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CEMENT DEVELOPMENT AND RESEARCH CENTRE

DP/TUR/72/084

(R) TURKEY,

Technical report:
STUDY ON THE OPTIMIZATION OF CEMENT KILN AND MILL PRODUCTIVITY, (1977).

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

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id.77-384

United Nations Development Programme

CEMENT DEVELOPMENT AND RESEARCH CENTRE

DP/TUR/72/034

TURKEY

Technical report: Study on the optimization of cement kiln and mill productivity

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

Based on the work of François Le Bel, cement industry expert

United Nations Industrial Development Organization
Vienna, 1977

Explanatory notes

The following abbreviations are used in this document:

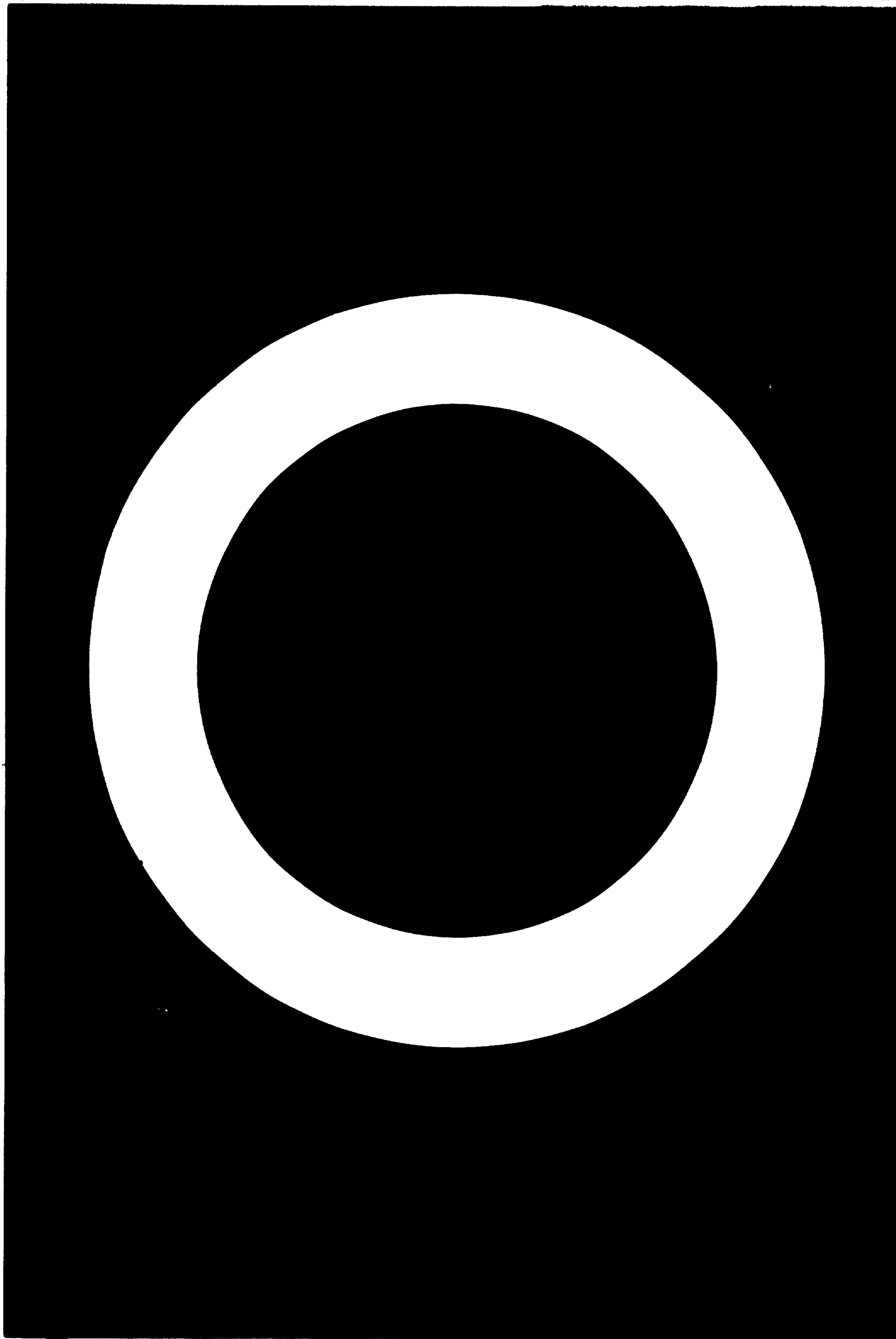
CERILH Study and Research Centre for the Hydraulic Binder Industry

PCA Portland Cement Association

PIARC Permanent International Association of Road Congresses

ABSTRACT

The report summarizes the mission carried out by an expert sent to Turkey from 18 November to 10 December 1976 by the United Nations Industrial Development Organization (UNIDO). This mission was part of the United Nations Development Programme (UNDP) project "Cement Development and Research Centre" (DP/TUR/72/034), for which UNIDO is executing agency.



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ANNEXES

INTRODUCTION

Immediately upon his arrival in Ankara on 19 November 1976, the expert had an opportunity to discover, in the course of a number of conversations with Mr. Yagiz and Mr. Abaffy, the extent of the investment programme that the Turkish Government intends to undertake in the cement industry as rapidly as possible. The programme entails the construction of 18 factories between 1976 and 1985 and probably a further 20 factories after that date.

Plant locations have already been partly chosen, as well as the manufacturing processes, but in theory only. This work would in practice have to be entrusted to highly competent consultant firms with wide experience in the cement industry field.

