other international and national bodies were also represented. The list of participants is given in annex XII.

Suez Cement Company (SCC) Chairman Mr. Mohmoud El Khouli said in his welcoming address that although Egyptian cement companies use the most modern equipment and employ very capable, well-qualified, and experienced engineers, the cement industry is a highly polluting industry, and public opinion is pressuring government to take remedial measures. In this regard, the SCC environmental policies add a new dimension and for the sake of a pristine environment the objective is to share the philosophy of waste minimization with its sister cement companies.

Mr. Tarek Genena, Director of the Technical Cooperation Office for the Environment at the Egyptian Environmental Affairs Agency, stated in a very brief address that Egypt's National Environmental Action Plan was being formulated for solids, air, water, and land pollution problems. One of the most important of these was noted as air pollution, number one of which is urban air pollution from vehicles, and number two, the cement industry in Helwan. Mr. Genena said he was looking for cooperation from UNIDO to solve this problem. (This is currently being addressed by another UNIDO project; however, cement industry personnel from this problem area were present at the seminar.)

During the two-day seminar, eleven technical papers were presented in four sessions, following the agenda given in Annex XIII. The last item on the agenda was a tour of the Quattamia plant where Mr. Hamdy Sadeek, Environmental Manager of SCC, formally closed the seminar.

The Audit and Reduction Manual for Industrial Emissions and Wastes was distributed to all participants. It describes the method used in the project to identify and implement waste reduction opportunities.

The seminar concluded the Egyptian part of UNIDO project US/INT/91/217 - Demonstration of Cleaner Production Techniques. Starting in spring 1992, the project provided 7.5 m/m of technical assistance to the Suez Cement Company through the Chief Technical Adviser Mr. Ken Bradley (2.5 m/m divided on three missions to Egypt and some home based work), and Mr. Abu-Zeid Osman, UNIDO National Expert (5 m/m, enabling weekly visits to both plants during the entire project period). The management and staff of the Suez Cement Company committed considerably more time to the project.

II. SUMMARY OF DISCUSSIONS

Session I. Introduction

The papers titled Foreword, and UNIDO and its Cleaner Production Activities, given in annex I and II, were presented by Mr. Abu-Zeid Osman, UNIDO National Expert, and a staff member of the UNIDO secretariat respectively. In the ensuing discussion the following was noted:

- Mr. Galal Yakout, Technical Manager of the Arab Swiss Engineering Company in Cairo, questioned the statement made in the Foreword by Mr. Mostafa Abou-Zeid that the dry kiln was a bad choice in Egypt. This was strongly denied as the paper includes the words "dry process with preheaters" as opposed to just "dry process", and in its delivery Abou-Zeid repeated the phrase "with preheaters".

Session II. Achievements in Project

The following papers were presented in session II:

- Waste Minimization Philosophy and its Implementation at the Suez Cement Company; presented by Mr. Ken Bradley, UNIDO Chief Technical Adviser, and given in annex III,
- Heat Treatment of Alkali By-Pass Dust at Quattamia Plant; presented by Mr. Hamdy Sadeek, Environmental Manager of SCC, and given in annex IV,
- Mixing of the Burned Alkali By-Pass Dust with OPC Clinker - Quattamia and Suez Plants; presented by Mr. Said Yazeed, Laboratory and Quality Control Manager at SCC, and given in annex V, and
- Properties of Cement Synthesized from Burned Alkali Dust/Clay Mix with Clinker and Gypsum - Quattamia Plant; presented by Mr. Said Yazeed, and given in annex VI.

In the ensuing discussion the following was noted:

- With respect to the paper titled Waste Minimization Philosophy and its Implementation at the Suez Cement Company, Mr. Fekri Abdel Nabi, Director of Suez plant, pointed out that the value for Loss on Ignition (LOI) used in the material balance calculation was incorrect. The paper has been revised using the correct LOI-value for 1991, 35.79%.

  Mr. Salah Abou El Foutoh, Laboratory & Quality Control Manager at Suez plant, supplied just recently compiled 1992 data showing a material balance which translates to a daily dust loss of 244 tons/day and compares with 1991 data as shown in table 1 below.

Table 1 Suez Plant Kiln Material Balances for 1991 and 1992
(estimated daily average)

	1991				1992			
	Input		Output		Input		Output	
Material	t/d	(%)[a]	t/d	(%)[a]	t/d	(%)[a]	t/d	(%)[a]
Kiln Feed	5668	100			5423	100		
Clinker	-	-	3164	55.8	-	-	3135	57.8
By-pass dust	-	-	80	1.4	-	-	80	1.5
Loss on Ignition (LOI)	-	-	2028	35.8	-	-	1964	36.2
Loss to atmosphere etc.	-	-	396	7.0	-	-	244	4.5
Total	5668	100	5668	100	5423	100	5423	100

[a]Percent of kiln feed

This table of data now reflects the results of source reduction efforts directed at the kiln operation over the last year and implies a reduction in losses, mainly as dust to atmosphere, of 152 tons/day.

Further improvements are also expected for 1993 as a preheater modification was recently made and the diameter of the by-pass duct was increased to decrease the velocity of the exit gas, thus enabling more of the dust to traverse the full length of the kiln and be converted to clinker. This is expected to increase clinker production and further reduce dust losses.

In the discussion, Mr. Bradley pointed out that a material balance should be performed by direct measurement rather than by difference. Because air emission data was not available the balance had to be done by difference. The data is not to be taken as the final word, because there may be errors of measurement. A balance only helps to give more assurance that the audit has not missed something significant. Thus, comparison with 1991 data, and later with those of 1993, should be made to see what kind of fluctuation is normal and at what level the apparent reduction can be sustained.

- Energy was not included in the balance in order to keep the process simple. This was noted in answer to a question on a balance of solids, liquids and gases as opposed to only solids. The moisture and loss on ignition of course are gases and had to be included as they were included in the input weight. If a carbon balance was done it would show a major emission of carbon as carbon dioxide that perhaps should be looked at in the long term as a raw material for storage perhaps as cellulose (in trees) for future use as a different kind of building material.

- The remaining papers in this session by Mr. Sadeek and Mr. Said Abo El Yazeed evoked lively discussion concerning specifications for cement, validity of some numbers and their meaning, potential for use of by-pass dust for cement clinker production, further testing required, and what equipment might be used (semi-pilot, pilot, dry/wet process kiln, etc.)

Session III. Further Achievements in Project

The following papers were presented in session III:

- Waste Minimization at the Quattamia Cement Plant, presented by Mr. A. Shebel of SCC and given in annex VII,
- Spotlight on the Limestone of the Suez Cement Plant, presented by Mr. Abu-Zeid Osman and given in annex VIII, and
- Re-Use of the Alkali By-Pass Dust at Suez Plant, presented by Mr. Hamdy Sadeek and given in annex IX.

In the ensuing discussion the following was noted:

- Mr. Fekri Abdel Nabi of SCC addressing Mr. Abou-Zeid claimed that the addition of 3% clay to the Suez limestone to solve the physical problems of dust and flowability deserved consideration for further study and presentation at a seminar (e.g. storage capacity was raised from 20,000 to 36,000 tons with 3% clay added). Mr. Ifraz Al-Halasa of Jordan Cement Co. claimed that adjustment of the crusher settings could solve the dust problem, and that a variable height (up and down) stacker could solve the problem of the angle of repose in the limestone storage building, along with addition of some 40-44% CaO to combat additional dust after grinding.

  These ideas were believed to have been considered and rejected by SCC's Mr. Ahmed Shebel, but he did agree that particle size distribution is very important. With so much of the limestone weight after crushing at less than 38 microns (definition of dust) another participant was inclined to suggest that a larger sample size (more representative) should have been taken for screen analysis. This point was considered for further study, especially as a briquetting machine would have to be sized to handle at least that portion of material considered as dust.

- Among the usual suggested uses for by-pass dust (in asphalt for roads, fertilizer, soil amendments) Mr. Fakri El Daly, retired SCC Chairman, indicated that with a little moisture, it made an excellent grinding aid by reducing electrostatic charges to keep the balls in the mill clean, thus maintaining grinding efficiency.

- Concerns were raised about the specification requirements for reuse of by-pass dust at Suez plant and discussed. Mr. Sadeek of SCC will be discussing specifications with the representative of the government agency responsible for specification standards, who was also present.

Session IV. Wider View and Follow-up Discussions

A staff member of the UNIDO secretariat presented the paper titled Waste Digestion in Cement Kilns; Possibilities and Constraints, given in annex X. Thereafter, Mr. Gouda from the International Finance Corporation presented the paper titled Activities of the International Finance Corporation (IFC) in the Cement Sector - It's Environmental Requirements for Cement Plants, given in annex XI. In the ensuing discussion about suitable ways to follow-up on the seminar and the project activities in Egypt, the following was noted:

- Mr. Bradley recommended the establishment of a cleaner production centre in Egypt, to serve industry and the cement industry in particular. He suggested that one of the first tasks of such a center would be to organize joint research on the by-pass dust problem. Staging of technical seminars, providing training in waste auditing and communication of information gathered on latest technologies and techniques could be other centre activities. The recommendation was greeted enthusiastically and adopted by the meeting.

- Due to lack of time, no further recommendations were discussed but two were received in writing. The Egyptian Atomic Energy Authority proposed cooperation in the analysis of waste materials. Mr. Malek, Deputy Director of the Air Pollution and Energy Department at Ministry of Environment and Land-Use Planning in Tunisia, recommended staging a similar seminar in Tunisia, which should preferably be more focussed on air pollution problems. He also expressed hope that UNIDO would repeat this type of waste minimization project for other industrial sectors, such as leather tanning, textile, chemicals and fertilizers.

Epilogue

The last item on the agenda was a tour of the Quattamia plant where Mr. Hamdy Sadeek of SCC formally closed the seminar. During the journey and in other breaks of the seminar the organizers noted the following:

- Many participants were surprised and encouraged by the amount and "newness" of the research and positive results, availability of the data, and eagerness of participants to share experiences. Hopes for an annual seminar were shared by many.

- There are no environmental regulations yet in place for emissions from the cement industry in Egypt. This will occur after a period of study and negotiation. The process may take two years or more.

- There are no environmental regulations yet in place for emissions from the cement industry in Egypt. This will occur after a period of study and negotiation. The process may take two years or more.

- When Suez Cement Company started up, it hired mainly personnel with experience from outside the cement industry in an effort to establish a very creative and motivated workforce, according to one SCC manager.

The organizers thank the participants for their very active participation in the discussions, both formal and informal. The many probing questions and thoughtful recommendations contributed to a valuable furthering of knowledge and most importantly, a sharing of that knowledge.

Annex I

Foreword

A presentation to the March 28,1993 Seminar on Cleaner Production in Cement Industry, Suez Cement Company, Cairo - Egypt, by Mr. Mostafa Abu-Zeid, National Expert at UNIDO

We had no problem with our raw materials when we used the wet process. The change to dry process with preheaters to save a part of the fuel cost was not a good choice, because the nature and the properties of our raw materials do not comply with this method. Large amounts of fines rich in alkalies and sulphur are created resulting in the problem we are facing now and which requires new investments that nearly compensates the fuel savings gained from the new process and still we need hard scientific research in each plant to find the proper solution which allows reusing the entire bypass dust at minimum additive cost, increasing the revenue and preventing pollution.

A time came when trials were made and still many are carried out to agglomerate the bypass dust using different binding aids or by mixing it with other ingredients to produce low grade hydraulic materials or new type of building bricks. But as a matter of fact this trend in treating the dust is not fruitful, as such products are not acceptable by the local market either as fillers for road construction or as building material.

The accumulations of the dust are increasing, a lot of funds are spent on buying and using truck to transport the dust away from the plants to the far areas of disposal. Such a way of getting rid of dust adds to the loss of its cost in quarrying, crushing, milling and burning which means a lot and especially if we take into consideration the serious problems that result from spreading the dust over vast areas to be carried by the wind causing pollution and poor vision everywhere.

Egypt has been chosen by UNIDO to execute the project called "Demonstration of Cleaner Production Techniques" funded by a special purpose contribution from the Norwegian Government. Suez Cement Company has cooperated with UNIDO to prove that with little or no new investment, improvements of production and environmental performance can be achieved.

We started our program with a meeting held under the supervision of the Chairmen of Suez Cement Company. In that meeting spotlights were thrown on the major emissions and wastes of the factories. A priority was made to conduct a scientific study that aimed at investigating the by-pass dust and to find if possible the optimum conditions of reusing it in both plants of Suez Cement Company.

A team of work groups, each for specific assignments was established in both the Suez and Quattamia plant. A lot of investigations, calculations and experimental work was done. The study handled the following topics:

1) Revision and recalculation of the material balance in both plants.

2) Investigation of the properties and the nature of the bypass dust in both plants.

3) Experimental work to determine the possibility of reusing the dust and in what form and what dosing.

4) Study of the nature and properties of the limestone of the Suez plant and its reflection on the production and environmental performance.

We obtained promising and encouraging results and the study proved that the bypass dust is not a waste material or a by-product, but it is a semi-finished clinker, as it is a part of the feed of the furnace which would not split from it if we were using the wet process.

The present work in the submitted paper paves the way towards the reuse of the bypass dust which may be without any need for new investments in some plant or modest requirement in others. Reuse assures an increase in the yield and undoubted success in preventing environmental pollution.

On behalf of every Egyptian citizen acknowledgment is made to the Chairman of the Suez Cement Company, and deep thanks are issued to everyone who participated in this project from Suez and Quattamia plant.

Annex II

UNIDO and its Cleaner Production Activities

A presentation to the Seminar on Cleaner Production in the Cement Industry, Cairo, Egypt, March 28-29, 1993, by the Secretariat of UNIDO.

The Suez and the Quattamia plants of the Suez Cement Company in Egypt have in cooperation with United Nations Industrial Development Organization completed a project that seeks to demonstrate that considerable environmental improvements can be achieved without major investments while also increasing the production efficiency. The purpose of this paper is to discuss the background and the objective of the subject project. This is done by providing a general description of UNIDO and its activities in the field of environment.

UNIDO wishes to express sincere gratitude towards the Suez Cement Company for their excellent cooperation in the execution of this project. Without the support of the Chairman Mr. El-Kholi and his predecessor Mr. Fakhri El Daly, and the efforts of the staff at the Quattamia and Suez plants this seminar would not have taken place. Recognition and gratitude also are due to the Government of Norway for financing this project, to Mr. Abu-Zeid Osman and Mr. Ken Bradley, UNIDO National Expert and Chief Technical Adviser respectively, for their tireless efforts in making a success of this endeavour, and to all of the seminar participants who have taken the trouble to come to Cairo to examine and discuss the results. UNIDO is also very glad for the opportunity to combine efforts with the World Environment Center, who will stage a training workshop on operation and maintenance on air pollution control equipment together with the Suez Cement Company immediately after the seminar.

UNIDO in General

UNIDO, United Nations Industrial Development Organization, as implied by its name, is the UN agency responsible for the promotion and acceleration of industrialization in developing countries.

UNIDO was established by the United Nations General Assembly in 1966. In 1986, it became the 16th specialized agency in the United Nations System. Headquarters in Vienna, Austria, now employ more than 1,300 persons (1). Our 159 Member Countries supply the funds for the Headquarters in Vienna and many regular outreach activities such as:

- studies on industry at different levels;
- inquiry service on technological information (cost-free for developing countries);
- investment promotion forums; and

- a range of other activities.

UNIDO has a permanent presence in a number of countries through, for example:

- Field Representation. Covering about 120 countries, 40 UNIDO Country Directors serve in field offices in developing countries in collaboration with United Nations Development Programme (UNDP) Resident Representatives. In Egypt, UNIDO is represented by the UNDP office.

- Investment Promotion Services (IPS). IPS offices in Athens, Cologne, Milan, Paris, Seoul, Tokyo, Vienna, Warsaw, Washington, D.C., and Zurich mobilize financial resources for investment projects by providing the business community and governments of developing countries easy access to their counterparts in industrialized countries. In 1990-1991, US$ 1.6 billion worth of investment projects was successfully promoted.

A very important part of UNIDO's work is technical assistance delivery. Typical components of UNIDO projects are: technical advice through international experts (UNIDO employs yearly more than 2,000 international consultants), training, and equipment.

Funds for UNIDO's technical assistance projects come mainly from United Nations Development Programme (UNDP), individual donor countries, and to a lesser degree from UNIDO's own Industrial Development Fund. As an example, in 1991 UNIDO carried out US$151 million worth of technical assistance distributed on 1,927 projects.

UNIDO and the Environment

UNIDO's role in the environmental arena in the past was much smaller than it is today. The reason for this is that UNIDO acts mainly on requests from recipient governments, and there were simply not many requests coming in for assistance in environmental matters.

Since 1990 there is, however, a dramatic increase of the organization's involvement in environmental issues. In 1991, UNIDO staged an international conference on Ecologically Sustainable Industrial Development, and the organization took an active part in the Earth Summit in Brazil last summer. Recently UNIDO was named an implementing agency of the Montreal Protocol to phase out ozone depleting substances.

Increasingly UNIDO is also receiving requests from Governments on assistance in environmental matters. Today, nearly 200 projects related to environment and/or energy issues are carried out by UNIDO in developing countries all over the world.

The recent upsurge in demand for assistance in environmental matters is not surprising because UNIDO has something unique to offer in this field and that is a knowledge about process technologies and industrial management that few other international organizations have. This knowledge is essential, crucial, with respect to preventing or reducing wastes at the source - cleaner production - as opposed to treating and disposing wastes that are already produced.

Increasingly, industry worldwide is finding it too expensive to comply with environmental regulations using only treatment at the end of the pipe. Instead an appropriate mix of end-of-pipe treatment and upstream measures to prevent waste generation is needed. For example, many waste water treatment plants are designed without consideration of how the effluent was produced because the design parameters are essentially effluent volume and contamination. However, to build a really efficient and low cost waste water treatment, effluent volume and contamination must first be minimized to the extent feasible. It is then possible to design a small and very effective treatment plant at minimum operating and financial cost. UNIDO has the combined knowledge about process technologies and treatment technologies to address industrial pollution in this integrated way.

It could be claimed that UNIDO has been active in protecting the environment long before the environment became a global issue. Because many UNIDO projects were, and still are, concerned with reducing energy and raw material losses in order to increase the production efficiency. It should be noted that these projects were executed to cut costs and increase the competitiveness, not to protect the environment. This shows that there is and has always been a way to reduce industrial pollution that is fully compatible with running an economically successful industrial operation. The general principle of this approach is that the best and most cost-effective pollution control is not to generate the pollutant in the first place.

As mentioned above, the economic incentive for pollution prevention is growing in many countries due to increased regulatory pressure combined with various fees and taxes for waste disposal and discharge. As an example, four initiatives for environmental improvement at Römerquelle, Austria's largest supplier of mineral water, yield yearly US$320,000 in revenues from product recycling and as much as US$360,000 in waste disposal cost reduction, (2). With total costs amounting to US$140,000 for the four projects concerned with recycling of plastic, paper, glass and waste water, the net benefit for the company is US$540,000. Although an isolated example, this shows the important role that governments can play, in this case via regulation, for stimulating industry's transition to cleaner production.

Project in Case

The recommendations on UNIDO action made by the delegates to the conference on Ecologically Sustainable Industrial Development (ESID), gave birth to the project Demonstration of Cleaner Production Techniques, the main subject of this paper. The Ministers attending the conference recommended, among other things, UNIDO action in (3):

"*a)* *Assisting developing countries, upon request, in building the technical and scientific institutional capacity to develop, absorb and diffuse pollution prevention techniques and cleaner production processes essential to making the transition to ESID. This could be done by:*

i) *Demonstrating the financial and economic advantages and environmental benefits of ESID by working cooperatively with industry and other technical experts, and with Governments, to undertake a programme of site-specific, country case studies;*

ii) *Providing technical support for the design, establishment, operation, evaluation and monitoring of pollution prevention techniques and cleaner production processes and technologies*".

At both the ESID conference and the Earth Summit it became obvious that there is something like a deadlock in the environmental debate. The environmental problems are hugh but the money needed to solve these problems in the traditional way is simply not available. Thus, the process of change to an ecologically sustainable development appears to be stuck in rhetoric mainly concerned with money.

The aim of this project is to show a way out of this deadlock by demonstrating that significant pollution reductions can be achieved with sometimes very limited resources if we address the problem from within - at the source. Because only when going to the source is there not only an environmental incentive but also a commercial incentive to pollute less. In other words, our ambition is to demonstrate that less waste of raw materials and energy give higher production yields <u>and</u> less pollution of the environment.

We did not want yet another theoretical study on what might be possible, but rather be very practical and assist a few industries in identifying and also <u>implementing</u> opportunities to minimize wastes, in order to find out what is possible in reality. If met with success, the results would show a way to improve the environment that would not conflict, nor compete for resources, with economic and social development.

If unsuccessful in terms of achieved pollutant reductions, then at least we would have learned more about the obstacles to a cleaner production and subsequent programmes could be designed to overcome these. Thus, there was nothing to be lost and with financial assistance from the Government of Norway the project started with activities targeting the cement industry in Egypt and the cane sugar industry in Mexico. The Mexican part of the project is not yet completed.