A world-wide call for bids will be made, based on a standard list of specifications, with instructions that will have to be followed by the constructors after examination of specimen material from the quarries. This procedure, in the opinion of the expert, constitutes a danger which could be partly guarded against by establishing a control and research laboratory as soon as possible. The construction of this laboratory has already started and is advancing rapidly.

Round-table meetings were organised by the expert, Mr. Yagiz and his assistants in order to inform the participants, listed below, of the duties awaiting them in the field and in the laboratory, and to provide effective assistance to existing factories and make specific recommendations to project managers responsible for investment.

The expert made several trips in the course of the mission. A round-table meeting was organised on 24 November, in Istanbul, with Mr. R. Dedeoglu, Director of the First Division of the Turkish Highway Department, from which it emerged that the promotion of the cement industry would enable bitumen, now being imported, to be replaced by cement for road works. Visits to factories at Pendik near Istanbul and at Smyrna showed that Turkish engineers were endeavouring to solve their problems intelligently, despite a certain lack of information, which the laboratory should be able to make up.

The following, among others, took part in the round-table meetings:

Mr. Faruk Yagiz, Project Director and Director of the Turkish Cement Industry Corporation

Mr. Sigmund Abaffy, Project Co-ordinator

Mr. Emin Bacaran, Planning Office, Laboratory

Mr. Kahiyan Köksal, Process Control Department

Miss Baĭdar, Assistant to Mr. Yagiz (Laboratory Office)

Mrs. Hilal Erkan, Planning Office

I. GEOLOGICAL STUDIES

After meeting the staff of the research laboratory and the geologists, the expert established that, although the geologists were performing their work very conscientiously, certain aspects of the geological studies were being neglected.

He endeavoured to draw attention to the relationships between comprehensive geological data, the choice of process and the quality of the products.

A. Study of the quarry

The first task must be, with the help of a geological map, to look for deposits that appear satisfactory in the geographical region which will constitute the market served by the future plant, and to undertake surface sampling in order to make sure that the geological map is accurate. Then a preliminary choice must be made between the various deposits and a decision taken, within this framework, on a site for a plant, with easy access for consumers and supply services (roads, railways, sea coast, etc.).

This choice having been made, a general sampling of the surfaces must be carried out, taking into account the topography of the deposit and its geological age - that is to say, using a fairly close grid to try to determine the nature of the stratigraphy and its irregularities (dips, faults, inclusions, etc.). The samples should be not simply picked up but extracted from the rocks in place.

A comprehensive analysis of these samples taking into account the place that they come from, will indicate whether the exploitation of the deposit is worth while. To decide upon this, it is necessary to know the CO_3Ca content, the MgO content and the quality of the silica.

Three samples of three categories of silicious raw material were examined with a scanning electron microscope. This examination can also be carried out by less elaborate means such as with an optical microscope, or by indirect means (measuring reactivity at different temperature levels).

	Conclusions
Pure quartz (crystals greater than 50 µ)	Use to be avoided
Aluminium silicate (particles between 3 and 10 µ in size)	Usable material
Clays (fibres with a diameter of a few ångströms and a length of a few microns)	First-class raw material

B. Test drilling campaign

After a superficial examination of the quarry, a first series of borings must be made to give a better idea of the deposit, in particular to confirm its stratigraphy and the value of the various beds identified. At least one of these borings should be deep, in order to determine the depth of the deposit. In this boring, one can measure the degree of homogeneity of each bed, endeavouring to establish an order of magnitude for the standard deviations revealed by analysis of the core samples, together with more rapid drillings (the powerful compressed-air wagon drill used in quarrying - bore speeds from 15 to 20 miles an hour) from whioh the rejected material (gravel and dust) is carefully collected, if possible metre by metre, to enable analyses to be carried out. At this point, it can be decided whether to choose or reject the quarry.

The grid of the quarry will have a mesh of 100-200 in depending on the above-mentioned indications. After an analysis metre by metre, or at greater intervals (acoording to the greater or lesser homogeneity of the beds), the cores, sawn in two to provide check samples, are orushed. Sampling, crushing and analysis will give a precise idea of the preparation of the type raw material, and make it possible to define the quantities of material to be extracted in order to obtain the same chemical and mineralogical mixture each time.

A model of the quarry will allow one to visualize the programme for the working of the quarry over a period of 15-20 years, or more if possible, to define the optimum composition of the raw material and to make recommendations on the choice of manufacturing process.

The above concludes in principle the task of the geologist, but his assistance will continue to be very useful and will certainly be called upon by the head of the construction project for the new plant, and by those who will be operating it, who know how difficult it is to run a plant of which the quarry has not been sufficiently researched, with perhaps some disagreeable surprises in store for them (a quartz silica stratum, pockets of clay, etc.). Traditionally trained geologists should be attached to the central laboratory for the Turkish cement industry.

It is therefore recommended that a Turkish geologist should be trained and that an expert should be sent to Turkey to assist him in practice, in accordance with a proposed plan of training and work (see annexes I and II).

II. INDUSTRIAL PREPARATION OF THE RAW MATERIAL

In the previous chapter, attention was drawn to the need to have a good knowledge of the standard deviatione in each deposit for the following essential substances: CaO, SiO_2, Al_2O, Fe_2O_3, MgO, SO_3, K_2O, Na_2O.

The preparation of the raw material means ensuring optimal proportions for obtaining a quality clinker, meeting etandarde at lowest cost. The second objective can only be obtained if the kiln operates in continuous dynamic equilibrium; it is necessary therefore that the input elemente - that is, the levels of essential substances, oxygen, calories recuperated, etc. - should be conetant. When this equilibrium has been obtained, an effort can be made to improve it through knowledge of the data relating to the entry and exit elements - e.g. potential composition of the clinker, analysis and temperatures of the exit gas, etc. - linked by the correlations which are the basis of the optimization work.

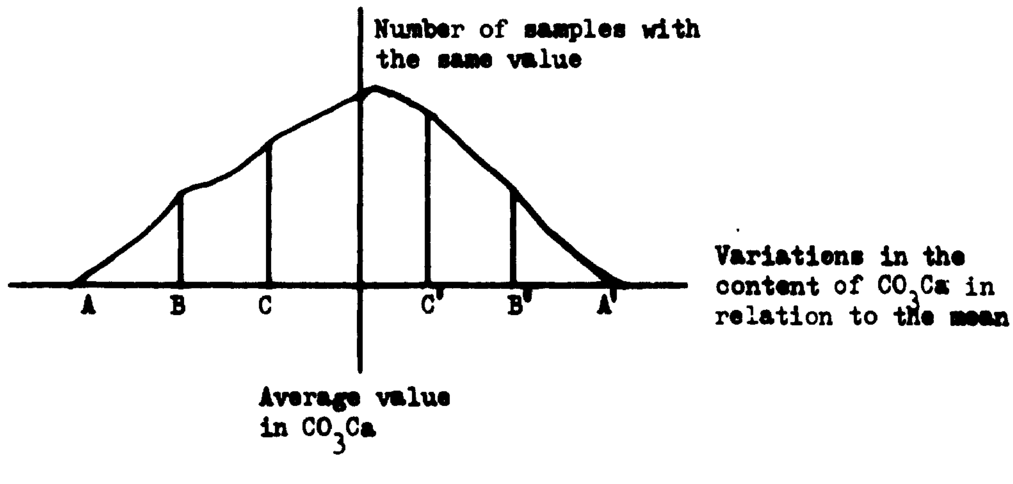
The problem is how to keep the raw material constant once the ohoice has been made. The geologist has determined in advance the standard deviations of variations in the analysis of the substances from the quarry in relation to their topographical location; the laboratory engineers have defined the proportions of raw materials for crushing and the fineness of grinding needed in order to obtain optimum reactivity. If these standard deviations are small and vary little, one can content oneself with normal orushing and storage and a raw grinding mill adequately equipped for the sampling and two homogenization silos placed before the kiln, which can serve direotly for storing the raw meal.

If the standard deviations are large, the shop will provide a meal which will vary continually in chemical and mineral composition; this will result in an unstable operation of the kiln, with immediate consequences: overburned olinker, which is less reactive (overburning is inevitable to avoid having uncooked olinker); premature wear of the refractory material of the burning zone; formation of rings (prinoipally in kilns equipped upstream with cyclone or grate exchanges), and the risk of avalanches of olinker which may damage the coolers; blocking of cyclones if the kiln is equipped with a cyclone exchanger; poor kiln utilisation coefficients with the economic consequences that result from this, etc. All these problems can be easily avoided if a prehomogenisation system is installed before the raw grinding mill. Many cement plants balk at this investment, without realising that it is generally less expensive than the installations found in traditional plants working with difficult quarries, involving storage of raw material in several (three or four) silos or a storehouse with a traveller, and multiple feeders (since we are speaking of difficult quarries), apart from the difficulties of extraction, handling and segregation which such an installation entails.

Studies carried out on quarries generally reveal their degree of homogeneity and that of their different beds - that is, the standard deviations in relation to average values for the various essential components contained in the deposits.

The preparation of the feed is preceded by mixing, in the crusher, materials coming from the various beds designated in the quarrying programme. A priori, 1,000 (metric) tons from bed I + 300 tons from bed II + 700 tons from bed III will give 2,000 tons of feed which will be of the right composition as a whole, but not at each instant. The problem is to produce after crushing a stock of 2,000 tons or a multiple of 2,000 tons - 8,000 tons for example (depending on the production of the plant) - which with simple processing will automatically provide a feed in which the ingredients are proportioned with precision (precision of the order of magnitude of chemical analysis). Results of an analysis of the material emerging from the crusher vary within certain limits which can easily be determined in advance and can be confirmed by means of a continuous sampling which enables a precise calculation to be made of the standard deviation for the variations in CO_3Ca, for example, with reference to the mean required (target value); if the quarrying is well carried out the curve of variation in the samples of the 2,000 tons processed is generally a Gaussian curve (see figure I).

Figure I. Gaussian curve



If the base AA' is divided into six equal elements, the element σ obtained is the standard deviation.[1]

In general, the Gaussian curve is limited to the part between the vertical lines at B and B', because the inner part contains 95 per cent of the measurements and the outer part 5 per cent, which is negligible.

This σ is very small if the quarry is highly constant in its composition; such quarries are increasingly rare or are situated far from markets and, in view of the high cost of cement transport, one often has to be content with quarries which are mediocre but situated close to markets.

Having recourse to prehomogenization makes it possible to bring σ down to the value required, thereby transforming a mediocre quarry into an excellent quarry, with all the consequences that this will have on the quality of the products and their production cost.

How is σ to be reduced?