About a year ago, Mr. Ken Bradley, the project's Chief Technical Adviser from Canada, and Mr. Abu-Zeid Osman, UNIDO National Expert on cement production managed to secure the cooperation of the Suez Cement

Company. They proposed to the Company to carry out what is called a waste reduction audit.

How to carry out a waste reduction audit is described in the Audit and Reduction Manual for Industrial Emissions and Wastes published jointly by UNIDO and United Nations Environment Programme. It is focused around determining material balances of key unit processes, such as, for example, the cement kiln itself. What goes into the process must come out - either as product or waste. That information shows where the largest losses occur and hence where efforts to achieve reductions should be focused. Since the material balance reveals how many Egyptian Pounds worth of product are actually lost every day, there is generally strong motivation for the following steps to identify and implement opportunities to minimize these losses.

Other papers will reveal more about how the work was carried out and the results achieved. It is however important to note that, without neglecting the contributions of the UNIDO experts and the management of the Suez Cement Company, the bulk of the work has been carried out by plant staff at the Suez and the Quattamia plant organized in waste audit teams. What Mr. Bradley wrote in his mission report after his first visit to Egypt last year gives a good picture of what waste reduction auditing, or source reduction, is all about: "...there is a good chance for success because results will be achieved by the people committed to doing the work. In this process of source reduction, solutions are not imposed from above or handed over with a grant from outsiders.... It is very important that those involved with the daily operating problems have the opportunity to look for improvements and are provided with top management support to do this. If this is allowed to continue, I have no doubts that it will succeed."

UNIDO is very pleased and encouraged by the excellent cooperation with the Suez Cement Company, and the results achieved in this project so far. It is worth emphasizing that the scope of the seminar is to discuss, not what may or should be done, as most seminars do, but what have and could be done, to reduce pollution of the environment.

UNIDO is committed to ensure that industrial development is also ecologically sustainable. In this respect the Organization sees this project as a very important pilot effort on which to draw experience for similar projects in other countries and regions. Although this seminar marks the conclusion of the Egyptian part of this UNIDO project it should be acknowledged that we are, in many respects, still at the beginning of a long journey. Some pollution reductions have been achieved at the Suez and the Quattamia plants but there are also many waste reduction options identified but not yet implemented. The main purpose of this seminar is to seek opinion and advice on the results achieved and forge partnerships that can make best use of the accomplishments in the future. Therefore, UNIDO is very much looking forward to continuing the cooperation with the Suez Cement Company, the Government of Egypt and any other party interested in a follow-up to this project.

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2. Greener Management International. Issue 1, January 1993. Greenleaf Publishing, ISSN 0966-9671, Page 41-49.

3. UNIDO Document GC.4/25/add.1, paragraph 44

Annex III

Waste Minimization Philosophy and its Implementation at the Suez Cement Company

A presentation to the March 1993 Seminar on Cleaner Production in the Cement Industry, Cairo, Egypt, by Mr. Ken C. Bradley.

Overview

The concept of material balance, as described in the UNEP/UNIDO "Audit and Reduction Manual for Industrial Emissions and Wastes", was used to provide an insight into material losses at two cement plants. Production records and laboratory data were used courtesy of plant personnel to determine input and output quantities over a period of one year. Because of a lack of direct measurement data, losses were determined by difference.

Analysis of the cement manufacturing process suggested that much of the material loss in one plant resulted from process interruptions and malfunctioning equipment, and that much of this should be correctable with improved preventive maintenance and greater attention to housekeeping activities. Improvements were made in at least one area that resulted in an estimated reduction of clinker loss of about 12 tonnes/day at that one plant.

Much of the material loss indicated for the other plant appeared to occur as a direct result of the physical nature of the raw material directed to it. This material when crushed or otherwise physically impacted by the various plant processes, broke into relatively high percentages of fine, flowable, light and dusty particulate matter, much of which was difficult to impossible to contain and process through the plant into clinker. Nevertheless, improved housekeeping may have reduced losses in the raw material area by perhaps 20 tonnes/day.

Waste Minimization

Just as accountants use a system of double entry book keeping for efficient money management and balancing their books - any time funds leave one account they are identified as an input to another - so should industry manage its materials. The waste audit, using the principles of material balance - the weight of material entering (input to) a process must equal the weight of material leaving (output from) that process - thus provides information for efficient materials management, which means a minimum of waste.

We have had two major problems with implementing the philosophy in the past:

1) The full cost of waste usually has not been allocated back to the process generating it. This made it too easy to generate waste material and throw it away.

2) The assimilative capacity of the environment to receive our industrial waste was thought to be more than adequate.

Now we are learning that pollution is a threat to our environment, and we are realizing what chemists and engineers have known for a long time - that it is much easier to manage small quantities of simple concentrated wastes where they can be more easily eliminated, reused, or recycled, usually at the source, then it is to manage large quantities of complex dilute waste streams usually found at the end of processes. We are also learning that treatment technologies are not only often incomplete, but expensive, and the full costs of disposal are not always known; so we are now strongly advocating this new philosophy of waste management which aims at eliminating waste at the source.

Waste minimization is a simple management technique whereby we focus on the waste where it is generated, and to help us locate its source, character, and quantity we look at our processes from a material balance point of view.

Quattamia Plant

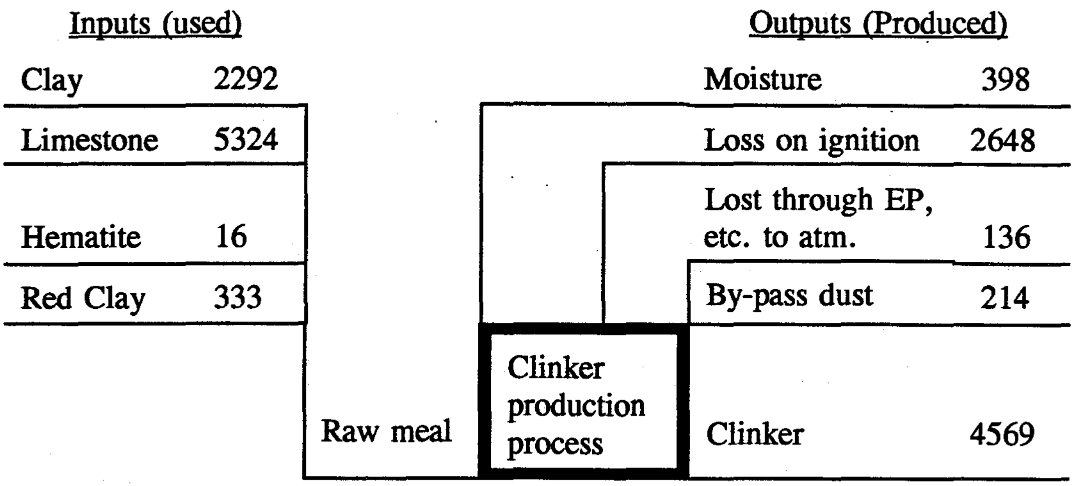
Production records averaged over an extended period of time indicated unaccounted for losses of material of 136 tonnes per day. See Table 1 and Figure 1 below.

Table 1. Quattamia Plant Production Data, 1991

Inputs (tonnes used)		Outputs (tonnes produced)	
701,443	Clay	1,397,926	Clinker
1,629,021	Limestone	65,600	Bypass dust to disposal
5,088	Hematite	121,867	Moisture @ 5%
101,796	Red clay	810,418	Loss on ignition (lab analysis)
		X	Losses to atmosphere, etc.
2,437,348	Total raw material feed to grinder and to kiln	2,437,348	Total outputs (By definition to balance inputs)

Solving for **X**, we get 41,537 or 136 t/day.

Figure 1. Quattamia Plant Material Balance (estimated daily average in tonnes)



7965 t/day <------- Totals ---------> 7965 t/day

Because equipment specification data suggests something less than 18 tonnes/day (see Table 1A) should be escaping via vents and leaks, closer examination of the cement-making process was warranted. Two important observations were noted: (1) The gravel bed filter (GBF) was almost hidden by dust; (2) There were numerous kiln stoppages throughout the year. Emissions from the GBF were quickly addressed allowing only a guess to be made by experienced observers as to the quantities involved. This reduction was suggested to be about 80% (from perhaps 15 tonnes loss per day to perhaps 3). Loss reductions in this area are very important because at this stage most of the manufacturing costs have already been put into the material, and all that upstream work will have been done for nothing if it is lost.

Kiln stoppages are very important too, because electrostatic precipitators (EP) are designed to work at plant operating temperatures; so if the air flow is not hot, the precipitator is by-passed until the proper temperature is reached. This means that for a period of time following kiln start-ups, instead of an estimated 99.8% collection efficiency, dust is not collected at all. It could even mean that more material in process is lost to atmosphere in several short periods of time as a result of a few kiln interruptions over several weeks than is lost during standard operating conditions over several years. In fact without kiln stoppages and malfunctioning electrostatic precipitators, losses should be reduced by perhaps 80% or more. It therefore should pay from both an environmental and material loss point of view as well as for other reasons to have kiln interruptions and precipitator malfunctions minimized. To do this, a good programme of preventive maintenance is required.

Table 1A. Emissions from Design and Engineering Specifications (est. t/day)

Kiln EP's	2
By-pass Dust EP	1
GBF	3
Unrecovered Other Plant Spills	12
Total	18
(From discussion with staff of Suez Cement Co. July 1992)	

It should be noted that according to the material balance exercise and above analysis, dust losses from equipment failures and leaks at well over 100 t/day make up a major loss in material second only to the deliberate disposal of by-pass dust.

Suez Plant

The limestone at the Suez plant is much drier and dustier than at Quattamia; so it is to be expected that production records would suggest higher unaccounted-for losses, and as we see in Table 2 and Figure 2 below, records over a similar period of time do show very high losses attributed to dust.

Table 2. Suez Plant Production Data, 1991

Inputs (used)		Outputs (produced)	
1,705,958	Kiln feed	952,357	Clinker
		24,085	By-pass dust to disposal (est.)
		610,562	Loss on ignition @ 35.79% (includes 0.8% moisture)
		X	Unaccounted losses to atmosphere, etc.
1,705,958	Total input	1,705,958	Total output (by definition to balance input)

Solving for **X**, we get 118,954 or 396 t/day.

Figure 2. Suez Plant Material Balance (estimated daily average in tonnes)

Inputs			Outputs	
			LOI & moisture loss	2028
			Dust loss to atm., etc.	396
			By-pass dust	80
Raw meal feed to Kiln	5668	Clinker Production Process	Clinker	3164

5668 t/day < ---------------- *Totals* ---------------- > *5668 t/day*

The above very preliminary material balance showing 396 t/day of dust to atmosphere suggests there to be a major problem with fine dust at the Suez plant. This indicated high emission of over 7% of raw meal feed compared to less than 2% at Quattamia really confirms other visual observations made concerning quarrying, crushing, conveying, and warehousing, some of which are addressed in another report (2).

The limestone raw material at this location, as indicated earlier, exhibits quite different properties from that at Quattamia. The extreme dusty nature is just one problem. In addition, it cannot be handled as efficiently as at Quattamia because of its highly flowable nature. It tends to run off the edge of conveyor belting and will not form a high pile in the warehouse. It would seem therefore that either the limestone properties must be changed to be more compatible with the existing plant equipment, or much of the plant equipment must be changed to be more compatible with the crushed limestone. Until this has been addressed it would only seem appropriate to tighten up equipment to reduce leaks and spills to a minimum while expecting only modest if any improvement in losses. This may well be the case as it is thought that the light and dusty nature of the Suez plant limestone causes a high percentage of it, on introduction to the kiln, to be blown directly to the stack where it is retained in the air pollution collection system for recycle back to the process, and on recycle to be blown again directly to the stack. This would in essence, along with the continuous introduction of new material, overload the air pollution collection devices unless some material is either deliberately by-passed to atmosphere or dumped to trucks for land disposal. Perhaps briquetting the EP dust would help the mineral portion traverse the full length of the kiln.

Perhaps even briquetting the fine dust fraction of the crushed raw material would reduce the flowable nature of the warehoused material allowing a higher angle of repose in the stock-pile and thus more efficient warehousing. This possibility was first brought to my attention by Mr. Abu-Zeid who will discuss it further in his presentation concerning Suez Plant limestone (2). On entering the kiln, perhaps less would then be blown immediately up to the electrostatic precipitators, making less collected material to be briquetted.

Aside from the above, application of the audit process as described in reference 1 (e.g. on page 14 "Any very obvious waste saving measures which can be introduced easily should be implemented immediately") drew attention to requirements in this area and led to almost immediate reductions in losses of perhaps 20 tonnes per day as a result of such housekeeping measures as plugging leaks and holes and changes in steel work to reduce spillage, especially in the raw mill area of the Suez plant. This could be very important as there is little sense in expending effort to bring material all the way to the plant if it is allowed to blow away.

Quantification of Particulate Emission

In both plants (at Quattamia and near Suez City) as it is with cement plants in general, it is extremely difficult to measure changes in material losses to atmosphere, except over long periods of time. Particulate emission sampling is tedious, expensive, time-consuming, and cannot be performed on a moment's notice. In addition, upset conditions resulting from kiln stoppages and air pollution control device failures, both releasing large quantities of particulates, are unpredictable. Sampling probably should be performed over air pollution control devices during both standard and upset conditions, but this as noted would not be easy.

As dust losses during kiln stoppages, at least at Quattamia, are believed to dwarf losses from other sources and situations, it would at first seem appropriate to minimize kiln stoppages with improved preventative maintenance programs, and compare production records of losses with those of previous periods of more numerous kiln stoppages. Results should justify the preventive maintenance program. At Suez, the nature of the problem as noted earlier, is believed to be different.

Conclusions

Because of the difficulties in measuring particulate emissions, it is not yet known what quantitative impact an improved housekeeping and preventive maintenance program would have in the cement plants at Quattamia and near Suez city.

At the Suez plant there is an estimate of about 20 t/day reduction in material lost as a result of increased attention to maintenance and housekeeping, but we do not know if this increased containment of very fine, light dust in the raw material area, because of its micron range particle size, only results in an equivalent increase in emission from the stack or elsewhere. However, there is a definite recognition of the necessity for a different approach to address fine dust losses here than at the Quattamia plant. This approach should involve investigation into agglomeration of fine particles and modification of material friability, or modification to processes, as a necessary step towards effecting major improvements in waste minimization (cleaner production) at the Suez plant.

Increased attention to housekeeping at the Quattamia plant has resulted in an estimated reduction of about 12 t/day of clinker dust lost through the GBF. Most other non-deliberate losses amounting to perhaps 120 t/day are believed to result from EP by-pass situations as a result of kiln stoppages and EP failures. This and other non-deliberate losses are thought to be addressed most appropriately by reducing failures and stoppages and tightening up leaks and spills with improved preventive maintenance and housekeeping programs.

Acknowledgments

The author wishes to acknowledge the assistance and data provided by Mr. Mostafa Abu-Zeid, National Expert, Mr. A.H Sadeek, and other members of the waste audit team, in order to look at waste management in the cement industry from a material balance perspective.

References

1. Audit and Reduction Manual for Industrial Emissions and Wastes, United Nations Publications, ISBN 92-807-1303-5.

2. Spotlight on the Limestone of the Suez Cement Plant, A paper presented at the March 1993 Seminar for Cleaner Production in the Cement Industry, by Mostafa Abu-Zeid, National Expert, in Collaboration with Suez Cement Plant Staff.

Annex IV

Heat Treatment of Alkali By-Pass Dust at Quattamia Plant

A presentation to the March 1993 Seminar on Cleaner Production in the Cement Industry, by A. Hamdy Sadeek and S.A. Yazeed, Environmental Protection Sector and Quality Control Departments, Suez Cement Company - Quattamia Plant, Box 2691, Cairo - Egypt.

Abstract:

Fresh samples of alkali by-pass dust are treated at high temperature (400 to 1400 C°) under equilibrium and non-equilibrium conditions. To simulate kiln burning under non-equilibrium conditions a prototype shaft kiln was built. Burning under equilibrium conditions retained the original SO3 content in the dust, whereas non-equilibrium burning indicated depletion of the alkalies Na, K, Cl, and SO3, thus promising possible further re-use of the disposed dust. A better terminology of the alkali by-pass dust could be partially sintered clinker-like material.

Introduction:

This report is the first in a series dealing with alkali dust treatment of the Quattamia Plant - Suez Cement Company.

To deal with the by-pass dust a precise knowledge of its chemical composition and properties are often required. However, it is not possible to list accurate chemical composition and physical data of the dust produced during clinker burning. The main reason, among others, for property variations of dust is its formation under conditions unique to its respective burning process which may vary hourly for the same kiln and from one kiln to another. In addition, the quantity of dust produced is dependent on the type and concentration of chemical components in the raw material which, again, may vary from one plant to another due to different quarrying locations, where Suez Plant disposes about 80-100 tons daily and Quattamia about 220-250 daily.

The dust carries a high content of free active lime and may reach up to 25-30%, dependent upon the degree of calcination, which is entirely slaked when moistened.

As expected, the dust produced at Quattamia plant is different from that of the Suez Plant in both quality and quantity and are about 80 km apart. At the Suez plant, experimentation was carried out by mixing the dust directly, without prior treatment except moistening, with clinker as explained in details of the Suez Plant report 1992. Whereas at Quattamia, a pre-treatment of dust is required before addition to clinker, because of its high alkali content.

The objective of this article is to thermally treat the Quattamia dust to a degree close to the clinker burning temperature of 1450 C° and to compare the resulting chemical analysis to that of the normally produced clinker. The re-use of the burned dust with clinker will be treated in another communication of this series.

Experimental Approach:

The burning of dust is performed as follows:

- In an enclosed muffle furnace simulating equilibrium conditions; and
- In a shaft kiln simulating non-equilibrium conditions similar to rotary kiln burning conditions.

1. Burning in an enclosed muffle furnace:

A few grams of freshly produced alkali dust is moistened with water and placed in a platinum crucible and heated at elevated temperature in a muffle furnace at 400 C° and increased step wise up to 1400 C°. At each temperature, the dust sample is heated for one (1) hour and its chemical composition was monitored via X-Ray fluorescence as listed in Table 1.

Table 1: Heat Treatment of the Alkali By-Pass Dust of the Quattamia Plant.

	Degree Centigrade					
Item, %	400	600	800	1000	1200	1400
SiO2	13.14	14.92	15.04	15.24	15.04	17.10
Al2O3	4.97	5.41	5.46	5.40	5.58	5.10
Fe2O3	1.73	1.75	1.79	1.80	1.96	3.11
CaO	48.64	52.58	53.02	55.38	58.08	61.06
MgO	0.85	0.87	0.90	0.95	1.00	1.09
SO3	8.28	9.47	10.80	10.10	10.30	10.10
K2O	4.32	4.50	4.17	3.55	2.88	0.67
Na2O	1.36	1.64	1.84	1.64	1.39	0.83
Cl	2.91	2.84	2.56	2.41	2.36	1.00
LOI	13.14	5.82	3.36	2.80	1.63	0.09
LSF	97.63	93.01	91.23	93.32	98.50	96.56
C3S						51.65

From Table 1 above:

- The sulphite (SO3) content has, for all practical purposes, remained the same and may be explained either the SO3 or fraction thereof is combined with the available CaO to form CaSO4 which may be retained within the burned sample because of the imposed equilibrium conditions rather than subliming at 1400 C°, or the SO_3 or fraction of it is strongly bonded in solid solution with other components in the burned mineral. Either explanation may be confirmed by the SO_3 content. Alternatively, extensive thermodynamic calculations are required.

- The K and Na content decreased to approximately 25% and 50% of their original values, respectively, and may be explained by alkali sublimation even at equilibrium conditions.

- The Cl content decreased to less than half of its original value possibly supporting the hypothesis of chloride formation with sodium (Na) and potassium (K).

- The C3S value for burned dust at 1400 C° is calculated free of SO3 contribution. The high value of C3S may promise further re-use of the burned dust.

2. *Burning in a Shaft Kiln:*

A few kilograms of the same dust composition used above was burned in a shaft kiln built at Quattamia for that purpose and shown in Figure 1. The shaft kiln is equipped with four (4) burners to deliver heat from an O2/Natural gas mix with temperature close to 1450 C° in which the samples are burned for about 6-8 hours.

The chemical analysis of the burned dust in the shaft kiln as compared to the normally produced clinker are listed in Table 2.

Figure 1: A Snap Shot of the Shaft Kiln Showing Entrance at the Far Right and Stack at the Far Left.