After the crushing it is possible, but not absolutely necessary, to carry out continuous sampling. The raw materials are scattered with the help of a stacker moving continuously to and fro at constant speed, creating on the pile a regular stratification in herring-bone form (cross-section aa'); the laws of statistics show that if one takes slices of this pile perpendicular to its axis, their analyses are very close and the σ' for the variations in these analyses is linked to the initial σ by the relationship

$$\sigma' = \frac{\sigma}{n'}$$

n' being the number of inverted V's. The greater n', the smaller σ', so knowing σ and requiring a given value for σ', one can deduce the desired n'; if a very large n' is needed, one must increase the speed of the stacker or, by mechanical contrivances, prepare a pile whose cross-section will have the form bb' (see figure II).

1/ Standard deviation formula.

$$\sigma^2 = \frac{\sum_1^m (x_i - x)^2 n_i}{m}$$

where	$x_i - x$	=	deviation in relation to the mean value x
	n_i	=	number of measurements giving the value x_i
	m	=	number of measurements made.

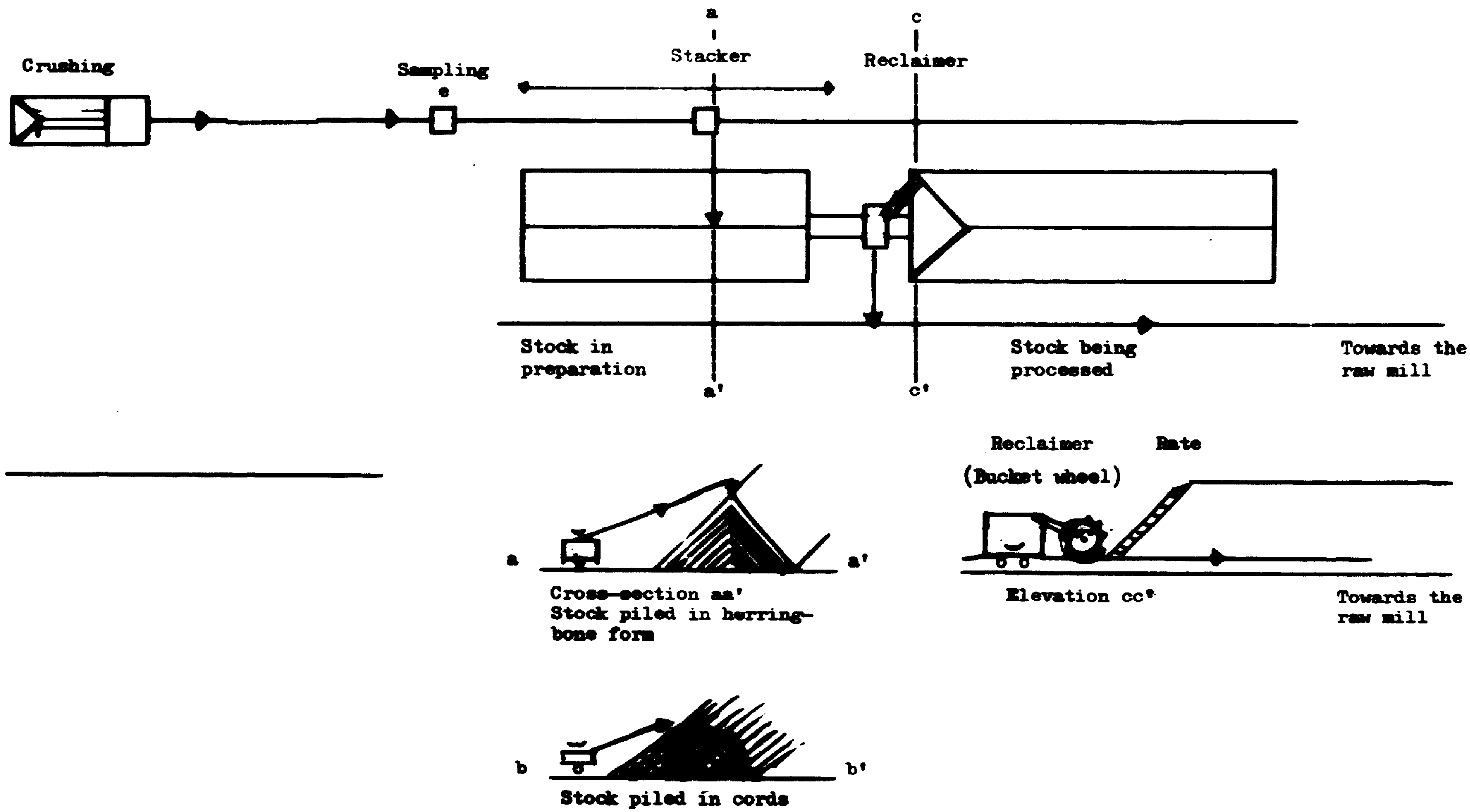


Figure II. Diagram showing the functioning of a statistical prehomogenization system

III. ESTABLISHMENT AND USE OF A DATA BANK

The objective of the three talks given by the expert in Ankara to the personnel of the research laboratory for the Turkish chemical industry, represented, in particular, by Miss Baillar, Mrs. Erkan, Mr. Bacaran and Mr. Köksal and the four geologists from the organization, including Mr. Sönmez, for whom an extensive training programme is recommended, was to equip the Research Centre with practical means for assisting the services responsible for erecting the 18 plants provided for in the investment programme for the period 1976–1983, and to optimize the choice of raw materials and manufacturing processes in order to increase profitability, endeavouring to manufacture the various products required by the market at the lowest cost, at the same time ensuring absolute continuity as far as quality is concerned. In order to carry out this programme, at least two stages are necessary. The first stage will consist in collecting, and then providing in automatic form, data relating to the operation of existing plants and to the specific qualities of their raw materials and products. The second stage will consist in beginning the utilization of the data bank - that is, in trying to establish, through a knowledge of the manufacturing processes of the plants, correlations between inputs and outputs (the inputs being the physico-chemical and mineralogical qualities of the raw materials and fuels, and the outputs being the qualities of the cements manufactured, expressed in potential compositions, levels of important constituents such as alkaline sulphates - K_2SO_4, Na_2SO_4, etc.). This will be long-term work, discouraging at the outset but rewarding in the end. The study of these correlations will enable the operators to establish cause-and-effect relationships, taking concrete form in the fixing of precise target values at all stages of manufacture, from the working of the quarry to the cement mill.