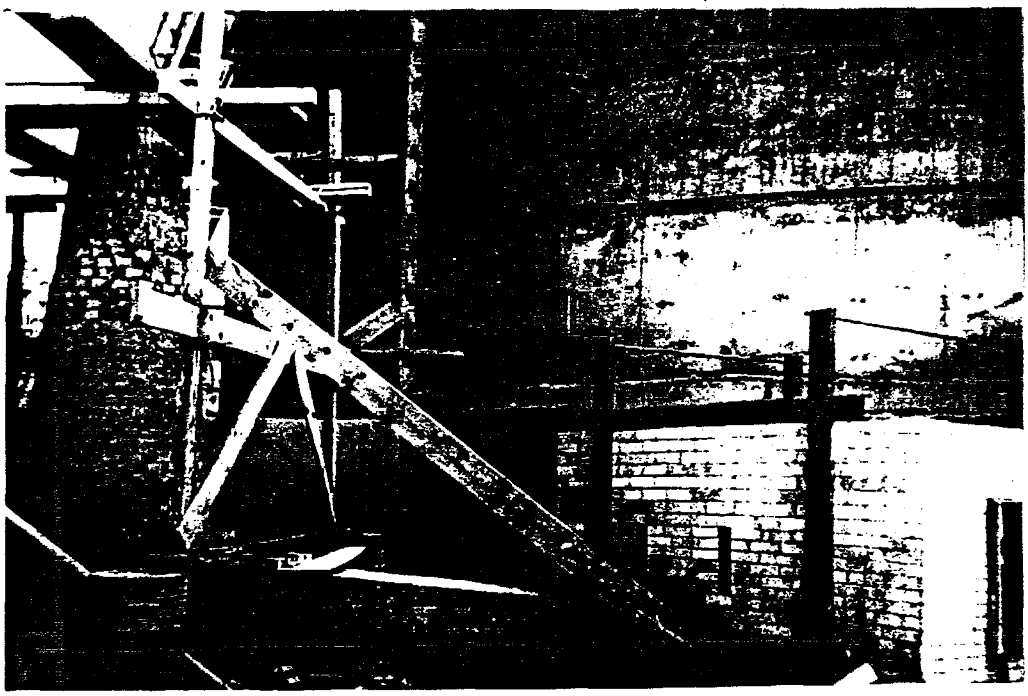


Table 2: Chemical Composition of the Dust Burned in the Shaft Kiln as Compared to Normal Clinker.

Item, %	Burned Dust 1400 C.	Av. Clinker Composition August 1992
SiO2	19.00	23.09
Al2O3	6.20	5.83
Fe2O3	2.60	3.40
CaO	60.00	64.16
MgO	1.00	1.30
SO3	6.90	1.60
K2O	1.31	----
Na2O	1.00	----
Cl	0.80	----
LOI	0.60	0.20
F.L.	1.40	0.30
C3S	54.45	41.48
C3A	12.67	9.72

Where free lime (F.L.) was determined by wet chemical analysis.

The mineralogical appearance of the burned dust was not the same if compared to clinker nodules obtained from the rotary kiln. The burned dust material had a glazed glassy appearance despite SiO_2 deficiency and may be due to over-heating.

The burned dust composition is comparable to that of the normal clinker produced in the kiln although with slight deficiency of the main components SiO_2, Fe_2O_3, and CaO but within any global specified range. Moreover, the results above may promise to re-use the burned dust as it is during cement grinding.

Should the slight deficiency of main components prove to be problematic in cement it may be possible to up-grade the quality by burning the dust with some clay and/or limestone. This possibility is the subject of another article which will be addressed in this March 1993 seminar on Cleaner Production in the Cement Industry.

Conclusions:

- To avoid excessive alkali enrichment in the burned dust it is recommended to burn at 1400 C°, or slightly above, under non-equilibrium conditions, as this simulate real kiln burning.

- It is possible to re-use the Quattamia alkali by-pass dust after being treated at the clinkering temperature of 1450 C°. The re-use will be in the form of addition of the burned dust in an optimum percentage to Quattamia clinker as long as it does not adversely affect the specifications of the finished product.

- To secure the active response of burned dust addition to clinker, complete chemical and physical testings of mixed samples of burned dust/clinker are required. In addition, cured cubes in different quality waters should be tested for an extended span period. This experimental approach will be treated in another report of this series.

- The terminology "Alkali By-Pass Dust" is considered commercial at best, and it is better, from the scientific viewpoint, that such dust be named "Partially Sintered Clinker-like Material" as it is essentially a fraction of the original feed to kiln, however, separated because of the dry process constraint of flow conditions. Hence, thoughts of mixing burned dust with clinker should not be prohibited, as it is essentially clinker as supported by its chemical analysis.

References:

1. Re-Use of the Alkali By-Pass Dust at Suez Plant - Egypt by the Environmental protection department, Suez Cement Company, Box 2691, Cairo - Egypt, November 1992.

Acknowledgement:

The full support of the Suez Cement Company Management is gratefully acknowledged.

Annex V

Mixing of the Burned Alkali By-Pass Dust with OPC Clinker - Quattamia and Suez Plants

A presentation to the March 1993 Seminar on Cleaner Production in the Cement Industry, Cairo, Egypt, by A. Hamdy Sadeek, S.A. Yazeed, Mamdouh Ramadan and Hamdy Hussein, Environmental Protection Sector and Quality Control Departments, Suez Cement Company, Box 2691, Cairo, Egypt.

Abstract:

In the laboratory, different percentages of alkali by-pass dust burned at 1400 C° were mixed with the normally produced clinker and gypsum from Quattamia. The resulting Ordinary Portland Cement (OPC) was tested for chemical and physical properties employing conventional techniques. All analyzed cement samples were within the global cement specifications. It is possible to re-use alkali dust, after burning by adding up to 5% of it, and maybe more, to clinker during cement grinding. The same may be achieved for the Suez plant as its by-pass dust is considered better quality as compared to that of Quattamia.

Higher percent addition of the burned dust will be investigated further in the future.

Introduction:

In the first article of this series (1) it was reported that the non-equilibrium burning of alkali dust at temperatures near the clinkering temperature yields a material very close in chemical composition, although slightly deficient in some of the main components, as that produced from a rotary kiln. This observation activated thoughts to possible re-use of the burned dust.

The objective of this report is to study, on a laboratory scale, the chemical and physical properties of cement prepared from a mix of the burned dust with ordinary produced clinker and gypsum.

Experimental Approach:

A few kilograms of alkali dust are burned under non-equilibrium conditions in the pilot shaft kiln for four (4) hours at 1400 C°. Fractions of 3%, 4%, and 5% of the burned dust are mixed with normally produced clinker from the Quattamia plant and a constant 6% gypsum.

X-Ray fluorescence, wet analysis, & conventional physical testing were the employed analytical techniques. Insoluble Residue (I.R.), Free Lime (F.L.), and Loss on Ignition (LOI) were determined by wet analyses. The results are listed as follows.

Table 1: Chemical Analysis of Base Materials Used in the Laboratory Investigation.

Item	Dust as Received	Burned Dust at 1400 C	Quatt. Clinker	Gypsum
	%	%	%	%
SiO2	15.04	19.00	22.60	
Al2O3	4.78	6.20	5.84	
Fe2O3	2.20	2.58	3.33	
CaO	50.46	60.00	64.32	
MgO	0.80	1.00	1.02	
SO3	9.11	6.94	1.70	30.00
K2O	3.74	1.31	0.84	
Na2O	1.23	1.00	0.01	
Cl	6.37	1.56	0.00	
LOI	6.02	0.60	0.20	
F.L.	18.00	1.40	0.30	
I.R.	..........Data not available...........			
LSF		88.49	87.13	
C3S		54.45	45.92	

The burned dust is obviously deficient in SiO2 and Fe2O3, although it is within the specified ranges of global specifications. In addition, its C3S is about 22% higher as compared to clinker, a fact that may contribute actively to cement early strength.

The burned dust is added in small percentages to Quattamia clinker during cement grinding to test its effect on cement quality. To the produced clinker a constant percent of 6% gypsum and 3%, 4%, and 5% of the burned dust are added. The mixed samples are analyzed, and results (Table 2) are as follows:

Table 2: Chemical & Physical Testing of Cement Synthesized from Burned Dust (D), Quattamia Ordinary Portland Clinker (KK) and fixed 6% Gypsum (G) as Compared to the E.S.373/91 Requirements.

	Mixed Cement Samples of D / KK /G			ES 373/91
	03/91/06	04/90/06	05/89/06	Requirements
Chemical Composition: (%)				
SiO2	21.78	21.76	21.05	
Al2O3	5.58	5.56	5.58	
Fe2O3	3.18	3.17	3.10	
CaO	62.84	62.30	63.30	
MgO	1.20	1.20	1.10	
SO3	3.05	3.04	3.00	3.5 Max.
K2O	0.40	0.40	0.40	
Na2O	Below the detection limit			
Cl	0.06	0.06	---	
LOI	1.62	2.35	2.85	4.0 Max.
I.R.	0.30	0.30	0.30	
LSF	87.04	86.17	90.46	
C3A	9.40	9.38	9.55	
C3S	39.49	37.05	47.17	
Physical testing:				
Blain, M2/Kg	300	290	286	275 Min.
W/C	26.5	26.5	28.5	
Setting Time, Vicat , Minutes:				
Initial	95	97	125	45 Min.
Final	115	119	151	600 Max.
Comp. St. N/mm2:				
3-d	33.4	33.4	31.6	18 Min.
7-d	42.0	39.1	41.3	27 Min.
28-d Optional	52.8	55.1	48.2	37
LeChatelier Expansion, mm:	0.1	0.1	0.1	10 Max.

One distinctive effect, from the above results, is the increase of C3S% by the addition of burned dust.

The results above are all within the E.S.373/91 specifications. In addition, testing above may follow the B.S.12/89 and ASTM C-150 specifications as given below in Table 3.

Table 3: Comparison of Properties Between Selected Mixed Composition of 03/91/06 and 05/89/06 (D/KK/G), and Requirements of the B.S.12/89 and ASTM C-150.

Comp't	B.S.12/89 Specs.	ASTM C-150 Specs.	D/KK/G 03/91/06	D/KK/G 05/89/06
	OPC/RHC (%)	OPC/RHC (%)	(%)	(%)
Chemical:				
LOI	3.0 Max.	3.0 Max.	1.62	2.85
MgO	4.0 Max.	6.0 Max.	1.20	1.10
SO3	3.5 Max.*	3.0/3.5** Max.	3.05	3.00
Cl	0.1 Max.	-------	0.06	----
C3A	---	--/15.0 Max.	9.40	9.55
I.R.	1.5 Max.	0.75 Max.	0.30	0.30
Physical:				
Air Content of Mortar (%):	---	12.0 Max.	2.8	2.9
Blaine (M2/kg):	275/350 Min.	280 Min./--	300	286
Setting Time, Minutes, (Vicat):				
Initial	45 Min.	45 Min.	95	125
Final	600 Max.	375 Max.	115	151
Expansion:				
LeChatelier, mm:	10 Max.	---	0.1	0.1
Autoclave (%):	---	0.8 Max.	0.15	0.09
Comp. Strength (N/sq.mm):				
1-d	---	--/12.4 Min.	17.2	16.5
2-d	--/25.0 Min.	---	---	---
3-d	25/-- Min.	12.4/24.1 Min.	33.4	31.6
7-d	---	19.3/--- Min.	42.0	41.3
28-d	47/52 Min.	---	52.8	48.2

Where: *) For C3A > 3.5 % and **) For C3A < 8.0 %, and 4.5% for C3A > 8.0%.

All samples are within the specifications of both British and US. The 28-d compressive strength of the 05/89/06 is below that of the BS Specifications and may be achieved by higher Blaine. The results cannot be compared to the C-150 Specifications as the compressive strength cubes used were that of the B.S. 12/89.

Conclusions:

- Burned dust at 1400 C° is deficient in main components SiO_2, Fe_2O_3, and slightly in CaO although are within the specified ranges of global requirements.
- Increase of C3S% in the cement samples upon the addition of the burned dust.
- Mixing of small percentages of the burned dust with the Quattamia clinker during cement grinding has no harmful effect on cement quality as all tested samples complied with the Egyptian and other global requirements.
- It is possible to mix up to 5% burned dust with clinker without adversely affecting the finished product specs.
- The addition of burned dust requires some capital investment and the return is an approximate 150 to 200 tons of cement daily.
- The re-use of the burned dust simply avoids the use of the expensive landfill and contributes directly to a cleaner vicinity and environment.
- Compressive strength testing over a span period of 3-6 years has been prepared and will be performed in due time every 6 months.
- Mineralogical studies are required, and will be taken into consideration for both the burned dust and cement samples. This approach is in progress.
- For completion of this task it is planned to use the prepared mixed cement in concrete to test the effect of adding the burned dust to cement clinker.

References:

1. Heat Treatment of Alkali By-Pass Dust by Environmental Protection and Quality Control Departments, Suez Cement Company - Quattamia Plant 1992. Box 2691, Cairo - Egypt.

Annex VI

Properties of Cement Synthesized from Burned Alkali Dust/Clay Mix with Clinker and Gypsum - Quattamia Plant

A presentation to the March 1993 Seminar on Cleaner Production in the Cement Industry, by A. Hamdy Sadeek, S.A. Yazeed, Mamdouh Ramadan and Hamdy Hussein, Environmental Protection Sector and Quality Control Department, Quattamia Plant, Suez Cement Co., Box 2691, Cairo, Egypt

Introduction:

Burned dust produces a clinker-like material (1) but deficient in some of the main components particularly SiO2 and Fe2O3. To compensate for components deficiency a few percent of clay may be mixed with the alkali dust and the mix is burned at temperatures near the clinkering temperature.

The mixing of dust with clay offer a better chance for clay silicates to actively react with calcium compounds, sulfates and chlorides, of the dust and possibly may release more of the enriched alkalies of the dust while increasing the content of SiO2 and Fe2O3. In addition, the clay-dust mix reaction may proceed with better burnability.

The objective of this communication is to study, on a laboratory scale, the properties of burned dust/clay mix and its effect on cement specifications when added to the normally produced clinker at Quattamia plant.

Experimental Approach:

- X-Ray fluorescence is the employed analytical technique, F.L. and I.R. are determined by wet analysis;
- Alkali dust and clay are chemically analyzed;
- Alkali dust is burned at 1400 C°;
- Mixed samples of 02/98, 03/97, 04/96 and 05/95 clay/dust composition are prepared, homogenized with little water and burned gradually in a shaft kiln at 1400 C° for 6 hours and analyzed.

Table 1: Chemical Analysis of Alkali Dust, Clay, Burned Dust and Clay/Dust at 1400 C°

	Alkali Dust	Burned Dust	Clay	Burned Clay/Dust Mix 02/98	03/97	04/96	05/95
	%	%	%	%	%	%	%
SiO2	15.00	19.00	45.49	21.40	21.40	21.50	22.00
Al2O3	4.78	6.20	10.98	6.27	6.22	6.20	6.25
Fe2O3	2.20	2.58	5.07	3.07	3.14	3.10	3.20
CaO	50.46	60.00	16.94	60.56	60.86	61.52	62.00
MgO	0.80	1.00	1.50	1.00	1.02	1.00	1.00
SO3	9.11	6.94	2.65	4.96	5.40	2.96	3.50
K2O	3.74	1.31	1.74	0.76	0.80	0.65	0.60
Na2O	1.23	1.00	1.30	0.78	0.50	0.47	0.65
Cl	6.37	1.56	0.32	0.92	0.80	0.09	0.10
LOI	6.02	0.60	14.50	0.40	1.60	1.35	1.10
F.L.	18.00	1.40	---	1.20	1.00	0.84	0.78
LSF	---	88.49	---	82.06	82.22	85.35	83.66
C3S	---	54.45	---	37.31	38.77	40.89	38.65

From the above results, it is clear that chemical composition of the burned clay/dust mix is nearly that of the normal clinker and less deficient in both the main components and alkali content when compared to burned dust.

Cement samples are prepared from the burned clay/dust mix, normal Quattamia clinker and gypsum. The proportions of cement samples and their chemical and physical testing are given in Table 2.

Table 2: Analysis of Cement Samples Made from Burned Clay/Dust Composition of 3%, Fixed 6% Gypsum and Quattamia Clinker as Compared to OPC made of Quattamia Clinker.

	Blank	CEMENT SAMPLES " C-D/G/KK"			
	Cement	02/06/92	03/06/91	04/06/90	05/06/89
Chemical Analysis (%):					
SiO2	21.42	21.89	21.90	21.95	22.06
Al2O3	5.70	5.68	5.72	5.74	5.82
Fe2O3	3.17	3.19	3.19	3.17	3.16
CaO	62.57	62.70	62.77	62.69	62.54
MgO	1.20	1.20	1.18	1.20	1.20
SO3	3.20	2.99	3.10	3.00	3.10
K2O	0.33	0.42	0.40	0.42	0.40
Na2O	----	----	----	----	----
Cl	0.01	0.05	0.02	0.05	----
LOI	1.79	1.65	1.82	1.60	1.82
I.R.	0.33	0.3	0.3	0.3	0.3
LSF	87.32	86.16	86.52	85.81	85.26
C3A	9.75	9.66	9.77	9.85	10.08
C3S	39.6	37.59	37.20	37.01	34.44
Physical testing:					
Blaine (M2/Kg):	349	280	315	297	298
W/C Ratio:	26.0	26.5	27.4	26.5	26.0
Setting Time (Minutes):					
Initial	123	95	100	95	110
Final	148	115	130	120	123
Comp. St. (N/mm2):					
3-d	31.3	30.4	32.6	27.6	32.3
7-d	39.6	39.9	42.7	38.4	
28-d		54.5	53.0	52.3	51.4
LeChatelier (mm):	0.1	0.1	0.1	0.1	0.1

Where: C-D : The 03/97 Composition of Burned Clay/Dust Mix;
G : Gypsum ; and KK : Quattamia clinker.

Table 3: Analysis of Cement Samples Made from Burned Clay/Dust Composition of 4%, Quattamia Clinker, and fixed 6% Gypsum.

	Blank Cement	CEMENT SAMPLES " C-D/G/KK" 02/06/92	03/06/91	04/06/90	05/06/89
Chemical Analysis (%):					
SiO2	21.42	22.00	22.08	22.21	22.30
Al2O3	5.70	5.62	5.66	5.68	5.54
Fe2O3	3.17	3.24	3.30	3.26	3.18
CaO	62.52	62.21	62.10	62.00	61.92
MgO	1.20	1.20	1.10	1.20	1.20
SO3	3.20	3.05	3.10	3.00	3.38
K2O	0.33	0.42	0.41	0.42	0.41
Na2O	----	----	----	----	----
Cl	0.01	0.06	----	0.07	0.03
LOI	1.79	1.84	2.10	1.60	1.80
I.R.	0.33	0.33	0.32	0.30	0.30
LSF	87.32	85.18	84.69	84.22	83.70
C3A	9.75	9.42	9.42	9.54	9.31
C3S	39.6	34.90	33.34	32.16	31.13
Physical testing:					
Blaine (M2/Kg):	349	305	291	297	285
W/C Ratio:	26	26.0	28.0	26.5	265
Setting Time (Minutes):					
Initial	123	95	100	95	90
Final	148	114	135	120	122
Comp. St. (N/mm2):					
3-d	31.3	30.4	30.8	32.7	29.3
7-d	39.6	42.4	42.5	41.2	40.5
28-d	51.0	50.2	52.8	52.6	51.4
LeChatelier (mm):	0.1	0.1	0.1	0.1	0.1

Where: C-D : The 04/96 Composition of Burned Clay/Dust Mix;
G : Gypsum ; and KK : Quattamia clinker.

Table 4: Analysis of Cement Samples Made from Burned Clay/Dust Composition of 5%, Quattamia Clinker, and fixed 6% Gypsum.

	CEMENT SAMPLES " C-D/G/KK"			
	02/06/92	03/06/91	04/06/90	05/06/89
Chemical Analysis (%):				
SiO2	21.14	21.32	21.64	21.68
Al2O3	5.63	5.61	5.60	5.62
Fe2O3	3.14	3.14	3.10	3.15
CaO	63.08	62.64	63.40	62.40
MgO	1.10	1.10	1.10	1.15
SO3	2.95	2.98	3.05	3.00
K2O	0.42	0.41	0.40	0.40
Na2O	0.02	0.03	----	----
Cl	----	----	----	----
LOI	2.67	3.05	2.94	3.00
I.R.	0.35	0.36	0.30	0.3
LSF	89.70	88.44	86.93	86.77
C3A	9.61	9.56	9.60	9.57
C3S	45.34	42.23	38.75	38.37
Physical testing:				
Blaine (M2/Kg):	294	301	290	285
W/C Ratio:	28.5	27.5	27.5	28.5
Setting Time (Minutes):				
Initial	138	140	128	160
Final	190	160	156	193
Comp. St. (N/mm2):				
3-d	31.2	32.1	30.4	29.0
7-d	41.2	40.4	41.4	40.9
28-d	55.6	53.1	51.2	53.4
LeChatelier (mm):	0.1	0.1	0.1	0.1

The following Table 5 lists the E.S.373/91, B.S.12/89, and the ASTM C-150 specifications and may be compared to the above results of Tables: 2, 3, and 4.

Table 5: List of the Egyptian, British, and U.S. Requirements for Ordinary Portland Cement: E.S.373/91, B.S.12/89, and ASTM C-150, Respectively.