It may be added that, in the case of new investments, comparison of the new raw materials with those of known plants will enable useful interpolations to be made and allow one thereby to avoid errors and over-investment; secondly, it will be possible to optimize the choice of processes by means of the knowledge acquired of the links between the inputs (raw materials) and the outputs (clinker, additives).

The following data must be recorded:

1. Raw materials

   Complete chemical analysis

   Grain-size analysis

   Chemical analysis of rejects to 100 μ

   Reactivity before 900° (thermo-gravimetric analysis)

   Burning aptitude

   Temperature of crystallization of the liquid phase (thermo-differential analysis)

   Percentage of quartz

   Granulation aptitude (specific surface area, BET).

2. Indication of the manufacturing process

   Clinker:

   Comprehensive chemical analysis

   Potential composition (C_3S - C_2S - C_4AF - C_3A)

   Alkaline (So_4K_2 - So_4Na_2 - So_4Ca) and alkaline-earth sulphates.

3. Cement after normal gypsum-processing in relation to the C_3A content (taking into account the SO_3 contributed by the sulphates)

   Nature of the cement

   Blaine surface area - dust dispersion in relation to the average

   Resistance at 2 days - dust dispersion in relation to the average

   Resistance at 28 days - " " "

This operation should be carried out every month in order to have a good idea of the quality of the products and, in particular, of their regularity, and to enable averages of the results to be kept up to date over 12 months. To assess whether the installations are functioning properly, the heat consumption and the consumption of electricity must be known.

As to how one uses a data bank, it is difficult to give this basic teaching on the spot owing to the lack of information; for this reason it is recommended that training should be given in a large cement-manufacturing company possessing a good data bank which is brought regularly up to date.

One cannot learn how to use a data bank to best advantage from a training course, however long. There must first be an awareness of the utility of a data bank, and the attention of managers of enterprises must be drawn to its advantages. The object seems to have been achieved in part, if one judges by the number of questions put tc the expert after his talks. The training of Mrs. Erkan, who has all the necessary qualities, will constitute a second stage. After the period of training she will have to initiate the operations, beginning with the simplest data; she will first need to acquire experience. It will also be necessary to motivate plant managers and their engineers so that they will be concerned to send in accurate information - information whose quality will undoubtedly improve with time, along with the progress made in their plants.

A highly qualified expert should come once again as soon as the central laboratory is completed, to continue the training programme. A possibility would be to ask for a senior expert from the Central Laboratory of the Lafarge Group, one of the few laboratories which have gone a long way in the interpretation of operational data, where Mrs. Erkan will have spent some time during her training in France.

It was noted how important the work of the geologists was and what an impact it had on the operation of the quarries with a view to obtaining the optimum raw material, as well as on the choice of manufacturing process, and capital investment planning (establishment of a new plant or setting up of a new production line).

It is recommended that every two years a technical meeting should be organized at Ankara, lasting for two days, for example, in the course of which scientific and technical subjects relating to the operation of plants and the quality of end products would be expounded and discussed, the meeting to be attended by the plant managers, certain plant engineers, the central laboratory engineers and high-level Turkish and foreign participants.

The meeting could take up general subjects and specific subjects in the following fields: solid-state physics, adapted to the cement industry; cristallography; reactions between solids; electron exchange; bonds, etc. Technological subjects of interest to plants should also be discussed: quarries; the working of quarries; optimization of the operation of kilns and mills; preparation of raw material; processes. At the same time, instruction should be given on how to assemble information and analyse it so as to be able to make useful recommendations for the operation of the plants and to improve the quality of the products - in other words, to achieve the objective set by UNIDO.

IV. OTHER ACTIVITIES

A. Research laboratory for the Turkish cement industry

1. Organization of the laboratory (in collaboration with Mr. F. Yagiz)

It is recommended that the following sections should be put in direct contact and under one authority:

Raw materials:	Geology; study of the primary materials, definition of feeds
Processes:	Studies on reactivity; burning tests; determination of characteristics of raw materials specific to the processes
Cement:	Standard cements; special cements; control

Steps should be taken to train the person who will be responsible for this undertaking (see the training plan for Mrs. Erkan in annex III).

With the exception of the management and a few specialists, there must be a rotation of personnel every five years, with staff being transferred from the laboratory to the plants and vice versa, in order to create the essential "interface" between the laboratory and the plants.

2. Advancement of the work on the central laboratory at Ankara

Date anticipated for the termination of the work:

Section	Start-up and equipment	Date anticipated for the termination of the work
Civil engineering		September 1977
Raw material	Equipment provided by the Federal Republic of Germany 2/	October 1977
Cement	Start-up dependent on a gift from the French Government	Not definite
Concrete	Start-up dependent on a gift from the Netherlands and Danish Governments	

During the course of his visit to Ankara, the expert endeavoured to make clear to the French Government, through the intermediary of the French Embassy at Ankara, the moral and probably economic value to France of the provision of equipment for the cement section of the laboratory.

Although the funds for cultural development aid for 1977 are already exhausted, the French Embassy will try to make two fellowships available to the Turkish cement industry: the first for a Turkish geologist from the central laboratory at Ankara to undergo training in applied geology in France; the second for sending a geological expert to Turkey to complete the training of the Turkish geologist on the spot and to prepare him for the training in Turkey of other Turkish geologists.

2/ Seven plants out of the 18 plants that Turkey has decided to construct between now and 1985, under its investment programme will be put up by the Federal Republic of Germany.

B. Road problems

A visit to the First Division of the Turkish Highway Department at Istanbul was organized by Mr. Ridvan Dedeoglu. He was provided with all the information required for the reliable construction of a section of the motorway between Istanbul and Ankara, employing cement-treated gravelly sand and concrete carriageway slabs.

On 25 November 1976, a meeting was held with Mr. Ridvan Dedeoglu and engineers from his department to discuss the general principles which had emerged from the Cembureau working group meetings concerning the construction of road infrastructures and road surfaces, held at Munich in September 1976.

The following are to be recommended:

1. Deep lateral drainage after levelling of the ground over which the road is to be constructed.

2. Soil stabilization to a depth depending on its consistency, plasticity and water-content; in general, by mixing to a depth of 20cm with 4 - 5 per cent lime, a mixture of lime and cement, or cement, followed by a compacting operation (depending on the consistency of the original soil). This stabilizing treatment consists in rendering the soil non-thixotropic, giving it more bearing strength and avoiding any rising of clay in the base, which is generally composed of a layer of cement-treated gravelly sand, 20 - 30cm thick, placed on this treated soil.

3. Laying of the base: 30cm of cement-treated gravelly sand, laid by conventional means, compacted and rolled afterwards in order to ensure good compacting, the gravelly sand being composed of two qualities of granulate material and sand, well washed (final granulometry between 0 and 2.5mm), mixed together at the central point with 4 - 5 per cent coarsely ground cement ($<$ 3,000 Blaine).

4. Road surface: bitumen concrete with 25mm coarse aggregates on the surface to limit the risk of aquaplaning, or a Portland cement concrete layer 20 - 25mm thick laid with a large-capacity slip-form paving-machine - the surface being automatically grooved crosswise in order to create the necessary reliefs to limit the aquaplaning risks. This solution, which has been adopted in many countries of Europe and the American continent, can be improved with the help of new developments (utilization of a retarding admixture in the gravelly sand in order to allow non-stop rolling for 5 - 6 hours, thereby enabling road work to continue throughout the day on one half of the carriageway without traffic being interrupted).

The general discussion which followed showed the validity of three possible methods applied very satisfactorily in Turkey, France and the United States for reasons of an economic nature (cost of labour, equipment (slip-form paving-machine)).

Turkish method:	- Soil drained and stabilized with lime; - Compacted gravelly sand, # 20cm - Cement-treated gravelly sand, # 20cm - Concrete road surface, 20-22cm	3 layers = 3 operations
French method:	- Soil drained and stabilized with lime; - Cement-treated gravelly sand, 20-30cm - Concrete road surface, 20-22cm	2 layers = 2 operations
American method:	- Soil drained and stablized with lime; - Concrete road surface, 30-40cm	1 layer = 1 operation

Annex IV contains for information a summary account of the Fifteenth PIARC Road Congress, held at Merico City in October 1975.

During visits to road construction sites around Istanbul on 24 November 1976, the expert had an opportunity to observe that the preparation and the laying of the cement-treated gravelly sand were fully satisfactory. The cracks in the gravelly sand foundations remarked on by the Bridges and Highways engineer Mr. Cosrum Erozkan can be reduced in frequency and size by adopting a few precautionary measures: the careful tamping down and compaction of the foundation, together with adequate rolling; the use of a water-reduction agent to facilitate the laying without increasing the water/cement ratio; the use of a cement which is low in C_3A (4 - 5 per cent) and coarsely ground (Blaine 3,000); as with the surface layers, the use of a cement of the same origin so as to avoid any work-site misalignment.

C. Thermal balance of one of the CORUM plant kilns (Report by Mrs. Erkan)

Mrs. Hilal Erkan went over in detail the theoretical calculations for the thermal balance of the furnace and compared the result with that calculated by the plant manager, after ten days of stable kiln operation, on the basis of simple factors: the quantity, nature and characteristics of the raw materials; the quantity, nature and characteristics of the clinker product; the quantity, nature and characteristics of the fuels used.

The results obtained by these two methods are very close, providing that the calculations and experimentation were performed with accuracy and objectivity.

Average heat consumption calculated for ten days of operation = 1,170 kilocalories per kg of clinker

Some of the factors on which Mrs. Erkan based her calculations appear on the attached diagram (see figure III), which was examined by those present in the light of the importance of the consumption of this kiln, leading to an interesting and very lively discussion.

It is to be noted that, given the process used, it should be possible to reduce this heat consumption by some 300 kcal, which is a very sizable amount and represents a fuel saving of the order of 25 per cent.