Comp't	Ordinary Portland Cement Specs. E.S.373/91	B.S.12 /89	ASTM C-150
Chem. Requirements:			
LOI (%)	4.0 Max.	3.0 Max.	3.0 Max.
MgO (%)	4.0 Max.(a)	4.0 Max.	6.0 Max.
SO3 (%)	3.5 Max.(b)	3.5 Max.(b)	3-3.5 Max.(c)
Cl (%)	---	0.1 Max.	---
C3A (%)	---	---	15.0 Max.
I.R. (%)	1.5 Max.	1.5 Max.	0.75 Max.
Physical Requirements:			
Air Content of Mortar (%):	---	---	12.0 Max.(d)
Blaine (M2/kg):	275 Min.	275 Min.	280 Min.
Setting Time, Minutes, (Vicat):			
Initial	45 Min.	45 Min.	45 Min.
Final	600 Max.	600 Max.	375 Max.
Expansion:			
LeChatelier, mm:	10 Max.	10 Max.	---
Autoclave (%):	(a)	---	0.8 Max.
Comp. Strength (N/sq.mm):			
3-d	18 Min.	25 Min.	12.4 Min.
7-d	27 Min.	---	19.3 Min.
28-d	---	47 Min.	---

Where: a) If MgO is > 4% & max. of 5%, the autoclave test shall be carried out with a max. result limit of the ASTM C-150 requirements,

b) For C3A > or = 3.5 %, and c) SO3=3% for C3A < 8%; SO3=3.5% for C3A 8%

d) For Suez Cement, the Max. value is 2.5 - 3.0 %.

The results in Table 5 cannot be compared to the C-150 Specifications as the compressive strength cubes were that of the B.S. 12/89.

Comparing Results of Tables 2, 3, and 4 with global specifications listed in Table 5, it is clear that all cement samples results are within their requirements.

Conclusions:

- Mixing a small percentage of clay with the alkali dust during burning at 1400 C° increase the main components content in the resulting clinkering material. As observed, the clay helps the burning process.

- Future plans is to try the addition of higher percentages of the burned clay/dust to normal clinker.

- Compressive strength testing over a span period of 3-6 years has been prepared and will be performed periodically every 3-6 months

- Mineralogical studies are required, and will be taken into consideration for both the burned dust and cement samples. This approach is in progress.

- For completion of this task it is planned to use the prepared mixed cement in concrete to test the effect of adding the burned dust to cement clinker.

- This laboratory investigation demonstrate possible re-use of the Quattamia dust. On a larger scale, however, some capital investment is needed to design a mini-process that may handle burning all the produced dust which amounts to approximately 220 to 280 tons daily. The preliminary feasibility studies suggest an approximately one to three million US dollars with an anticipated pay-back period of one to two years.

- It is clear that re-use of the Quattamia alkali dust after burning in such manner will contribute to cleaner environment and to capital gain.

- Last but not least, we must invest if we really care for our environment.

References:

1. Heat Treatment of Alkali By-Pass dust by Environmental Protection and Quality Control Departments, Suez Cement Company - Quattamia Plant 1992, Box 2691 - Cairo , Egypt.

Annex VII

Waste Minimization at The Quattamia Cement Plant

A presentation to the March 1993 Seminar on Cleaner Production in the Cement Industry, Cairo, Egypt, by A. Hamdy Sadeek and A. Shebel, the Environmental Protection Sector and the Production Department, Suez Cement Company, Box 2691, Cairo - Egypt.

In this context, waste is defined as any material losses and it could be raw materials, end products or by-products that may contribute to environmental hazards during handling and/or processing.

The approach for waste minimization developed by UNIDO will be implemented at the Quattamia Cement Plant, Suez Cement Co., Egypt. The approach known as "Waste Audit Approach" (1) is based upon the knowledge of accurate information about the origins and sources of material involved. Once the sources are identified the most cost-effective options for avoiding, reducing and recovering wastes can be evaluated. For Quattamia Plant and due to the high alkali content in raw materials the by-pass dust, product of the dry process (2), is only recovered and cannot be minimized. It may be possible to reduce such dust but that only may be achieved by using better quality materials with less alkalies which often isn't possible.

The objective of this report is a trial to implement the Waste Audit Approach at the Quattamia Plant hoping to reduce emission of waste materials to the environment and to reach the cleanest status possible under the present working conditions. To achieve the goal, the plant was divided into unit operations where each will be dealt with, and assessed, separately, and then the entire process, focusing on the kiln section, will be evaluated in terms of material balance.

For illustration, Figure 1 is a flow block diagram for the cement plant at Quattamia.

Figure 1: Block diagram for the Quattamia Plant

```
   -----------------------          ----------------------------
  : L/S Crusher           :        : Clay Crusher               :
  : Hazimag Impact        :        : Buckaw Wolf Double Roller  :
  : 1000 T/h              : ------ : 400 T/h                    :
  : Power: 2 X 1000  KW   :   :    : Power: 2 X 132  KW         :
  : RPM:   1000           :   :    : RPM:    750                :
   -----------------------    :     ----------------------------
                              :
                              V
         ---------------------------------------------
         :            L/S and Clay Storage            :
---------: L/S:   2 X 50000 t ; 152 m X 38 m  each    :-------------
:        : Clay:  2 X 15000 t ; 104 m X 25 m  each    :            :
:         ---------------------------------------------            :
:                                                                  :
:    ---------------------            ----------------------       :
:   : Raw Mill 1          :          : Raw Mill 2           :      :
:   : 210   T/h           :          : 210   T/h            :      :
--> : Pol. Cent. Disch.   :----------: Pol. Cent. Disch.    :<------
    : Single Drive        :     :    : Single Drive         :
    : 2.6 MW ; 15.85 RPM  :     :    : 2.6 MW ; 15.85 RPM   :
     ---------------------      :     ----------------------
                                V
       ---------------------------------------------------------
       : Storage Silo                  :   Homo Silos, Batch   :
       : 2 X 10000   T                 :   2 X 3717   T        :
       : 18 m X 38 m each              :   18 m X 25 m each    :
       ---------------------------------------------------------
                               :
                               V
  ---------------------------------------------------------------------
  : Pol. PREPOL Kiln, 4500 T/h, 5 m dia., 83 m length, 2 X 500 KW,    :
  : 480 - 1480 RPM Drives.                                            :
  : Preheater w/ PC, 4 burners, 60% of fuel, IDF = 450000 M3/h each   :
  : Grate Cooler, 30 m length, 4.2 m width, 3 Drives 70 Kw each.      :
  ---------------------------------------------------------------------
                               :
                               V
               ---------------------------------
  -------------:         Clinker Storage        :
  :            :  Concrete Silos, 3 X 20,000  T :-------------------
  :            ---------------------------------                   :
  :                                                                :
  :   -------------------------       ------------------------     :
  :  : Cement Mill 1           :     : Cement Mill 2          :    :
  :->: Closed Circuit, 140 T/h :-----: Open Circuit, 140 T/H  :    :
     : Double Drive, 2 X 2.6 KW :  : : Double Drive, 2 X 2.6 KW :<--:
     : RPM = 15.1              :  :  : RPM = 15.1             :
      -------------------------   :   ------------------------
                                  V
                  ----------------------------------
                  :   Six (6) Cement Silos         :
                  :   15.000 T each                :
                  :   18 m dia. and 54.5 height    :
                  ----------------------------------
```

The Limestone Quarry Unit Operation

The limestone quarry features a Hazemag crusher and a network of dust collectors. All units of dust collectors are functioning properly.

Possible origin and sources of spillages in this area are:

- During blasting of the limestone face, done twice weekly, the blast is accompanied with fly off dust and is uncontrollable. The only way to avoid fly off L/S dust into the remote vicinity is to cover the whole area, about one square km, with a plastic bubble;

- During loading of trucks and dumping in the L/S hopper and both are beyond control. See comments below.

It is assumed, however, that flying off L/S dust in the near vicinity is going back to nature, and with favorable wind direction which is often the case in Quattamia the dust eventually settles on the hilly deserted side south of the crusher with no chance to harm even the wild life. Wild life in the valley isn't more than wandering camels, donkeys, desert foxes and the deadly desert snakes, and the few Bedouins in the area are far off the plant site.

The Limestone Storage Unit Operation:

Crushed limestone is conveyed for almost one km distance and is completely enclosed with little chance, if any, of spillage. Along the belt conveyor stretch there is a chance of L/S particles, $< 200\ \mu m$, escaping through the contact surface between the conveyor belt and the cover of the steel support, and the quantity of which is little as compared to the quantity conveyed, $>$ 1.6 million tons per year.

The crushed L/S is Chevron's stacked within the enclosed area where the fine L/S particles are flying off the height of the storage hall where they accumulate and settle on both sides of the piles. The estimated enclosed spillage on both sides of the stacked piles is:

$$\text{Spillage} = m * (n*h*w*L) * d$$

where:

L = Length of the 2 piles in meters, and is equal to 300 m;
n = 2, as the fine dust accumulates on both side of the stacked piles with: height $h = 0.3$ m, and width $w = 2$ m;
m = 2, as both sides are emptied twice/year;
d = 1.3 ton/m^3, is the fine L/S density.

Hence:

$$\text{Spillage} = 2 * (2*0.3*2*300) * 1.3 = 936 \text{ Ton/year.}$$

Most of the 936 Ton/year spillage is reclaimed back into the system with little chance of losses to the vicinities.

Feasibility studies, technical and economical are in progress concerning the design of a new spray water system, to minimize dust emission, on L/S trucks while dumping in the hopper and at the movable L/S tripper involving the full length of the storage hall.

The Clay Quarry Operation:

The dual crusher system is equipped with a properly maintained network of dust collectors with little chance of clay dust escape. Only during loading and dumping in the hopper is there some dust observed escaping to the natural remote vicinity and back to nature. Because of the moisture content of the clay, which may be as high as 18%, fly off dust here is less than in the case of limestone.

Occasional blasting, once/month, taking place where the fly off fraction, estimated at $< 0.1\%$, resettles within the natural vicinity south of the crusher.

The Clay Storage Unit Operation:

Because of the high moisture content of the clay reserves, 10-18%, the storage location is in the open atmosphere where under the mostly sunny weather of Egypt some of this moisture escapes an action that may contribute to energy savings during thermal processing.

The crushed clay is conveyed about 1.2 km to its storage location with little chance of spillage, as the conveyor is covered, except when the belt is cut loose and/or escaping of the very fine dust occurs at the contact surface between the belt and the covered steel support. The material is reclaimed back to the system when the belt is cut and the remaining escaped fly off dust is very little with no harm to nature.

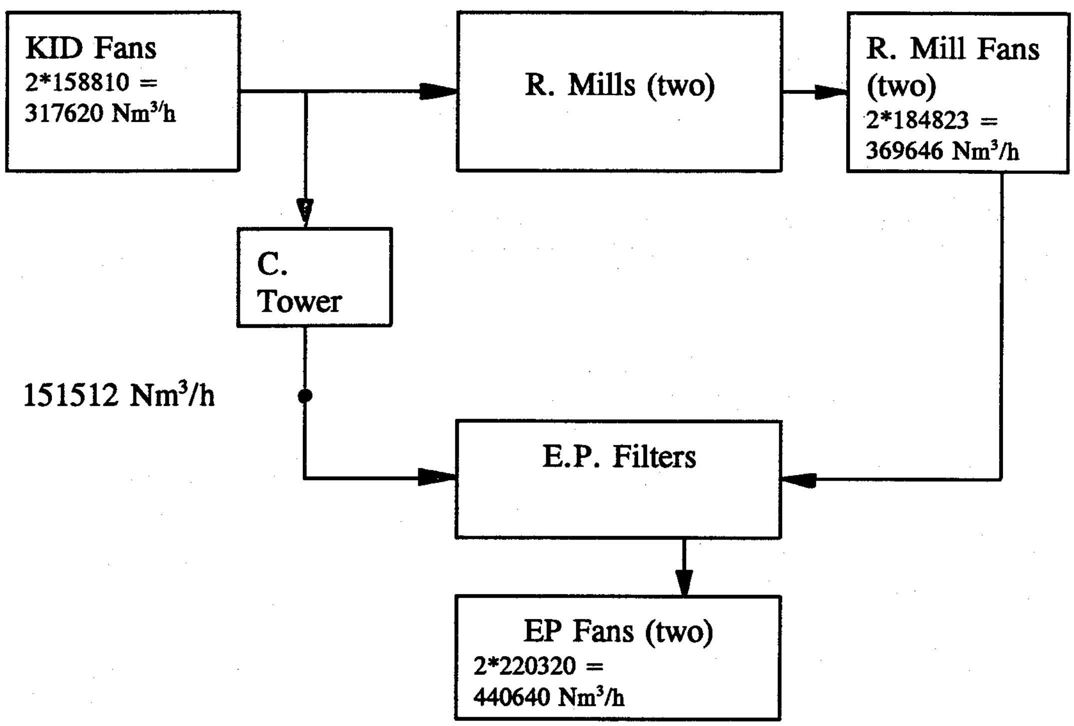
The clay piles are Windrow stacked and depending on wind direction, mostly South, there are frequent chances of fly off clay dust southward and it is difficult to estimate, but fortunately the wind driven clay dust is accumulated on the northern side of the nearby L/S storage steel structure wall where it may be reclaimed periodically and fed back into the system.

Raw Mills Unite Operation:

This area is considered problematic because of:

a) Over-pressure is experienced because of false air. The two EP fans, known as the stack fans, are designed to run efficiently in absence of any false air and they are. However, the two EP fans appears less efficient with the false air resulting in dust jets pouring either from the mills when in operation or from the cooling tower when the mills are being maintained. For illustration see the following sketch:

Figure 2:



Difference between gases produced and gases taken by E.P. fans =
= 440640 - (151512 + 369646) = - 80518 Nm^3/h (as over pressure)

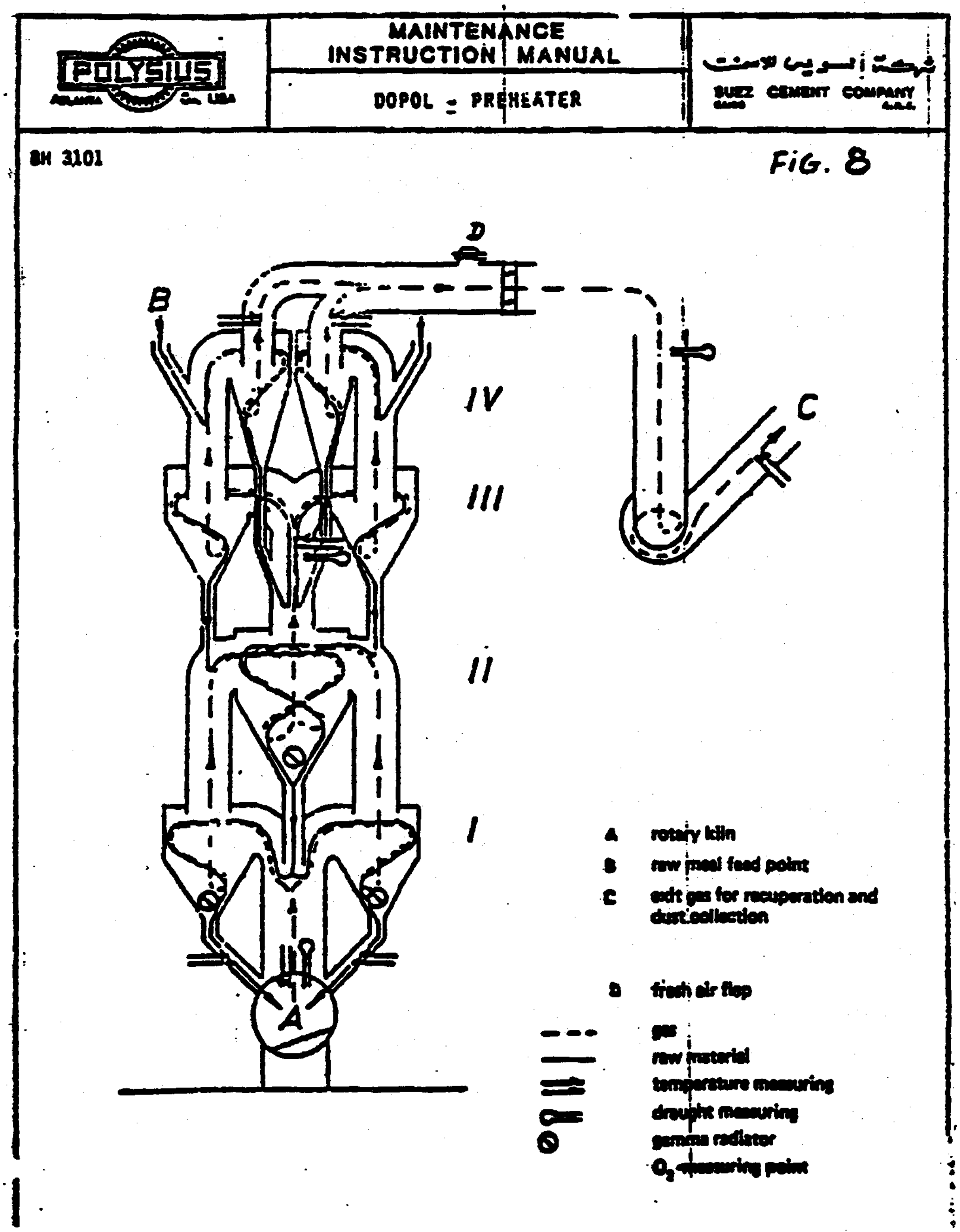
b) No way to control the quantity of hot gas flow from the preheater tower going into the raw mills as there is no modulated gate between the raw mills and cooling tower. An addition of a properly located gate, see above sketch, and/or higher EP fan capacity is required to avoid the over-pressure and feasibility studies of these matters are in progress;

c) Experienced spillage from the conveying networks, bucket elevators, de-dusting pipe...etc., of the milled raw mix to the homo-silos due to worn out steel casings within the system, and was properly maintained with less spillage, however, this area still require further investigation to be accepted by the Environmental Sector standards of the Suez Cement Company;

d) Generally, it is difficult to assess the quantity of spillage, however continuing overhaul of the steel casings of the ducts, cyclones, and bucket elevators is helping somehow.

Pre-Heater, Kiln-Cooler and Clinker Transport Center:

Figure 3:



The Quattamia Plant has been in operation for eight years, and through the 4-stage preheater tower the temperature ranges between 360° C for the exit gas at stage 4° to 1000° C at the kiln inlet. Because of the excessive heat and the dozens of installed super air blasters, needed for automatic cleaning of stage 1 and kiln inlet due to the high content of alkalies in the raw mix, in key locations of the pre-heater led to weakening of the tower casings at different spots. There is continuous overhaul of worn-out areas of the steal casings to avoid emission of materials from the tower.

In cement industry, stoppages of the production line is expected for variety of reasons. In case of high CO, < or = 0.5% setting for the Quattamia Plant which is considered the lowest for any plant, the EP filters must trip while the kiln ID- and EP-fans continue to operate, resulting in directing the path of the heavily entrained gas flow through the main stack with excessive dust load.

There are about 20 stoppages per year because of high CO, and each may require 10 minutes or less to get the process line in operation meaning an estimated 7 to 8 tons of dust, or a total of 150-160 tons dust/year through the stack. The amount of dust purged through the stack may not be re-routed into the system because of the high content of alkalies and is considered beyond control unless better raw materials are used which is not possible. In fact Suez Cement Co. is investing heavily in purchasing better quality clays from far distant remote areas to minimize forced dust emission through the stack.

In addition to the above CO halt, it is seldom, yet it happens about twice/year, that power dips occur because of problems in the main power lines feeding the plant. Such action lead to a complete halt of the production line resulting in an over-pressure all along the process stretch. Auxiliary drives are available for kiln only. The estimated dust emission through the line and the stack is estimated at less than one ton for 1-4 hours stoppages.

Other short stoppages, estimated at 50-60/year, are due to different reasons, electrical and/or mechanical, and with the EP filters on line there is a minimal quantity of dust emission as during such short stops the dust is passed into the system.

The level probes of the clinker cooler flabs are obsolete type and are out of order most of the time because of the heat involved resulting in isolating the cooler from the drag chain leading to excessive spillage of clinker dust in the cooler outlet area. A dust collector was installed with partial success and further studies concerning the state of the art of level probes is in progress. The spilled clinker dust, however, is being reclaimed periodically with minimum losses to the environment.

The uncovered steel conveyor, for reasons of further cooling by wind to the already quenched clinker, is transporting the crushed clinker while the fine dusty fraction is collected by the gravel bed filter (GBF) with efficiency of 150 mg/m^3h. Windy days result in some fly off clinker dust and cannot be estimated.

The chances of falling crushed clinker from the elevated steel conveyor is infrequent and estimated at few tons/year and all are reclaimed and fed via the emergency clinker hopper.

As of the clinker silos they are totally enclosed concrete structures with no chance of clinker dust to escape through. It is only during discharging clinker from silos to feed cement mills is the chance, under wind effect, for escaping of dust from the open conveyor and may not be estimated.

Cement Mills and Cement Silos Center:

This center is equipped with a properly maintained network of EP and bag filters. It is difficult to estimate the quantity of spillage involved. Generally, this area is considered in good working conditions.

Packhouse Center:

This operation is in good condition except for spillages from damaged cement bags at the rotary packers amounting to 0.2-0.3% or 3000 to 4500 tons/year assuming 20 bags/ton for 1,515,047 tons/1992. This means that Quattamia Plant used 30,300,940 bags/1992 assuming little bulk cement is shipped. The total amount of the spilled cement from broken bags is conveyed back into cement bins via a ground screw conveyors and re-bagged on daily basis. The location of the non-automatic rotary packers is, relatively, immaculate considering the huge number of bags involved.

Material Balance:

In cement industry, it is difficult, sometimes it is impossible, to perform material balance for each individual unit operation. However, material balance for the entire process is considered an estimate at best but rather close to reality. The following is the material balance for the kiln only as it is possible to weigh the produced clinker within 5% error.