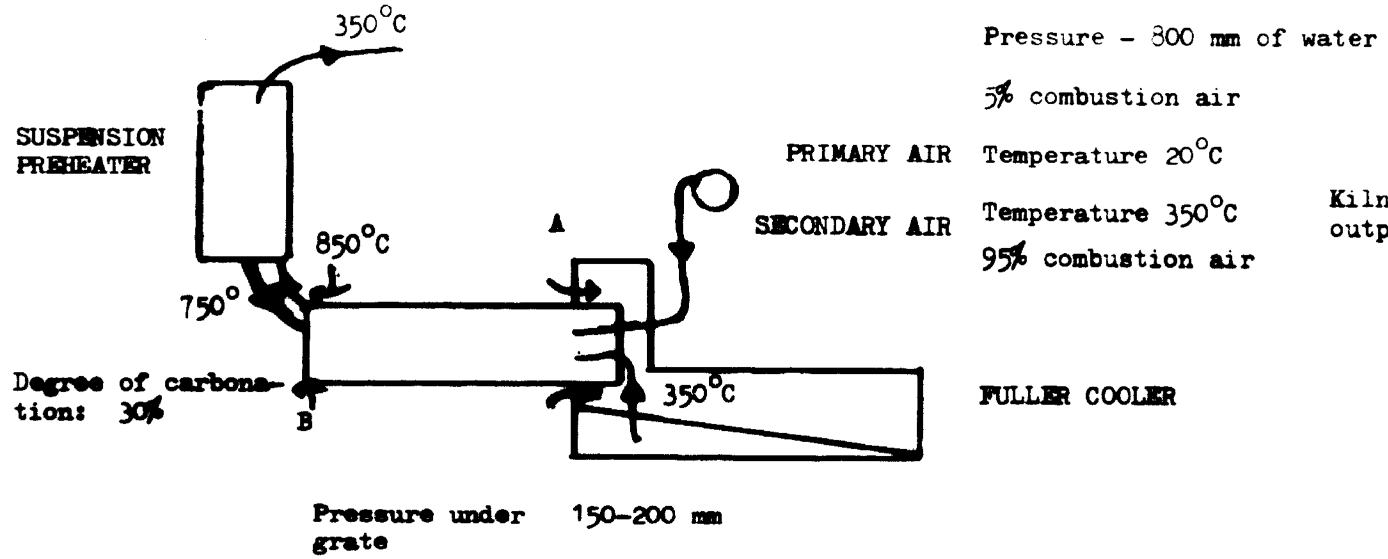
If one examines the operating characteristics of this facility, the secondary air temperature (350° C) is found to be far too low; this temperature ought normally to be in the neighbourhood of 850 - 900° C (its measurement is a delicate operation for which an aspiration pyrometer should be used).

There are two possible explanations for this low temperature:

1. Joints upstream and downstream of the kiln underpressurized, causing the entry of cold stray air: at A, where it reduces the heat carried by the secondary air; at B, where it reduces the heat carried by the air leaving the kiln in the direction of the exchanger. The temperature of the gas at B is 850° C whereas in general it should be 950 - 1,000° C. The result is that the performance of the cyclone heat-exchanger is impaired because of this temperature drop, and the normal degree of decarbonation of the material when it reaches the kiln at point B is not achieved; the temperature is only 750° C whereas it should be about 900 - 950° C. The burning of this poorly prepared material in the kiln requires an abnormally high caloric value in the burning zone.

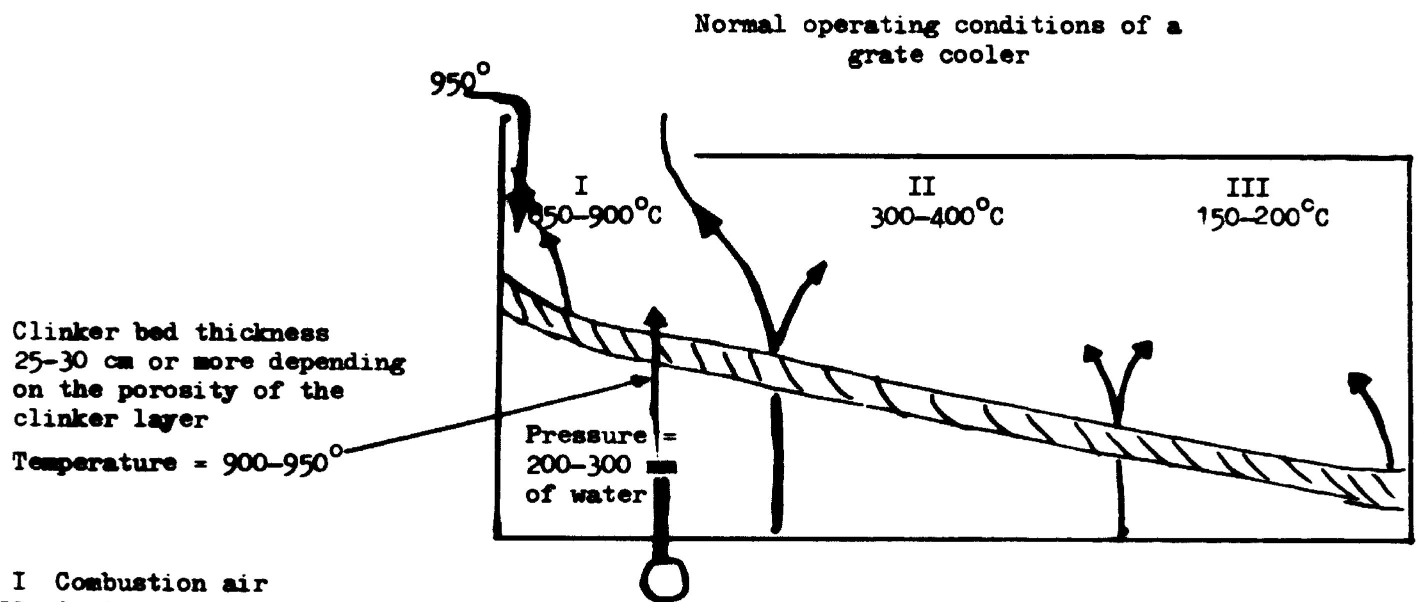
A check of these two joints is therefore to be recommended, especially the upstream joint B. The efficient performance of joint A is difficult to achieve mechanically, but performance can be considerably improved by checking the underpressure of the external firing-cap; this underpressure should never exceed 1 to 2mm of water, and in the case of a long tuyère (burning zone at some distance from the firing-cap) the cap may be kept under slight pressure (1 to 2mm of water). If this recommendation does not produce a definite improvement in the thermal balance, the operation of the grate cooler must be checked. Although this device is a clinker cooler, it is also a heat-exchanger, the appreciable heat of the clinker being transferred largely to the air of combustion (secondary air), the temperature of which is found to be too low (350° C instead of 850 - 900° C) - on the assumption that joints A and B are in good condition, i.e. that the foregoing recommendation has been taken into account.