Data of Material balance:

Date of Test: Thursday October 26 - 27, 1990
Duration: 24 hours
Disturbances: 1.38 hours due to tripping of the pivoting steel conveyor.

Actual Measured Data:

Raw Meal Input (kiln feed):	8091 tons/24 h
Fuel Consumed in kiln burner:	216.5 m^3/24 h
Fuel Consumed in the pre-calciner:	294.5 m^3/24 h

Actual Clinker production:	4841	tons/24 h
Weight of by-pass dust:	216	tons/24 h
Wt of EP dust (kiln dust only):	1128	tons/24 h

Clinker factor (X) calculation

KF	=	Kiln Feed,
KK	=	Clinker,
KD	=	Kiln Dust and
BP	=	By-Pass Dust

where: X = weight of KF / weight of KK, and
KK = KF*(1-LOI) - KD*(1-LOI) - BP*(1-LOI),

hence: X = KF*(1-LOI of KK) / KF*(1-LOI) - KD*(1-LOI) - BP*(1-LOI).

LOI values as submitted by Quality Control Lab:

KF = 35.2%, KK = 0%, KD = 36%, BP = 4%

X = X*KK*(1-0) / X*KK*(1-0.352) - KD*(1-0.36) - BP*(1-0.04) =
= X*4841 / X*4841*(0.648) - 1128*(0.64) - 216*(0.96) =
= 1.839 = Clinker Factor, and the real kiln feed is then:

Real Kiln Feed = 4841*(1.839) = 8902 tons/24 h

The actual LOI of kiln feed through the stack is:

LOI of Kiln Feed = LOI retained in the By-Pass Dust + LOI retained in Kiln Dust + LOI through the stack
8902*(0.352) = LOI through the stack + 216*(0.04) + 1128*(0.36), and the calculated value of LOI through the stack is 2719 tons.

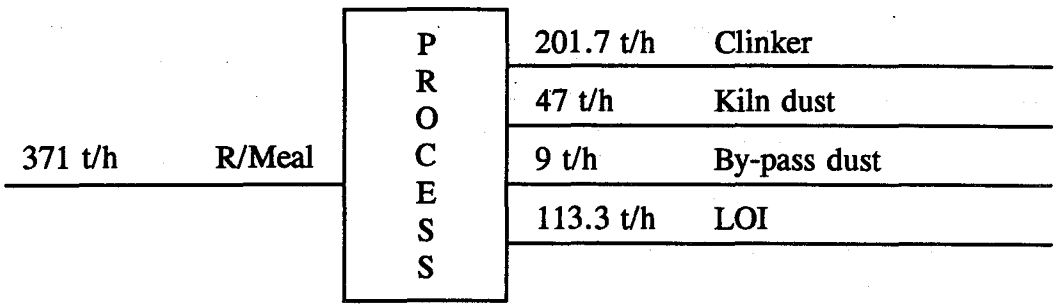
Fuel Consumption:

Considering an estimated of 3.3 % error in the precalciner counters and 1% of the fuel is used to heat up oil to 120° C and 9640 Kcal/kg is the calorific value of the bunker C fuel, then actual fuel calculations are:

Fuel used	=	216.5 + 294.7 + 294.7 * 0.033 = 520.925 m^3/24 h
Heating Fuel	=	520.925 * 0.01 = 5.209 m^3/24 h
Total Fuel used	=	526.134 m^3/24 h
Fuel density at 120° C	=	0.871 Ton/m^3
Total tons of fuel used	=	526.134 * 0.871 = 458.3 Ton
Kcal/kg clinker	=	458.3 * 9640 / 4841 = 913 Kcal/kg clinker

The material balance may be presented by the following:

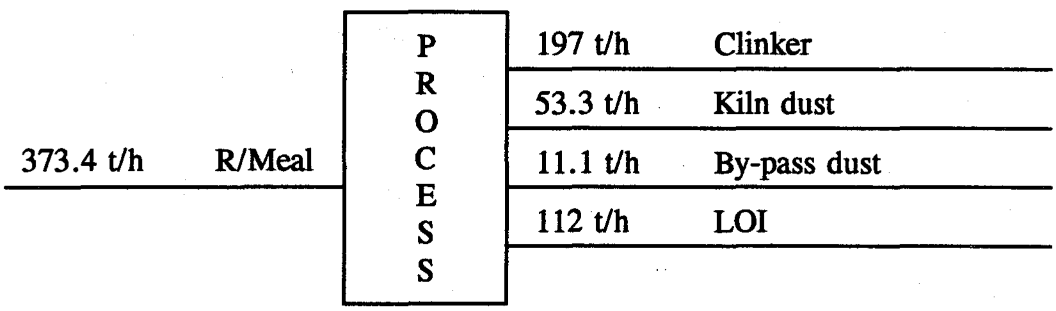
Figure 4:



371 tons in -------------------> 371 tons out

Similar results are obtained during 1993. The test was made for four hours. The same calculational technique as mentioned above was performed and results follows:

Figure 5:



373.4 tons in -------------------> 373.4 tons out

A plant the size of Quattamia has many filters of different types and some forced emission of particulates to the environment is imposed by filters efficiency, and examples are:

- Two main EP filters are contributing dust emission:

$$\frac{2 * 357{,}850 \ m^3/h * 0.100 \ gm/m^3 * 24 \ h/d}{1000{,}000 \ gm/ton} = 1.72 \ T/d$$

- One by-pass EP filter contributing:

$$1 * 357{,}550 \ m^3/h * 0.0000{,}001 \ T/h * 24 \ h/d = 0.86 \ T/d$$

- GBF filter contributing:

  1 * 865,000 m^3/h * 0.00000015 T/h * 24 h/d = 3.11 T/d

  In addition to many other bag filters.

The plant is considered clean meaning spillage through equipment is at minimum, while the heavy stack emission often observed is due to malfunctioning of one of the main EP transformers.

Material Balance Assessment:

The above kiln material balance indicating:

- Re-processed kiln dust is 47 T/hr whereas the ideal quantity anticipated and specified by Polysius is 35 T/hr;

- Re-covered by-pass dust is 9 T/hr instead of the ideal 6 T/hr specified by Polysius.

Possible Increase of Kiln Dust Intake:

The re-use of more kiln dust require higher efficiency of the pre-heater tower. In so doing, the saturated alkali content is decreased allowing more kiln dust back into the system. The status of the pre-heater as it is now:

- Stage 4 has four cyclones with high efficiency of separation: diameter = 5.08 M, and Vortex tube length = 2.46 M;

- Stage 3 has two cyclones with medium efficiency because of the larger diameter of cyclones and inlet gas ducts as compared to stage 4: diameter = 6.63 M, and Vortex tube length = 4.07 M;

- Stage 2 has one cyclone with very low efficiency where: diameter = 9.3 M, and no Vortex tube.

- Stage 1 has two cyclones with very low efficiency where: diameter = 6.63 M, and no vortex tube.

Improvement Approach:

- Adding vortex tubing to stage 1 and 2 should increase separation of cyclones;

- There are no isolating valves (tipping or pendulum) in the lower cyclones. Adding such valves will improve separation efficiency;

- Reducing the cross-section of the inlet gas ducts to cyclones will increase gas speed to the inlet cyclones result in high separation and higher production as well;
- Reduce the fineness (finer fraction) of the kiln feed by better grain size distribution via the adjustment of the ball charge of the raw mills;
- Improve the design of the tertiary air duct to reduce the pressure drop in that section to run at a lower draft. The suppliers will offer their opinion.

Reducing the Quantity of By-Pass Dust:

The Quattamia Plant is operating with maximum 60% by-pass opening and is limited by the by-pass fan, meaning 60% of the enriched kiln gas is driven out of the system. To decrease the quantity of dust the by-pass opening must decrease and is achieved only by using better quality clays, clays with less alkali content (SO3, Cl, Na, K). The Suez Cement Company is investing heavily to find the best clay supplies which should help the by-pass losses dramatically.

Raw Mills Dust Losses:

No practical way to perform material balance for the mills due to the difficulty of weighing the product. As discussed above, the over-pressure in this area require little process modification and it is in progress.

Low Cost Action Plans:

1. Plans to renew the worn steel to reduce false air and spilled materials from gas ducts, static separators, cyclones, mill hoods, casing of bucket elevators...etc.
2. No modulating dampers available in the system to control the gas fraction for both raw mills, and temporary using the inlet gates.
3. Fan suppliers are advised to submit plans to increase the EP fans capacity by 20% as soon as possible.

REFERENCES:

1. Audit and Reduction Manual for Industrial Emissions and Wastes. United Nations Publications, Sales No. 91-III-D6, ISBN 92-807-1303-5, UNIDO - Vienna International Center, P.O. Box 300, A-1400, Vienna - Austria.

2. Environmental Protection Sector, Suez Cement Company, Box 2691, Cairo - Egypt. Re-Use of the Alkali By-Pass Dust at Suez Plant. A paper Presented at the March 1993 Seminar for Cleaner Production in Cement Industry.

Annex VIII

Spotlight on the Limestone of the Suez Cement Plant

A presentation to the March 1993 Seminar on Cleaner Production in the Cement Industry, by Mostafa Abu-Zeid, Egyptian National Expert in Cement Manufacture in Collaboration with Suez Cement plant staff.

Limestone (LS) is the main ingredient as a raw material for cement production from which we obtain the CaO needed for the different calcium silicate and calcium aluminate compounds. The LS quarry site is one of the main factors which must be taken into consideration when deciding on the location of the cement plant.

The chemical composition and physical properties of the LS should permit simple preparation. It should be fairly easy to crush, possess good grinding properties and develop suitable reactivity in the burning process.

The LS used in the Suez Cement Company's Suez plant complies with all the above mentioned needs, but exceeds them a little bit in its excessive friability and its low compressive strength. It is easy to quarry, easy to crush, easy to grind and liable to soft burning; The only disadvantage is that it creates a lot of fine dust during blasting, crushing, conveying and piling.

A part of the dust during all these stages escapes to the air this is very recognizable in points where the crushed LS is transferred from one stage to another on the belt conveyor and both inside and outside stock pile construction during the fall from the stacker.

The air carrying the fines travels several miles away, depending on the velocity and direction of wind, causing pollution wherever it goes. Part of this dust settles inside the belt conveyor tunnel and accumulates with time, causing a difficult maintenance operation.

The quantity of dust created by blasting is unknown exactly because no degradation measurements have been carried out, but significant quantities of it is noticed on the floor of the quarry. Such measurements should be carried out especially when it may be intended to install a sieving system before the crusher as will be mentioned later. From my point of view, fine dust is created mainly from the crushing process rather than from blasting.

In blasting, the quick change of dynamite from the solid state to the gaseous state creates a calculated amount of gas in a very short time in a confined space, the result of which is a high pressure action on the volume of rock between the line of holes and the free face.

The shorter the time for the explosive material to change from the solid to the gaseous phase, the more fragmentation there will be in the blasted rock.

Thus, dynamite blasting with its very short (almost instantaneous) phase change time results in a great deal of fragmentation and virtually no hammering action on the rock to create dust except in a very short distance around the dynamite charge.

In the crusher the LS is subjected to hammering and impact action between the hammers and lining plates, and the hammers and the grits of the crusher. This hammering action cracks the hard LS and pulverizes the soft LS. Thus the main part of the dust and fine material on the belt conveyor are created from the crusher.

According to experience, the LS crusher does not run according to its nominal capacity which is 1000 t/h. If the crusher runs according to its nominal capacity, the crushed fine material will flow over the two sides of the rubber conveyor,even though the belt is designed to convey all the crusher's output. This overflow is a result of the existence of high percentages of dust and fine crushed LS which have a high flowage property.

Also because of the high percentages of dust and fines with high flowage properties the stock pile cannot store according to its nominal capacity.

Sieve analyses had been carried out on samples taken from the crushed LS from the belt conveyor at different intervals and in different time. Table 1 shows the results of the analyses. Five samples were taken. The average weight percent of material less than 10 mm was 59.26% the highest value was 70.87% and the lowest value was 45.25%, and the range was 25.62.

The average percent by weight of material sized less than 38 microns (dust) was 14.98%. The table throws light on the grain size distribution of the crushed LS which is reflected in the problems that exist in conveying and piling, and which causes pollution (excessive energy in conveying and storing , and excessive airborne dust).

Table 1 Sieve test of the output of the limestone crusher

SIEVE TEST OF THE OUTPUT OF THE LIMESTONE CRUSHER

Sample No.	1	2	3	4	5
SIEVE	SIEVE RESULTS (%)				
40 mm	23.78	13.18	3.09	11.29	2.40
40 - 25 mm	10.47	6.5	5.35	7.49	5.31
25 - 10 mm	20.45	19.33	19.88	22.94	21.62
10 - 6.3 mm	6.92	6.73	9.08	7.67	9.12
6.3 - 4.0 mm	6.00	7.08	11.90	8.23	9.27
4.0 - 3.35 mm	2.66	2.19	2.81	3.08	3.07
3.35 - 2.0 mm	4.25	5.28	10.02	6.69	7.21
2.0 - 1.0 mm	5.10	6.45	10.52	6.81	7.92
1.0 - 0.20 mm	6.09	0.30	7.15	-----	0.26
0.2 - 0.09 mm	3.75	5.72	4.77	12.15	0.43
0.09 - 0.075mm	0.24	1.33	0.32	-----	-----
0.075 - 0.063mm	1.12	0.97	1.67	0.95	0.49
0.063 - 0.045mm	1.07	1.82	1.52	0.90	0.52
0.045 - 0.038mm	0.22	0.67	0.77	0.44	0.54
0.038 mm	7.87	13.45	11.15	10.66	31.77
T O T A L	100	100	100	100	100

Many trials had been carried out to overcome the high flowage property of the fine crushed LS and the dust carried by air, and which causes pollution. In one of these trials the crushed limestone was subjected to a spray of water to settle down the dust and fines but much trouble resulted because the damp fines adhered to the rubber belt conveyor and made a lot of noise and disturbance when it came into contact with the supporting roller, moreover it was not easy to clean the belt. Further studies should be carried out with this approach.

In another trial, clay was added in the crusher together with the limestone during crushing. The managers of the Suez plant said that the trial represented some success as the inventory increased in the stock pile. This result can be explained through the hypothesis that the fine dust adheres to the surface of the moist clay particles forming bigger particles which decrease the flowage property thus improving the angle of repose of the stocked material allowing the inventory to be increased, however, the improvement was not sufficient to allow the crusher to run at its nominal capacity nor to enable the filling of the stock pile to its nominal capacity. In fact some of this capacity was taken up by the added clay.

As mentioned before, there is the potential intention to install a sieving unit before the crusher to separate the fines that are less than 20 mm in diameter before entering the crusher. The following question then arises; what is the weight percent of this fine dust in respect to the total quantity of material fed to the crusher. Up to date this amount of fines is still not known, however it is expected to be a small percentage of the feed to the crusher.

Moreover it does not form any considerable load on the crusher; further the separated portion of material less than 20 mm in diameter will be added again to the crushed limestone on the belt conveyor to the stock pile, and the existing problem of flowage will not be solved. The expected benefit may be a slight increase in the output of the crusher which does not represent a real success if we take into consideration the fact that the actual process limiting problem is the flowage (and consequent spillage of the fines from the conveyer) which prevents the crusher from working at its nominal capacity. On the contrary, the conveying problem will increase with any increase in output from the crusher.

From my point of view, I believe that the best solution for the existing problem will be in using a briquetting machine for the dust and fines of the crushed LS.

This idea has been successfully executed in the Egyptian iron and steel company. It is based on pressing the dust and fines of the burnt lime into briquettes using a briquetting machine and a trace amount of oil. Dust and fines in the form of briquettes are then easily reused. The iron and steel company faced serious problems from the accumulated fines and dust of the burnt lime from the lime and dolomite kilns especially after the implementation of current environmental regulations. With the cooperation of the japanese side, they found that the best economic solution of reusing this dust is to turn it into briquettes using high pressure briquetting machine.

A recent trial was very successful both from the economical and environmental points of view. According to the records of the Egyptian Iron and Steel Company, the funds invested in this project had been recovered in 18 month.

The machine accepts fines less than 6 mm which should also include less than 1 or 2 m.m or about 25 % of the crushed limestone in the Suez plant quarry.

The idea in brief is to install a sieve under the crusher to separate the flowable (dust and fines) fraction which will then be fed to the briquetting machine and from the machine to the main conveyor again, thus overcoming the problem of flowage of fines and dust of the belt conveyor, and providing the best solution for running the crusher and filling the stock pile at their maximum nominal capacities, while simultaneously preventing air pollution.

This idea is worthy of study for early adoption. It is expected that implementation will help increase production and prevent environmental pollution, with humble requirements of financial aid and technical assistance.

The staff of the Suez Cement Company is hardworking, self-starting serious and sincere. Management is doing its best and with further study of this and other projects is looking forward to demonstrate a Clean production company.

Annex IX

Re-Use of the Alkali By-Pass Dust at Suez Plant - Egypt

A presentation to the March 1993 Seminar on Cleaner Production in the Cement Industry, by A. Hamdy Sadeek, Sarhan A. Elhady and S. Fettouh, Environmental Protection Sector and Quality Control Department Suez Cement Company - Suez Plant, Box 2691 Cairo - Egypt.

Overview:

The ever rising concern for a pristine environment has activated the industrialized nations to search and develop new ways and means to control, minimize and/or eliminate emission and disposal of gaseous, liquid and solid phase by-products. The very same trend has been in practice, although at a lower pace, by the developed and third world countries.

Cement manufacturing is one industry where disposed dust and gas emission are its major nightmare. The fine dust may affect, when stored in landfills, the precious underground reserves, while CO2 emission, among others although minimal, is contributing actively to the greenhouse phenomenon.

It is imperative, therefore, in one way or another to deal with such waste products to render their action passive for less natural risk.

The Suez Cement Company and Alkali By-Pass Dust:

Generally, the Egyptian raw materials "carbonates & clays" used for clinker manufacturing are known to be semi-rich in alkali content but of little or no effect when the wet process technology is employed. In the dry process, however, a fraction of clinker components enriched with alkalies must be vapor transported, to avoid their clogging action, and exit the process line via the by-pass duct at the kiln inlet where the temperature may reach 1100 C°. The by-passed quenched vapor is considered partially sintered clinker-like material and commercially is known as alkali by-pass dust, so named because of its relatively high content of Na, K, Cl, and S compounds. The quantity of dust is dependent upon raw material nature and the process flow conditions.

To avoid confusion, the terminologies partially sintered clinker, sintered dust, alkali by-pass dust, or simply dust will be used synonymously in the text.

The Suez Cement Company (SCCo.) has two (2) plants employing the dry process using pre-calciner kilns and four (4) stage pre-heater with by-pass and among both may produce 250 to 350 tons of dust daily which amounts to $< 4\%$ of the total daily clinker production.

The quantity and composition of sintered dust for each plant are different for reasons mentioned above. The dust is about 80% calcined and possesses some hydraulic properties with compressive strength approaching 1 N/mm^2 for 7-days.

The common practice, in many nations, for dust deposition is either to pile in an expensive landfill or to allow a major fraction to exit through the stack to spread over a wide geographic area, thus affecting the surroundings.

Raw materials at Suez Plant are of relatively lower alkali content, and so also is its alkali dust, as compared with those at Quattamia Plant. The low alkali content of the partially sintered dust may allow its re-use, without prior treatment, by addition to clinker.

The objective of this article is to persuade the cement industry, through experimental findings, that addition of dust to clinker is not, in any way, adversely affecting the finished product as it meets the Egyptian as well as other global specifications.

Experimental Approach:

To implement addition of the partially sintered dust to clinker in optimally calculated proportions with the resulting product (cement) retaining the chemical, mineralogical, and physical properties within the currently acceptable standard specifications.

The fundamental laboratory studies carried out during 1990 and 1992 were established by adding the sintered dust to cement rather than clinker. This approach was considered easier for lab personnel to avoid extra grinding and testing of clinker thus saving time for their primary routine operations which often runs around the clock.

The laboratory work done at the Suez Plant during 1990 and 1992 was carried out by the addition of dust to Ordinary Portland Cement (OPC) produced at the same plant according to the following steps:

- Dry partially sintered dust is chemically analyzed;

- Dust is nodulized with water in a nodulizing machine and chemically analyzed;

- Different compositions are prepared by mixing dust with either OPC or Rapid Hardening Cement (RHC). The mixed compositions of 1% to 5% dust are thoroughly homogenized and analyzed chemically and physically;

- Chemical analyses were performed by X-Ray fluorescence;

- Free Lime (F.L.), Insoluble Residue (I.R.), and Loss On Ignition (LOI) are determined by wet methods;

- Physical testing of both dry & nodulized dust as well as cement-dust mixes are performed employing conventional methods.

Table 1: Chemical Analysis & Physical Testing of Dry and Nodulized Partially Sintered Dust of Suez Plant.

	Partially Sintered Dust					
	Dry				Nodulized	
Comp't	**1988**	**1989**	**1990**	**1992**	**1990**	**1992**
Chemical Analysis:						
	%	%	%	%	%	%
LOI	11.42	12.03	10.51	11.48	17.20	22.80
CaO	55.16	56.51	57.12	53.78	56.89	51.63
SiO2	12.81	12.10	12.73	11.71	9.85	10.30
Al2O3	2.64	2.49	3.63	2.47	4.09	1.79
Fe2O3	2.93	2.37	2.84	2.08	2.50	1.92
MgO	1.78	1.75	1.72	1.45	1.47	1.10
SO3	2.99	2.96	6.02	6.45	4.42	4.60
K2O	2.88	3.95	2.56	3.23	1.52	2.20
Na2O	0.36	0.11	0.08	0.07	0.12	0.10
Cl	3.33	4.24	2.72	5.12	1.40	3.40
I.R.	----	----	13.70		11.50	18.00
F.L.	----	----	25.90		22.85	20.60
Comp. Strength (N/sq.mm):						
3-d	----	----	----		0.8	---
7-d	----	----	----		1.0	---

From Table 1 above, and as expected, the composition of the alkali by-pass dust is time dependent reflecting the extent of variability of flow conditions for the same kiln.

Table 2: 1990 Chemical Analysis results of OPC/Dust Mix as Compared to the Produced OPC at Suez Plant and the E.S.373/91 Egyptian Specifications.

Comp't	ES373/91 Specs.	OPC SCCo.	Cement - Dust Mix 99/01	98/02	97/03	96/04	95/05
	%	%	%	%	%	%	%
LOI	4.0 Max.	1.59	2.02	2.13	2.73	2.95	3.32
CaO	----	62.33	62.03	61.77	61.40	62.04	60.72
SiO2	----	21.01	21.28	21.22	20.92	20.07	20.87
Al2O3	----	5.43	5.66	5.63	5.52	5.39	5.53
Fe2O3	----	3.46	3.53	3.51	3.48	3.40	3.48
MgO	4.0 Max	2.11	2.05	2.05	2.02	2.06	2.04
SO3 *	3.5 Max.	2.81	2.84	2.90	2.95	3.34	3.50
K2O	----	0.16	0.16	0.18	0.20	0.21	0.22
Na2O	----	0.15	0.13	0.15	0.14	0.17	0.20
Cl	----	0.01	0.02	0.02	0.07	0.14	0.25
I.R.	1.5 Max.	0.83	0.92	1.11	1.20	1.36	1.89
F.L.	----	1.40	1.62	1.91	2.28	2.46	2.56
C3S	----	45.08					
C2S	----	23.91					
C3A	----	8.52					
C4AF	----	10.52					
LSF	----	0.89					
S/R	----	2.36					
A/R	----	1.57					

(*) : For C3A > or = 3.5% , and Blaine is 275 M2/kg minimum.

From Table 2:

- The LOI increases with increasing rate of dust addition. Such trend is expected, and all samples are within the imposed Egyptian specifications;

- The I.R. for the 95/05 composition is off limit of 1.5%;

- The content of free lime is not specified in any standard specifications, yet Suez Cement Co. always keeps it less than 2%. The figures of the 97/03, 96/04, and 95/05 cement/dust mix exceeded the limit of 2% F.L.. However, the physical testing of prepared mortar cubes including expansion, given in Table 3, of those mixes showed acceptable results.

- Modulii C3S, C2S, C3A and C4AF of mixed compositions are not listed as such phases form only at high temperature of > 1100 C°.

Table 3: 1990 Physical Testing Results of Cement/By-Pass Dust Mixed Composition as Compared to the Produced OPC and the E.S.373/91 Egyptian Specifications.

Item	ES373/91 Specs.	OPC SCCo.	Cement - Dust Mix 99/01	98/02	97/03	96/04	95/05
Blaine (sq.M/kg), for C3A > 3.5:							
	275 Min.	321	330	331	337	347	330
Setting Time, minutes (Vicat):							
Initial	45 Min.	150	130	130	125	125	120
Final	600 Max.	175	150	140	135	135	135
LeChatelier (mm):							
	10 Max.	1.0	1.5	1.5	1.5	2.0	1.5
Compr. Strength (N/sq.mm):							
3-d	18 Min.	23.9	23.2	22.8	22.8	23.2	22.2
7-d	27 Min.	31.3	32.5	32.0	32.0	33.0	28.0
28-d	37 Min.		Optional				

From Table 3:

- Compressive Strength is within specifications being marginal for the 95/05 mixed composition.

The above testing approach is performed in 1992 using new batches of dust and RH Cement. For compressive strength measurements the mortar cubes were cured in normal, acidic, and basic waters. These cubes will be tested periodically every 3 to 6 months for an extended duration of 3 to 4 years to insure cement stability under the effect of different ground water chemical conditions.

The following Table 4 is a summary of results obtained during 1992 at the Suez Plant using Rapid Hardening Portland Cement and OPC.

Table 4: 1992 Chemical & Physical Testings for Dust, Rapid Hardening Cement (RHC), RHC/Dust Mixed Compositions, and E.S.373/91.

Item	ES373/91 Specs.	Dust	RHC	RHC - Dust Mix 99/01	98/02	97/03
		Suez Plant				
Chemical:	%	%	%	%	%	%
LOI	4.0 Max.	22.80	1.70	1.8	2.3	2.5
CaO		51.63	62.50	62.36	61.53	61.59
SiO2		10.30	21.36	21.15	21.04	21.18
Al2O3		1.79	5.16	5.32	5.10	5.18
Fe2O3		1.92	3.49	3.50	3.48	3.47
MgO	4.0 Max.	1.10	2.30	2.30	2.60	2.60
SO3*	3.5 Max.	4.60	2.84	2.96	3.04	3.2
K2O		2.20	0.2	0.2	0.2	0.3
Na2O		0.10	0.2	0.19	0.20	0.18
Cl		3.40	0.01	0.07	0.1	0.13
I.R.	1.5 Max.	18.00	0.88	0.98	1.10	1.20
F.L.		20.60	1.60	1.90	2.00	2.20
C3S			44.5			
C2S			25.2			
C3A			7.8			
C4AF			10.6			
LSF	> 66 < 102		90			
Physical:						
Blaine (sq.M/Kg):	350 Min.		374	378	370	375
Setting Time (Minutes):						
Initial	45 Min.		150	165	160	160
Final	600 Max.		185	195	195	195
LeChatelier (mm):	10 Max.		1.0	1.5	2.0	1.5
Comp. Strength (N/sq.mm):						
3-d	24 Min.		32.5	32.0	29.6	31.4
7-d	31 Min.		39.3	35.8	40.7	39.3
28-d	40, Optional		53.5	52.0	49.1	50.1

*) For C3A > 3.5 , Blaine 275 M2/Kg.

The above results are for normal waters, pH close to 7.0. The results for acidic & basic waters practically showed the same trend with the exception of the strength. While 7-d & 28-d were practically the same for all types of waters the 3-d, early strength, indicated about 11 to 13% decrease for basic water as compared to normal and acidic waters. The following table is continuation of Table 4 using Ordinary Portland Cement (OPC) for mixed composition during 1992 at Suez Plant.

Table 4 continued.

Item	ES373/91 Specs.	Dust	OPC	OPC - Dust Mix 99/01	97/03	95/05
		Suez Plant				
Chemical:	%	%	%	%	%	%
LOI	4.0 Max.	22.8	1.40	1.50	1.90	2.20
CaO		51.63	61.39	61.77	61.71	61.91
SiO2		10.30	21.50	21.48	20.82	21.13
Al2O3		1.79	5.34	5.40	5.39	5.48
Fe2O3		1.92	3.77	3.76	3.82	3.86
MgO	4.0 Max.	1.10	2.40	2.40	2.50	2.40
SO3	3.5 Max.	4.60	2.86	2.88	2.85	2.95
K2O		2.20	0.10	0.20	0.20	0.30
Na2O		0.10	0.37	0.35	0.35	0.26
Cl		3.40	0.01	0.04	0.17	0.24
I.R.	1.5 Max.	18.00	0.70	0.80	1.34	1.63
F.L.		20.60	1.50	1.80	2.10	2.90
C3S			36.30			
C2S			32.20			
C3A			7.80			
C4AF			11.50			
Physical:						
Blaine (sq.M/Kg):	275 Min.		340	345	346	357
Setting Time (Minutes):						
Initial	45 Min.		115	115	130	135
Final	600 Max.		140	140	145	170
LeChatelier (mm):	10 Max.		1.5	1.0	2.0	2.5
Comp. Strength (N/sq.mm):						
3-d	18 Min.		27.3	27.0	26.3	24.9
7-d	27 Min.		42.4	40.0	37.3	34.4
28-d	36 (Optional)		50.3	49.3	49.1	45.1
W/C	---		28.0	28.0	29.0	31.8

In the following, Table 5, the properties of one selected composition is compared to the B.S.12/89, and ASTM C-150 requirements. The selected composition is the 97/03 for OPC/Dust and RHC/Dust.

Table 5: Comparison of the Selected Mixed composition, 97/03 for OPC/Dust and RHC/Dust, Chemical & Physical Properties to the B.S.12/89, and ASTM C-150 Requirements.

Comp't	B.S.12/89 Specs.	ASTM C-150 Specs.(a)	OPC/Dust 97/03	RHC/Dust 97/03
	OPC/RHC (%)	OPC/RHC (%)	(%)	(%)
Chemical:				
LOI	3.0 Max.	3.0 Max.	1.90	2.50
MgO	4.0 Max.	6.0 Max.	2.50	2.60
SO3	3.5 Max.*	3.0/3.5** Max.	2.85	3.20
Cl	0.1 Max.	-------	0.17	0.13
C3A	---	--/15.0 Max.	7.8	7.9
I.R.	1.5 Max.	0.75 Max.	1.34	1.20
Physical:				
Air Content of Mortar (%):	---	12.0 Max.	2.6	3.0
Blaine (M2/kg):	275/350 Min.	280 Min./--	346	375
Setting Time, Minutes, (Vicat):				
Initial	45 Min.	45 Min.	130	160
Final	600 Max.	375 Max.	145	195
Expansion:				
LeChatelier, mm:	10 Max.	---	2.0	1.5
Autoclave (%):	---	0.8 Max.	0.10	0.09
Comp. Strength (N/sq.mm):				
1-d	---	--/12.4 Min.	14.7	18.0
2-d	--/25.0 Min.	---	---	---
3-d	25/-- Min.	12.4/24.1 Min.	26.3	31.4
7-d	---	19.3/--- Min.	37.3	39.3
28-d	47/52 Min.	---	49.1	50.1
W/C	---	---	26.5	29.0

Where:

*) For C3A > 3.5 % , and **) For C3A < 8.0 %, and 4.5% for C3A > 8.0%.

a) Unvalid comparison as the strength cubes used were that of the B.S.12/89 and not ASTMC-150.

From the above table, the 3% mixed sample is off limit only for the Cl content as compared to the B.S.12/89, and is off limit for the I.R. if compared to the ASTM C-150 requirements. Insoluble Residue content may be decreased to within the specified value by using high purity gypsum. The compressive strength, however, is way above the specified values.

Advantages of Mixing By-Pass Dust With Clinker:

- Avoid conveying of dust to an expensive landfill with the risk of harming the natural vicinities;

- Mixing up to 2% dust in cement clearly allows the addition of the same, if not more, to clinker. The Suez Plant may consume the total amount of dust produced daily (80 to 90 ton/day) as it amounts to less than 3% of the average clinker capacity of 3200 tons per day;

- Mixing of dust with clinker is dependent upon its chemical composition. In our case the Suez Plant dust may be added without any pre-addition treatment at no extra cost. At the Quattamia Plant, however, the high level of alkalies may, if at all, permit addition of untreated dust of up to 0.5% at best.

- Possible re-use to prevent desertification (1), either as a fertilizer for plants or simply by spreading over sandy areas may lead to a higher packing density of sand.

Conclusions:

- The selection of an appropriate methodology for dust utilization will vary from one plant to another mainly because of raw material variations. At Suez Plant, SCCo., dust without pre-addition treatment may be mixed with clinker during comminution;

- The above experimental study unravels, beyond doubt, the controversy of dust mixing with clinker. It is possible to add up to 2% dust or more depending upon the dust and clinker quality;

- At Suez Plant, the C3S% of clinker is about 50% and may allow addition of dust without adversely affecting the finished product properties;

- The dust may act as a grinding aid thus minimizing consumption of grinding media. In addition, the electrolytic properties of the moist dust may prevent coating on the grinding media surface, an action that may contribute to energy savings;

- Dust addition at Suez Plant does not require high capital expenditure to modify the existing process facilities for proper dust handling as the dust may be added directly through the gypsum crusher into a spare additive bin equipped with weigh feeders where it may be dosed at will following Quality Assurance recommendations;

- It is obvious that technological achievement must be used to the benefit of both protecting the environment and meeting our economic expectations. Thus extra revenues combined with tidy location & surroundings, are certainly expected by transforming the dust into a saleable product;

- The present investigation does not mean a demand to ease-up restrictions on the current global specifications to allow mixing dust with clinker but to show one way of how to complement the environment rather than fighting it in a very simple way remembering the fact that what we may apply at the Suez Cement Company may not be of the same value for other manufacturing locations.

Abstract:

The selection of appropriate methodology for dust utilization may vary from one plant to another mainly because of raw material variations.

Low alkali content of the sintered dust at Suez Plant, Suez Cement Company, allows its direct addition to clinker without adversely affecting the resulting product specifications. The finished product, after addition, still retains the chemical, mineralogical and physical properties of cement.

During 1990 & 1992 one to five percent, by weight, dust were added to either OPC or RHC rather than clinker, then chemically analyzed and tested physically. X-Ray fluorescence and conventional physical testing were the employed techniques. Free lime and Insoluble residue were determined by wet methods.

The mortar cubes prepared in 1992 were cured in normal, acidic, and basic waters and where possible, testing will span 3 to 4 years in order to ensure cement stability under the effect of different ground water chemical conditions. The 3-d strength, however, indicated 11 to 13% decrease for basic water as compared with normal & acidic waters.

For the Suez Plant - Suez Cement Co., it is possible to add up to 2%, or more, by-pass dust to clinker depending on the dust quality.

The addition of the partially sintered clinker-like dust may act as a grinding aid thus minimizing grinding media consumption, whereas the electrolytic properties of the moistened dust may minimize build-ups on grinding media surface resulting in efficient grinding & energy savings. Possible prevention of desert expansion either re-use as plant fertilizers or by spreading over sandy areas may lead to higher packing density of sand.

Little capital expenditure is expected to handle dust addition. Dust may enter the process line via the gypsum transport facilities where it may be dosed at will following Quality Assurance recommendations.

Addition of dust benefits the environment and meets economic expectations by transforming dust into saleable product.

Utilization of dust is one approach that may demonstrate one way to preserve our environment in the cleanest possible fashion.

References:

1. Private communication.

Acknowledgement:

The continuing support of the Suez Cement Company Management is gratefully acknowledged.

Annex X

Waste Digestion in Cement Kilns - Possibilities and Constraints

A Presentation to the March 28, 1993, Seminar on Cleaner Production in Cement Industry, Cairo, Egypt, by the Secretariat of UNIDO.

Preface

Industrial waste and other kinds of rejects, like household waste and different sludge, are increasingly polluting the environment and poisoning ground water and rivers. A reduction of the waste production is therefore desirable. The preferred solution is cleaner production, enabling the factories to produce less or no waste. Some waste will however still occur and it is therefore important to have environmentally safe technique to deal with the waste in order to avoid pollution.

The traditional way of dealing with waste used to be landfills, but the volume of the waste from the throw away societies have increased to such an extent that alternative solutions are a necessity. One answer is incineration, but this only reduces the waste to an incineration ash, frequently without making use of the available energy. This technique further neglects the possible existence of useful materials in the waste.

A new approach gaining increasing importance is to use the waste as raw materials and fuel in industry, thus saving virgin resources for coming generations. Few industries are however suited for integrating a multitude of industrial wastes in their manufacturing processes without disturbing both the chemical processes and the end products beyond acceptable limits.

The rotary cement kiln has however proven itself as a very efficient reactor for the thermal cracking of waste and the caustic process environment in the cement kiln helps to absorb practically all residues from the cracked waste. Digestion of waste in cement kilns is therefore gaining increasing importance in the industrialized countries.

Since cement factories exist in nearly all developing countries, they could presumably contribute to solve the growing waste problem in these countries. However, an important prerequisite for any cement company contemplating engaging in waste digestion is that they can operate efficiently and has a good record of clean production.

Introduction

The traditional cement and concrete industry exploit virgin resources and manufacture end-products (mainly concrete) that seems to last forever and, when demolished, has a high potential for recycling. The integrated and energy intensive production process from minerals resources through cement to concrete could be described as a transition in which rock and stone materials are turned into building elements and artificial stones. These serve as construction and building materials for structures like dams, bridges, foundation, roads as well as linear concrete elements for infrastructure, housing and agriculture.

The most obvious (energy saving) substitution process in construction, would be to use rock and stone material directly in building structures. This substitution is however only feasible up to a certain size of structures.

The best known building materials for large and monolithic building elements, from girders and beams to hydro-power dams, are steel reinforced, prestressed and normal concrete, which besides serving as a very important and well controlled construction material, automatically serves as long-term storage for all the components built into the concrete matrix.

Concrete may therefore be used for the direct end-storage of waste residues when they are efficiently neutralized in artificial aggregate. The use of artificial aggregate material can both save virgin rock and stone reserves and may in addition be an important entry point for reducing the need for waste dumps, which eventually could poison ground water and the environment. Similarly may Portland cement be produced partly with the use of combustible waste as fuel and thus save virgin fuel reserves and open for the safe digestion of selected waste otherwise difficult to dispose of.

End-storage of neutralized waste products in cement and concrete is expected to become an important necessity in the coming years. However, it will only be an advisable solution when processing and control methods are developed locally to ensure clean production and environment protection both during the digestion of the waste and in the application of the resulting materials in normal concrete.

Binders: From the Past to the Present

Portland cement is a modern construction material building on experience and traditions reaching back to the early days of civilization. The first binders, of which traces have been found, namely lime and gypsum, were used in construction more than 3000 years ago for instance in Egypt and Yemen. Today we can only guess how the experience for the burning of lime and gypsum has developed.

The most important of the two was presumably burned lime, because it could be disintegrated by slaking and, depending on how well it was burned, the slaked lime needed little or no grinding before it was applicable in mortar and plaster. Burned gypsum could not be slaked and needed grinding before it could be applied as a binder. It is therefore tempting to assume that lime was the first binder ever discovered, presumably by coincidence, when limestone blocks were used as support for cooking pots over an open fire. Part of such burned lime blocks may have been slaked away after heavy rainfalls and found to harden with the ashes in the fireplace.

It is obvious that it takes a good observer to convert such experience into organized production of lime, no matter how primitive the first processing was arranged. Another problem was the visual similarity between raw limestone and raw gypsum, as well as the problem to burn these materials at the right temperature. Even today it is nearly impossible to burn lime uniformly in a field kiln and the result is that only a part of the burned lime will slake immediately while some lime may not slake at all because it is insufficiently burned while other parts slake much later because of over-burning and lead to popping when the mortar or the plaster is in place in the construction. (In the traditional small scale lime production in the Hadramout valley of Yemen, popping is avoided by beating the slaked lime with wooden clubs until it is as fine as silk)

Some stones, thought to be lime, did not slake at all and since labour costs were low, these stones were presumably crushed and ground as extension of the experience gained from slow slaking lime. Anticipating further the obvious difficulties in differentiating between raw limestone and gypsum, the combined burning and grinding to powder, when necessary, would therefore also make gypsum into an applicable binder for masonry work. Similar would a marly limestone or hydraulic lime, yield a strong binder comparable to Portland cement. The main purpose of presenting the above history for cementitious materials is to suggest that binders from early on were products of both a firing and a grinding process.

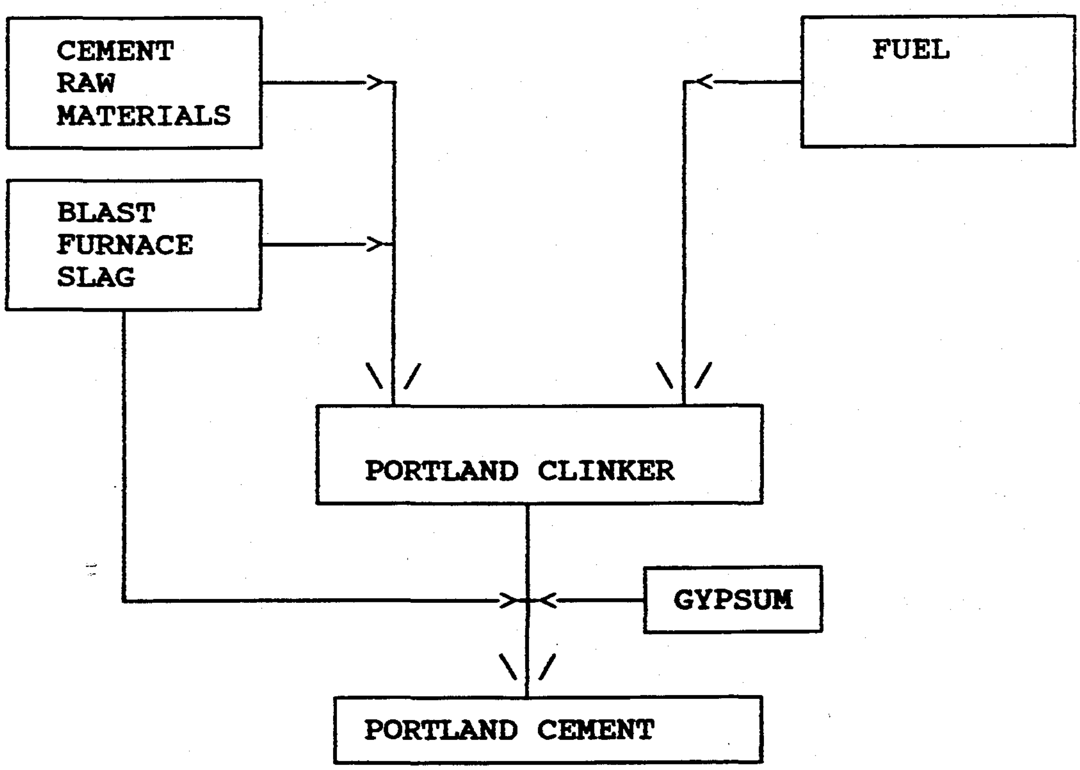
Good lime burners were recognized for making a building lime which slaked readily when drowned in water and was safe in use in regard to popping and expansion. Prior building codes prescribed slaked lime kept in the pit for three years before use to eliminate the mentioned problems.

The popularity of lime as the most common binder was only surpassed by Portland cement, invented around 1820, when burning and grinding became manageable for large quantities of materials through the invention, around 1890 - 1900, of the tube mill and the rotary kiln.

The industrial development during the last centuries not only yielded Portland cement, but also another important building material, namely industrially produced steel, opening new possibilities in building and construction. The bridge over the Firth of Forth and the Eifeltower are interesting examples of the perspectives opened with steel produced in large quantities with the help of blast furnaces, converters and rolling mills; however, the real breakthrough for modern construction only came with steel reinforced concrete now being the most versatile and common construction material of our time.

A problem with the steel production of former times was that for every ton of steel produced, the same process yielded four cubic meters of waste as blast furnace slag. An industrial solution was needed and found, namely to use the slag as raw material in the cement production. This was the first industrial scale recycling of waste presenting itself in the graph in Figure 1.

Figure 1: Recycling of Blast Furnace Slag



The past development of the cement industry may in a way be a demonstration of what could be expected in the coming years. The cement industry has been in steady development since the fifties because cement was needed in ever increasing amounts for the development of industry and infrastructure. Developments after the second World War focussed on adding new (wet) production lines to the existing and build new factories of increasing size to respond to the growing demands. After 1970 and the oil price increase, the cement industry changed to dry processing and increased the application of solid fuels like coal. Oil and gas is still preferred in many oil and gas producing countries.

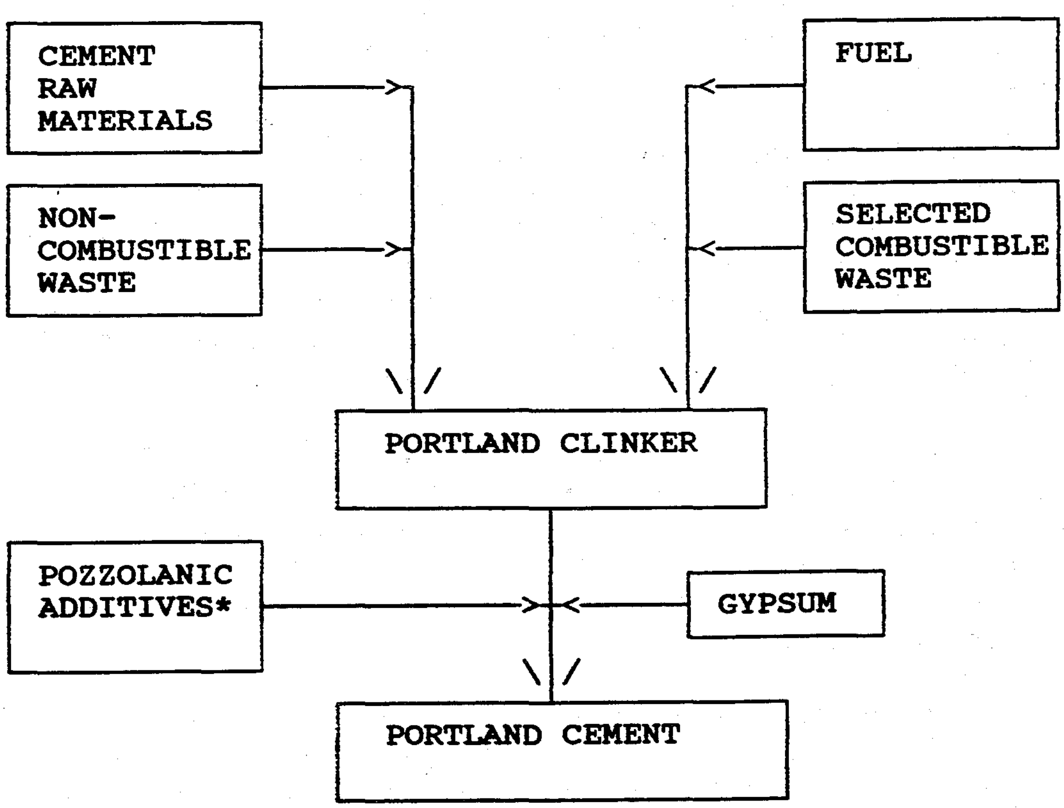
The increasing demand for cement will presumably continue in the coming years. This will lead to the building of very large cement factories, as pioneered in Asia in favour of economy of scale, and the concentration of the productive facilities as near as possible to the consumption centers. Other industries will follow the same trend to larger units and the most immediate results will be more industrial waste and an increasing demand for fuel.

A problem for the cement industry in this development scenario is to secure adequate access to raw materials and fuel. The cement industry should therefore in its own interest engage in cleaner production and the application of supplementary raw materials and fuels so as to respond to the needs of the future.

Possibilities and Constraints

Clinker production in a rotary kiln offers several other raw material substitution possibilities than the use of blast furnace slag. The potential application of combustible and non-combustible waste in the cement making process could be presented with the graph given in Figure 2.

Figure 2: Industrial Digestion of Waste in the Cement Process



* (fly ash, steel slag or volcanic ash)

It is important to differentiate between two major types of clinker, namely Portland clinker as required for the production of Portland cement and artificial aggregate clinker used as a storage medium[1] for immobilized pollutants like heavy metals and alkali rich waste.

In the production of Portland clinker, various limits for the acceptance of waste residues in the raw materials and in the fuel exist. The cement kiln is, however, a proven reactor for the thermal cracking and neutralization of selected wastes difficult to dispose of elsewhere. It is therefore possible in the cement making process to substitute a part of the virgin fuel with combustible waste, like used tyres, waste oil, plastic and paper etc.. It is also possible to digest more complicated types of waste as for instance chlorinated organic compounds and different types of sludge, pharmaceutical industry waste, chemical industry waste, paints, paint thinners etc. in limited and carefully controlled quantities.

Some cement plants have used household waste as a supplementary fuel, but the economic suitability of this substitution depends heavily on the composition, the heat value and the handling costs involved. Household waste is, depending on the local possibilities, usually dumped in landfills or incinerated, while composting is less frequent. Dumped household waste may be both hazardous and toxic, because the disposers frequently neglect the environmental dangers and throw away, in the same waste deposit, a mixture of used batteries, paint residues, lacquers, solvent and scrap of unknown origin.

The classical approach for combustible waste is incineration. However, incineration requires special filters to retain the fly-ash and for the neutralization of the exhaust gases (lime washing). Furthermore, the filter cake and the incineration ash are classified as hazardous waste, while the digestion of the same waste in the cement kiln would be without ash residues, because they are completely incorporated in the clinker matrix. Incineration ash may be used in limited amounts as raw material in the cement making process.

Cement production, in terms of pollution, is a low risk industry and well managed factories avoid pollution by collecting or recycling all rejects. Very efficient filter installations are available and commonly used for recycling the kiln feed in the pyro-processing system, and only a minor part, which is unsuited for returning to the process, is collected and deposited in consultation with local authorities.

The chemically controlled processing of waste into harmless components and materials has already started in the industrialized countries' cement industry. It reduces the need for landfills and incinerators while saving virgin fuel and raw materials in the production of cement and concrete. The developing countries need assistance to upgrade their cement industry to cleaner production so that they can engage safely in this activity.

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[1]glass phase storage

The limits for how much waste it is possible to digest in the cement making process depends entirely on the absorptive capacity (chemically spoken) of the clinker in production. The final products must satisfy all requirements (specifications). Although cement is produced in large quantities, the total waste digestion capacity of the cement industry in any country remains limited. It is therefore of utmost importance that the industrialization process is supported by the development of processes which produce less or no waste. The limited digestion capacity available in the cement industry should be reserved for the elimination of waste which may be specially difficult to recycle or neutralize by other means. Naturally, the cement industry would expect to be paid for their acceptance of waste since they would need special equipment and procedures for transporting, storing, controlling and neutralizing the waste.

Waste Based Aggregates

As mentioned earlier, only limited possibilities for using waste as fuel and raw materials exist in the cement industry, because Portland cement is a standardized product and it would be totally unacceptable that cement produced with waste fuel or waste raw materials would be different in performance from cement produced exclusively from primary raw materials and fuel.

Another possibility for the safe conversion of thermally cracked waste into useful products is the production and application of artificial aggregates produced through the co-processing of waste for the sintering of minerals. The production of such ceramic aggregates open possibilities for the digestion of larger amounts of ashes and incombustible waste than acceptable in Portland clinker.

Inspiration for the design of waste based aggregate sintering may be found both in the production of glass and expanded clay aggregates both having a high proportion of glass phase in the final products. Heavy metals are, for example, essential components in the glass making process, including household goods, where crystal glass and colored glass, with high amounts of heavy metals in the glass formula, serve for food storage without risk of releasing poisonous components. Lead crystal is for instance as stable as normal glass of which we still find undisturbed artifacts from the time of the Roman empire.

Research, Training and Control

Clean production and digestion of waste represents a new industrial approach which is still under development. Subsequently, both fundamental and applied research is necessary to clarify the limits of the local waste digestion potential and to open for an increased industrial waste recycling capacity.

The use of waste fuel therefore not only requires applied research and new equipment. Also special training of operators and workers is needed to promote the development of the necessary safety chain(s) with containment and control from the waste occurrence to the end products, where efficient monitoring will be part and parcel of the process. Monitoring and control must focus on all critical waste digestion parameters like dust, organic components, oxygen, NOx, and SOx as well as on the nature of the applied waste. Special control for Thallium, Cadmium, Quicksilver, Lead, Chromium, Zinc, Tin, Dioxin and Furan is mandatory.

The use of waste fuel call for special work routines, including certification and testing of the by-products before they leave the producer. Upon arrival to the treatment factory the waste should be controlled and tested again to ensure that the content is correctly declared and no mistakes made in the shipping. The sample taken at the gate should be divided so one part is reserved as reference sample and the rest used for checking of the possible presence of critical components like Thallium, Quicksilver, Lead, Sulphur, Chlor and Zinc which can be done on an X-ray analyzer, while for instance the content of Poly-Chlorinated-Biphenyl (PCB) is examined with gas-chromatography.

The check-in sampling and the analysis of the check-in sample should at best be made while the delivery truck is waiting (15 to 20 minutes) and the consignment should only be accepted if the shipment corresponds with the suppliers certificate accompanying the shipment. Otherwise the truck must be rejected and returned to the waste fuel supplier.

The application of waste fuel in a cement plant can further only be permitted when the kiln is in full production at normal operating conditions. During start up, close down and during irregular operating, it is not advisable to burn waste.

Many cement plants have in the past been less concerned with pollution than with production. This has frequently brought them in conflict with the public which is increasingly concerned about their local environment. The strained relationship has resulted in very critical attitudes or outright rejection of nearly all new solutions, making the development of documented experience on waste digestion difficult. It is therefore important that the public is fully informed about the intentions and the expected results and participate both in the decision making process and in the evaluation of the results.

The skeptical attitudes towards the cement industry take nourishment from the fact that many cement factories continue to pollute their nearest environment. In such situations it is obviously more than difficult to convince the neighbors that it would be absolutely safe and without any problems to burn waste. It follows that cement companies contemplating burning waste, should first invest in the training of their personnel and in improving the existing installations so they can show that they can operate without polluting the environment. The next step would be, in consultation with the authorities, to burn some easier to handle waste like used rubber tyres to prove their efficiency and pave the way for the burning of other types of waste.

The cement industry, especially in the developing countries, need international support to develop their capacity for the digestion of waste. International cooperation is therefore needed to produce convincing scientific information regarding the efficiency of waste burning in cement kilns.

Finding the limits and possibilities of digesting hazardous and toxic waste requires international and well controlled long term and full scale tests. These trials should be carried out in selected installations with minute control of products and rejects. The digestion of different types of waste under controlled conditions as well as the development of monitoring and control routines under real work conditions during the digestion of waste are essential for the development of environmentally safe work routines suited for the developing countries.

Extensive laboratory testing of products and rejects will be required to trace and quantify where the cracked products from the waste digestion end up and to prove that the end products are safe. Concrete produced with Portland cement manufactured with waste fuel, could for instance be tested for stability in leaching and corrosion tests. Artificial ceramic aggregates could be tested for their suitability as aggregate in asphalt or in concrete with special attention to wear and corrosion and the possible release of unwanted components.

It is of immediate importance to promote cleaner cement production and exchange information and experience among the pioneer waste digesters. Pioneers should engage in research and development activities expanding the knowledge about safe application of industrial waste as fuel and raw materials in the manufacture of building materials. Finally, the following seven steps are offered to further the introduction of cleaner production and the digestion of waste in the cement industry:

- **Advanced training of Personnel in**
  CLEAN BASE LINE OPERATION WITHOUT WASTE DIGESTION
  demonstration of best performance cleaner production

The purpose of this training is to improve maintenance and operational routines so factories not yet authorized to burn waste can prove that they can operate with minimum dust emission etc. and thus qualify for engaging in waste burning with all necessary safety preparations.

- **Advanced Training of Factory Personnel in**
  POLLUTION MONITORING AND CONTROL
  part of preventive measures to help factories in cleaner production

Only by measuring the pollution as it occurs with the existing work routines is it possible to verify improvements when they are introduced. A continuous record of the environmental performance is essential in negotiations with the local authorities.

- **Advanced Training of External Controllers in**
  FACTORY MONITORING AND CONTROL
  periodic or permanent environment oriented performance check(s) organized by the local authorities in cooperation with the factory

Local authorities may not always accept the performance reported by specific factory employed controllers. It is therefore important that they have similar opportunities as the factory management to evaluate and check the environmental performance of the plant under review, hence the need for training of external inspectors.

- **Application of Training Experience in**
  BASELINE REPORTING
  establishment and evaluation of monitoring routines

Base line reporting is less complicated than the reporting required when a cement factory is burning waste, nevertheless, after the basic training is completed, it is essential that trainees apply their training experience by establishing specific routines for monitoring and evaluating the performance of their factory.

- **FUNDAMENTAL AND APPLIED RESEARCH**
  for examination of the waste disposal possibilities

It is essential to learn how much of a given kind of waste a given set of raw materials can digest during the production of clinker or aggregate in a given cement kiln. Another question in need of clarification is how much of the different types of waste escapes to the environment and how much can be tolerated.

- **Advanced Training of Personnel in**
  APPLICATION OF ALTERNATIVE RAW MATERIALS AND FUELS
  establishment of waste digestion work routines

With the research based limits for the digestion of waste in the cement kiln, it is essential to test the experience in full scale and to train operators and controllers in their work routines.

- **Application of Training Experience in**
  PERFORMANCE REPORTING AS AGREED WITH AUTHORITIES
  monitoring and control as agreed with authorities including surprise sampling and checking of performance

Both pollution controllers from the factories and the inspectors from the local authorities need to tune in on an agreed pollution reporting in balance with local conditions and the actual production conditions. The establishment of agreed routines and continuing cooperation is essential.

Annex XI

Activities of IFC in the Cement Sector - It's Environmental Requirements for the Cement Plants

A Presentation to the March 28, 1993, Seminar on Cleaner Production in Cement Industry, Cairo, Egypt, by Mr. George Gouda, Technical and Environment Department, the International Finance Corporation (the World Bank Group), Washington D.C., USA.

Ladies and Gentlemen,

I am very pleased to represent the International Finance Corporation (IFC), an affiliate of the World Bank Group in this seminar. It is a great honor for me to be invited by UNIDO, WEC and Suez Cement Company to attend and speak in this seminar.

My talk covers 5 main topics:

1. What is IFC and its role,
2. IFC's role in privatization,
3. Activities of IFC in the Cement Sector,
4. IFC and the environment, and
5. IFC environmental requirements for the cement plant.

What Is IFC and Its Role

IFC is the largest source of direct financing for the private sector in developing countries. IFC invests in the developing countries by providing financial resources, technical expertise and international experience. IFC is very deeply involved with pollution prevention and environment control.

The International Finance Corporation was established in 1956 with the objective of assisting economic growth in its developing member countries by promoting private sector investment. IFC is a member of the World Bank Group, which also includes the International Bank of Reconstruction and Development (IBRD), the International Development Association (IDA), and the Multilateral Investment Guarantee Agency (MIGA). Although IFC's activities are closely coordinated with, and complement, the overall development objectives of the other World Bank Group institutions, IFC is legally and financially independent, with its own Articles of Agreement, shareholders, management, staff and financial structure. IFC is headquartered in Washington, D.C., and has offices in London, Paris and Tokyo and in other developed countries, as well as Regional and Resident Missions in 17 developing countries. IFC has an office here in Egypt, located in El Mohaudessin.

IFC combines the characteristics of a multilateral development bank and of a private financial institution. Its share capital is provided by its 147 developed and developing member countries, and we will soon have 14 former Soviet Republics (FSR's) as new members. IFC raises most of the funds for its lending activities through its triple-A rated bond issues in the international financial markets. Like a private institution, IFC charges market rates for its loans and seeks profitable returns. IFC is also able to make equity investments in private enterprises, and it does not require government guarantees for its financing.

IFC's long experience in risk-management and thorough project appraisal contributes to the success of the projects it supports. IFC shares full project risks with its partners. These qualities enable IFC to play an important catalytic role in restructuring the project technically and financially and in mobilizing additional project funding from other investors and lenders, either through cofinancing or through loan syndications, underwritings, and guarantees. IFC offers a full array of advisory services and technical assistance, helping private business in the developing world increase their changes of success and encouraging governments to create an environment hospitable to private investment.

In its 37 years of operation, IFC has provided nearly US$11 billion in financing for more than 1,000 companies in 98 developing countries. IFC has a vital role to play in helping developing countries to make the transition to open, market-oriented economies and to build strong private sectors. As more and more developing countries adopt market-based policies, demand for IFC's services -- loans, equity investments, resource mobilization, and advice -- continues to grow.

At the end of fiscal 1991, the Board of Directors approved a capital increase from US$1.3 billion to US$2.3 billion. The US$1 billion increase was intended to enable IFC to increase new investment approvals in all regions by 10 percent a year until 1998. With the accession to membership of the former Soviet republics, this rate of growth will probably be increased to 12-15 percent.

In addition to project financing and resource mobilization, IFC emphasizes four main activities:

a) expansion of capital market activities,
b) increased privatization and corporate restructuring,
c) increased technical and financial assistance to small and medium-sized enterprises, and
d) the financing infrastructure and large-scale projects. With the addition to its capital base, IFC expects to approve financing of US$4 billion annually by the end of the decade for projects with total costs of US$31 billion.

In FY92, which ended on June 30, IFC approved financing for its own account of US$1.76 billion for 167 projects costing US$12 billion in 48 different developing countries. This means that for every US$1 of financing approved by IFC for its own account, other investors and lenders provided more than six dollars. Net income for FY92 was US$181 million. The following is the highlights of 1992's operational results:

Highlights of 1992 -
OPERATIONAL RESULTS

Projects approved	167
Total financing, including syndications and underwriting	$3.2 billion
Financing for IFC's own account	$1.8 billion
Total project costs	$12.0 billion
Disbursed loan and equity portfolio for IFC's own account at June 30, 1992	$5.0 billion

Demand for the Corporation's advisory services and technical assistance grew substantially during 1992. It stepped up its advisory activities in connection with privatization and corporate restructuring, working on assignments in Asia, Europe, and Latin America during the year. It also worked on 30 assignments involving the provision of technical assistance in capital market development.

IFC's Role in Privatization

IFC's role in the area of privatization has been growing rapidly over the past few years as part of a World Bank Group effort to foster private sector activity in developing member countries. IFC has been able to make a valuable contribution to the implementation of the privatization process, either by advising governments and enterprises on the process, or by investing in the newly privatized companies.

IFC's assistance may be provided in either the sale or the purchase of privatized enterprises. IFC may advise sellers on structuring, negotiating, and implementing specific privatization transactions. Or it may act as an adviser and investor in the acquisition of state-owned properties and help buyers raise some of the financing needed by the privatized companies. IFC's special character as an international institution, as well as its background in project financing and its experienced staff, all contribute greatly to its ability to provide understanding, credibility, and transparency in the privatization process.

IFC has in-house technical, financial, legal, and economic staff, many of whom had experience at senior levels in their industries or professions before joining IFC, and who are accustomed to working in countries around the world. To date, IFC has been involved in more than 40 privatization assignments in either an advisory or an investment capacity.

With regard to the Cement sector, IFC is acting as adviser for the Polish Cement Industry in 3 phases:

1. Analysis of the existing cement companies,
2. Preparation of a sector-wide diagnosis and strategy, and
3. Privatization of selected companies.

Activities of IFC in the Cement Sector and Building Materials

IFC has been involved in the cement, aggregate, ceramic tiles, and marble industries since 1956, and its worldwide experience has generated a thorough, broad knowledge of the sector among the technical staff. The Corporation has financed over 100 projects undertaken by some 70 companies worldwide. IFC's involvement in cement has been substantial: total investment for IFC's own account has amounted to about US$721 million, representing about 8 percent of the portfolio. Of this, about US$658 million consisted of loans, with the balance in the form of equity and quasi equity investments.

IFC has promoted private sector development of the cement industry more than any other organization. Total capacity of the cement plants IFC has financed exceeds 50 million tons, and the Corporation's experience in the industry includes wet and dry processes (suspension preheater and precalciner), complete production facilities (from quarry to packing house), clinker grinding facilities, cement terminals, harbor development, raw materials, and process engineering, and covers a wide variety of kiln capacity, including one kiln with a capacity of 10,000-ton per day clinker, the largest kiln in the world.

From the technical standpoint, IFC works very closely with its clients, reviewing and evaluating all available studies and making technical and engineering recommendations to ensure the project's success. IFC's technical experts discuss appropriate know-how with clients to minimize costs and advise them on cement prices on national, regional and international markets. In other words, IFC serves as an active advisor and reference source to its clients in the cement industry, which is why clients from both developing and industrial countries have been attracted to the Corporation.

Before an investment is approved, IFC technical staff evaluate the technical and environmental aspects. To this end, for any cement project clients should provide IFC with the following information:

- A thorough feasibility study;
- A qualitative and quantitative evaluation of the raw materials and their suitability for the selected process;
- A description of the plant site and the availability of infrastructure;
- A detailed plant engineering plan;
- An account of equipment design, the reasons for its selection, and the intended suppliers;
- A description of how the project will be implemented, including civil work, erection, and installation;
- A complete summary of project costs and expected production costs;
- An account of capacity build-up and the type of cement to be produced;
- An assessment of the regional and national markets as appropriate;

- A description of plant management and technical assistance sources.

IFC also helps the client in preparing and gathering these information through IFC technical expertise and consultancy.

In addition to new plants, IFC is also active in evaluating existing cement sectors in particular countries and advising governments aimed at modernizing and privatizing the cement sector on the optimal structure, and it was mentioned earlier.

As of 1992, IFC has a total of 232 projects: 26 are cement and construction projects. The average economic rate of return of all the projects is 12.7% and the financial rate of return is 11.3%, while that for the cement and construction projects are 12.0% and 10.3%, respectively.

IFC and the Environment

It is the policy of IFC that all of the Corporation's operation are undertaken in an environmentally responsible manner. IFC has made significant progress during the past five years in incorporating environmental concerns into its operations in a systematic way. IFC developed a procedure for environmental review of projects, to ensure that projects financed by IFC are environmentally sound.

The Environment Unit is responsible for the environmental review and subsequent monitoring of IFC projects. While the Environment Unit plays a major role, respectively for ensuring that IFC's operations are conducted in an environmentally sound manner lies with each member of the organization. In order to ensure that IFC's investments meet the highest possible environmental standards, each potential project is subject to a detailed environmental review.

The environmental review is an interactive process in which sponsors and IFC representatives (investment officer, technical specialist and environmental specialists) work together to ensure that the project eliminates or minimizes waste and negative environmental impacts, enhances environmental benefits, and safeguards workers' health and safety.

All IFC projects must also meet the environmental requirements of the host country. At a minimum, the more stringent of the host country's requirements or World Bank policies and guidelines apply to each project. In those cases where no appropriate World Bank policies or guidelines exist, IFC applies internationally accepted standards to the project. IFC does not disburse funds to any project unless plans are in place to address satisfactorily all environmental issues and a written commitment from the sponsor that he will comply with the World Bank Guideline is obtained. The length of time required for the environmental review depends on the information provided by the sponsor and the overall complexity of the project.

The environmental review process involves consideration of the following, as appropriate:

- Assessment of the baseline environmental situation
- Sustainable use of natural resources
- Pollution prevention and waste minimization
- Pollution controls (liquid effluents and air emissions) and solid and chemical waste management
- Protection of human health, cultural properties, endangered species, and sensitive ecosystems
- Use of dangerous substances
- Major hazard assessment
- Occupational health and safety
- Fire and life safety
- Resettlement issues
- Socioeconomic concerns
- Consideration of environmentally preferable alternatives.

Projects are categorized according to their potential impacts on the environment. There are three project categories:

- Category A Projects- may result in diverse and significant environmental impacts, thus requiring a detailed environmental assessment. Preparation of the environmental assessment is the responsibility of the sponsor.

- Category B Projects - may result in specific environmental impacts and require adherence to certain predetermined performance standards, guidelines, or design criteria to mitigate impacts. These projects do not normally require preparation of a detailed environmental assessment, but the sponsor must provide sufficient information for IFC to conduct an environmental analysis. A wide range of environmental guidelines for such projects has been developed by local or country authorities, as well as by a number of organizations, including the World Bank Group. In addition, specific environmental design criteria can be developed by IFC for individual projects.

- Category C Projects - normally do not result in any environmental impact and thus do not require any further environmental review[1/].

Examples of category A and B projects are given below.

Category A

- Large chemical and petrochemical plants
- Major oil and gas developments, including major pipelines
- Pulp and paper plants
- Logging operations
- Large ferrous and non-ferrous metal operations
- Open pit mining and related processing operations
- Large agribusiness and agricultural projects
- Large thermal and Hydropower developments
- Domestic and hazardous waste disposal operations
- All projects which pose serious occupational or health risks
- All projects which pose serious socioeconomic concerns.

Category B

- Manufacture of construction materials and cement plants
- Medium and small agribusiness and agricultural projects
- Electrical transmission projects
- Oil and gas pipelines (small scale)
- General manufacturing
- Textile plants
- Tourism (including hotel projects)

The purpose of the environmental review process is to determine if the project is in compliance with appropriate World Bank policies and guidelines, host country requirements and/or internationally accepted standards. When the project is deemed by the Environment Unit to comply with appropriate requirements, the Unit gives an opinion to the effect in writing to the Regional or Specialist Department. Project monitoring requirements are also identified as are recommendations regarding any other obligations of the project sponsor. Whenever there are short falls in compliance, IFC's environmental and technical specialists work with the project sponsor to outline an appropriate plan of action.

1/ The examples are illustrative only, as actual project categorization depends on the potential impact of each specific project.

Project Supervision

IFC monitors the environmental performance of projects in its Investment Portfolio. Project monitoring in practice usually occurs in one of the following ways:

- Annual reports prepared by the project sponsor;
- Supervision missions carried out by IFC personnel.

IFC Environmental Requirements for the Cement Plants

The sponsor of a cement project should submit a written commitment that he will comply with these requirements as well as to supply to IFC regular reports on the environment, health and safety.

Enclosed are the World Bank Requirements for cement and clinker grinding plants. There are:

Attachment 1: Environmental requirements
2: Health and safety guidelines.

Pollutants Emitted to Atmosphere during the Cement Manufacture

- Dust
- Sulfur dioxide and other sulfur compounds
- Nitrogen oxides and other nitrogen compounds
- Organic compounds, in particular hydrocarbon
- Heavy metals and their compounds
- Chlorine and its compounds
- Fluorine and its compounds
- Carbon monoxide

Principal Pollutants

Dust: this is the main problem and has received considerable attention. Dust emissions are classified into one of three categories:

- Process dust emissions: arising from the exhaust gases
- Dust air emissions: arising from venting air in contract with dusty materials.
- Fugitive dust emissions: results from vehicle movement or entrainment of dust by wind.

Dust emitted from the kiln disperses from the stack, and contribute to long range and transboundary air pollution. Dusty air emission vary significantly depending on the dust source. Fugitive and dusty air emissions settle mainly within the plant and its immediate vicinity.

Sulfur Dioxide (SO_2): Sulfur compounds present in the fuel are oxidized to SO_2 during the combustion process, and passes through the kiln with the hot gases. Normally, however, only a small amount of SO_2 generated within the kiln (whether from the raw materials or from the fuel) is released to atmosphere, since it is mainly incorporated into the clinker.

Nitrogen Oxides (NO_x). There are 2 principal mechanism for NO_x formation:

- Fuel NO_x: where nitrogen containing compounds,chemically bound in the fuel, react with oxygen present in air to form various oxides of nitrogen.

- Thermal NO_x: where some of the nitrogen component in the combustion air reacts with the oxygen component to form various oxides of nitrogen.

The formation of fuel NO_x is influenced by:

a) quantity of excess air fed to the burners,
b) leakage air, and
c) the nitrogen content of the fuel.

Other Pollutants

- Trace elements: at high temperatures, some trace elements vaporize and are exhausted from the kiln burning zone with the fuel gas. These vapors tend to condense on dust particles and/or incorporate in the clinker.

- Carbon monoxide and hydro carbon: these result from incomplete fuel combustion and are generally negligible as the kiln operates in an excess oxygen conditions.

- Hydrogen Sulfide: occurs in the case of strongly reducing conditions.

- Fluorine and Chlorine compounds: a portion of the fluoride and/or chloride of feed materials is trapped in the clinker and the other portion deposits on dust particles and is mainly removed via the dust collection.

Operational Controls in Cement Plants

1. Temperature of exhaust gases should be above the dew point to prevent blocking.

2. Prevent air leakage.
3. Stock of fine materials should be stored under cover.
4. Particulate matter in exhaust gases should be monitored continuously.
5. Disposed collected dust should be either pre-conditioned or covered.
6. Clinker should be stored in closed buildings or silos. Materials handling should be covered.
7. Prevent emission of fugitive dust.
8. All the dust collector equipment should be operated efficiently.
9. Shut-down the kiln, if dust collector of kiln exhaust gas or cooler are not operated at the design parameters.

<u>Specific Elements Concern the Cement Industry Environment</u>

1. Area disturbed: plant, quarry, roads, etc.
2. Work force and infrastructure.
3. Air emissions: from quarry, materials handling and storage particulate from the process, exhaust gases, leakage, cement packing and loading, etc.
4. Waste water discharge
5. Solid waste
6. Noise levels: plant, quarry, road traffic.
7. Transport traffic
8. Monitoring and reporting.
9. Operation and maintenance of pollution control equipment.
10. Comply with the occupational health and safety procedures.
11. Storm water management
12. Quarry reclamations.

IFC is proud of its record and in:

1. Private Sector Development
2. Work with companies through staff and consultants
3. Working with the Company to protect environment and public worker safety

Finally, I would like to thank UNIDO and WEC for their kind invitation to participate in this seminar. Many thanks also to Mr. Mahmoud El-Kholi, Chairman and Managing Director of Suez Cement for hosting this seminar.

L:\minhn\lecture

Attachment 1

WORLD BANK ENVIRONMENTAL REQUIREMENTS

CEMENT AND CLINKER GRINDING PLANTS

LIQUID EFFLUENTS

pH	6 to 9
Total Suspended Solids	
Leaching plants	150 g/metric ton of product
Non-leaching plants	5 g/metric ton of product
Oil and Grease	10 mg/ℓ
Temperature	Maximum of 5°C above ambient at the edge of the designated, site specific mixing zone (3°C above ambient if receiving waters are greater than 28°C).

It is recommended that cooling water be recycled whenever feasible.

STACK EMISSIONS

Particulates

Kiln	50 mg/Nm^3
Alkali Bypass, if applicable	50 mg/Nm^3
Clinker Cooler	50 mg/Nm^3
Cement Mill	50 mg/Nm^3
Coal Mill, if applicable	50 mg/Nm^3

SO_2

Kiln Operations	400 mg/Nm^3

NO_x

Kiln Operations as NO_2	400 mg/Nm^3

AMBIENT AIR QUALITY

All facilities must demonstrate compliance with the following World Bank general industry ambient air quality guidelines.

Particulates

Annual Geometric Mean	100 μg/m^3
Maximum 24-hour Peak	500 μg/m^3

SO_2

a) Inside Plant Fence:

Annual Arithmetic Mean	100 $\mu g/m^3$
Maximum 24-hour Peak	1000 $\mu g/m^3$

b) Outside Plant Fence:

Annual Arithmetic Mean	100 $\mu g/m^3$
Maximum 24-hour Peak	500 $\mu g/m^3$

NO_x

Annual Arithmetic Mean (as NO_2)	100 $\mu g/m^3$

Ambient air quality monitoring may be required by the local regulatory authority depending on local requirements and the existing concentrations of these contaminants in the affected areas.

QUARRY RECLAMATION PLAN

Project sponsors are required to prepare and implement a quarry reclamation plan. The plan should include reclamation of sedimentation basins, and abandoned access roads and camp sites. The main objectives of the quarry reclamation plan are:

- return the land to conditions capable of supporting prior land use or uses that are equal to or better than prior land use, to the extent practical and feasible; and
- eliminate significant adverse effects on adjacent water resources.

Quarry reclamation plans should incorporate the following components:

- conserve, stockpile, and use topsoil and overburden for reclamation;
- recontour slopes of more than 30% to minimize erosion and runoff;
- plant native vegetation to prevent erosion and encourage self-sustaining development of a productive ecosystem; and
- schedule and budget for pre- and post-abandonment reclamation activities.

Final grading for the quarry closure should ensure proper run-off of stormwater to prevent accumulation and contamination of surface waters.

OTHER ENVIRONMENTAL REQUIREMENTS

Dust Control Measures

The plant should be provided with air pollution control systems to control the dust emitted throughout the different stages of the process.

- All the equipment related to material handling and storage such as conveyor systems should be covered, and all transfer points should be equipped with a suitable dust collector.
- Clinker should be stored in a covered storage facility and cement storage silos should be equipped with dust collectors.
- If the kiln is equipped with a bypass, the dust collected should be safely disposed of and a description of this dust disposal system should be provided.

Sewage Sludge Disposal

Sewage sludge must be disposed of in an environmentally acceptable way in compliance with local laws and regulations.

Solid Wastes Disposal

Project sponsors will be encouraged to recycle or reclaim materials where possible. If recycling or reclaim is not practical, these wastes must be disposed of in an environmentally acceptable way in compliance with local laws and regulations.

Notes:

1. Source: Cement Manufacturing Industrial Pollution Control Guidelines. The World Bank. October 1992, DRAFT.

2. Stack emissions guidelines will apply to cement facility with major power generating equipment (see Thermal Power Plant Guidelines).

Attachment 2

WORLD BANK OCCUPATIONAL HEALTH AND SAFETY GUIDELINES

CEMENT AND CLINKER GRINDING PLANTS

HEALTH - GENERAL

a) sanitary and washing facilities with equipment and supplies (e.g. protective creams) allowing personnel to protect themselves from and/or wash away dust
b) policy of encouraging employees potentially exposed to dust to wash frequently
c) eating room separate from work areas
d) pre-employment and annual medical examinations for all personnel
e) immediate re-assignment of any employee with indications of silicosis detected in the annual medical exam

TEMPERATURE AND HUMIDITY

a) adequate ventilation to reduce work area temperatures and humidity
b) procedures allowing more frequent breaks away from work areas for personnel required to work in high-temperature areas, in order to prevent heat stress
c) provision of and easy access to clean drinking water and salt substitution solutions

NOISE

a) provision of hearing protection to personnel exposed to noise levels above 70 dBA
b) maximum noise level of 90 dBA in normal work areas
c) provision of sound-insulated rooms with noise levels below 75 dBA from which personnel can monitor and control equipment, wherever possible
d) regular maintenance of equipment to minimize noise levels

WORKPLACE AIR QUALITY - DUST

a) dust control and collection equipment to keep workplace total airborne levels of inert or nuisance dust below 15 mg/m^3 and airborne respirable inert dust levels below 5 mg/m^3 (8-hr time-weighted average)
b) maintenance of free silica levels in dusts below the following levels:

total $$\frac{30\ \text{mg/m}^3}{\%\ SiO_2 + 2}$$

respirable $$\frac{10\ \text{mg/m}^3}{\%\ SiO_2 + 2}$$

c) for areas involving exposure to coal dust, maintenance of average total dust concentration to 2 mg/m^3; maintenance of free silica levels, same as b) above
d) regular monitoring of workplace air quality for dust levels

e) provision of protective respiratory devices for use when dust control equipment breaks down

SAFETY - GENERAL

a) thermal insulation on all steam pipes
b) shield guards and guard railings at all belts, pulleys, gears, or moving parts
c) handrails, toeboards, nonslip surfaces on all elevated platforms, walkways, stairways, and ramps
d) electrical equipment grounded, well insulated, and in accordance with applicable national and local codes
e) provision of hard hats and special footwear as appropriate, and masks and dust-proof clothing to personnel working in areas with high dust levels
f) use of special gloves, helmets, face protection, leggings, non-slip footwear and other protective equipment, as necessary, for work near high-temperature materials
g) provisions for preventing non-authorized use of explosives and blasting materials
h) immediate repair of leaks that generate dust levels in excess of those noted above
i) provisions for preventing fires and explosions for coal handling, storage and processing facilities
j) good housekeeping procedures including: keeping walkways clear of debris and immediately cleaning up spills, and regular inspection and maintenance of equipment

TRAINING

a) training of all personnel in safety and accident prevention including: safe lifting practices; proper control and maintenance of process facilities; use of personal protective equipment; causes, symptoms, and prevention of silicosis
b) training of all personnel in emergency response, including: location and proper use of emergency equipment; procedures for raising the alarm and notification of emergency response teams; and proper response actions for each foreseeable emergency situation

RECORDKEEPING

a) maintenance of records of all accidents and illnesses involving plant personnel, and provision of this information to IFC
b) periodic evaluation of this information, and assessment and improvement of the effectiveness of the occupational health and safety program

Notes:

1. Source: Occupational Health and Safety Guidelines. The World Bank. September 1988.

2. Additional health and safety guidelines will apply to cement facilities with major power generating equipment (see Thermal Power Plant Health and Safety Guidelines).

Annex XII

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Annex XIII

Programme
for the
Seminar on Cleaner Production in the Cement Industry
Cairo, Egypt, March 28-29, 1993

March 28

8^{00}-9^{00}	Registration and coffee	
Session I	**Introduction**	Chair: Mr. M. Abu-Zeid
9^{00}-9^{40}	Welcome Address - The Chairman of the Suez Cement Company Mr. Mahmoud El Khouly	
9^{40}-10^{10}	Government Address - Mr. Tarek Genena	
10^{10}-10^{30}	Foreword - UNIDO National Expert Mr. Abu-Zeid Osman	
10^{50}-11^{20}	UNIDO and its Cleaner Production Activities - UNIDO staff member Mr. Mats Zackrisson	
11^{20}-12^{00}	WEC/Suez Cement Company Training Workshop in Operation and Control of Air Pollution Equipment - Mr. George Lombardo, World Environment Center	
Session II	**Achievements in Project**	Chair: Mr. Hamdy Sadeek
13^{30}-14^{05}	Waste Minimization Philosophy and its Implementation at the Suez Cement Company - Mr. Ken Bradley	
14^{05}-14^{40}	Heat Treatment of Alkali By-pass Dust at Quattamia Plant - Mr. A. Hamdy Sadeek	
15^{00}-15^{35}	Mixing of the Burned Alkali By-pass Dust with OPC Clinker at Quattamia and Suez Plants - Mr. Said Yazeed	
15^{35}-16^{10}	Properties of Cement Synthesized from Burned Alkali Dust/Clay Mix with Clinker and Gypsum at Quattamia Plant - Mr. Said Yazeed	
16^{10}-16^{30}	Summary Discussion	
16^{30}	End of first day	

March 29

Session III	**Achievements in Project**	Chair: Mr. Ken Bradley
9^{00}-9^{40}	Waste Minimization at the Quattamia Cement Plant - Mr. A. Shebel	
9^{40}-10^{30}	Spotlight on the Limestone of the Suez Cement Plant - Mr. Abu-Zeid Osman	
10^{50}-11^{30}	Re-use of the Alkali By-pass Dust at the Suez Plant - Mr. A. Hamdy Sadeek	
11^{30}-12^{00}	Summary Discussion	

Session IV	**Wider View and Follow-up Discussions**	Chair: Mr. Carl Rydeng
13^{30}-13^{50}	Waste Digestion in Cement Kilns; Possibilities and Constraints - Mr. Rydeng, UNIDO	
13^{50}-14^{20}	Activities of the International Finance Corporation (IFC) in the Cement Sector - It's Environmental Requirements for Cement Plants - Mr. George Gouda, IFC	
14^{30}-15^{30}	Open floor discussion - brief interventions are invited - followed by adoption of the meetings recommendations on follow-up action	
15^{30}	Closing of Seminar	

Plant Tour

15^{35}-16^{30}	Travel to the Quattamia plant
16^{30}-17^{30}	Plant tour
17^{30}-	Return to Pullman Hotel