2. Too thin a bed of clinker on the grate (less than 25cm), with too much heating air in the first compartment for the amount of clinker on the grate. In this case the movement of the grate should be slowed down so as to increase the thickness of the clinker bed. There will be a rapid rise in the temperature of the secondary air provided the air pressure beneath the grate is sufficient to overcome the head loss caused by the clinker bed (minimum below-grate pressure required = 180-200mm of water). If this head loss is significant (clinker with continuous granulometry), the pressure beneath the grate may be boosted to as much as 300mm of water. The condition of the grate must be carefully checked, particularly with respect to its longitudinal mechanical tightness (air leaks around the edges). If the below-grate pressure is normal, one must check whether the flow too is normal - i.e., whether the secondary air required by the kiln (95 per cent of the air of combustion) comes from the first compartment of the cooler.



Heat consumption = 1,170 kcal/kg of clinker

Kiln output = (a) Coal firing 1,000 tons/day; (b) Fuel-oil firing 1,300 tons/day



I Combustion air
II Coal or raw material drying air
III Degraded air to be rejected

Figure III. Corum plant

Annex I

JOB DESCRIPTION

Expert's name:	Mr. Kalman Havas
Country:	Turkey
Industry:	Turkish Cement Manufacturers' Association
Purpose of the mission:	To continue locally the training received in France by the Turkish geologist Mr. Cahit Sönmez, helping him to apply in Turkey, on the spot and in a specific case (under the investment programme provided for in the Plan), the knowledge he has acquired (applied geological study of a quarry for a cement plant under consideration).
Duration of the mission:	Six weeks
Starting date of the mission:	April or May 1977 (after the snow melts), following a test drilling campaign.
Duty station:	Ankara and at the site
Expert's qualifications:	Geologist with a degree from the Faculty of Sciences, Paris; geologist with the Société des Ciments Lafarge for more than ten years. Project manager, expert in process selection based on the findings of a rational quarry survey, which he can organize and supervise.
Languages:	French, English and Hungarian
Background information:	The expert will work within the organization. He will be directly responsible to Mr. Abaffy, the UNIDO Project Co-ordinator.

Annex II

TECHNICAL ASSISTANCE

Name of the trainee: Mr. Cahit Sönmez

Organization applying for the assistance:

Turkish Cement Manufacturers' Association

Sponsoring ministry: Ministry of Industry

Object and purpose of the activity:

Further training of a conventionally trained geologist and adaptation of his knowledge to the study of deposits of raw materials for the cement industry, with a view to the optimization of quarry operation, the formulation of raw material mixtures, and the selection of the production process.

This programme of assistance is included in the Five-Year Plan:

International technical assistance and scientific co-operation;

Principles and application (para. 1382-7);

Implementation programme (articles 124, 125 and 126).

In view of the number of plants which are to be built within a brief period, there is an urgent need for persons with an extensive knowledge of geology as it applies to the cement industry. It will be the geologist's task to transmit his knowledge to other Turkish geologists.

Start of the training period: February or March 1977. Duration: Six weeks.

Experts required for this training programme during the period spent in France:

the experts of the Lafarge Central Laboratory and of the Technical Department with responsibility for matters relating to geology, mineralogy and the selection of production processes.

Expert required in Turkey (following the training in France): Mr. Kalman Havas.

Training programme:

The purpose is to upgrade the skills of one of the geologists of the Turkish Cement Manufacturers' Association

Geological surveying by the taking of surface samples;

Partial identification of stratification structure by the physical, chemical and mineralogical analysis of samples;

Test drilling programmes;

Recommendations on how to carry out such programmes;

Processing of test drilling results: precise determination of the stratification structure and characteristics of deposits;

Determination of the homogeneity of different parts of deposits;

Determination of the optimum method for working the quarry;

Determination of the optimum raw material mixture for cement;

Advising on the selection of the process.

List of the equipment requested to complete the outfitting of the central laboratory for the Turkish cement industry, supplementing the material supplied by the Government of the Federal Republic of Germany:

Electric furnace, with programme control, for testing the reactivity of the raw mixture;

Gas furnace (1,200–800°) adjustable at 20° intervals, with controlled atmosphere;

Electric sample-drier;

Le Chaterlier and Vicat equipment (for cement setting);

Autoclave;

Controlled-temperature bath;

Recording microcalorimeter;

Control calorimeter;

Precision balances (0.001 or 0.0001);

Calibrated glass equipment for analytical purposes (atomic absorption);

Laser granulometer (second stage);

Porosimeter (paste and mortar);

Equipment for the preparation of mortars (Rilem Cembureau);

Presses (for compressive and tensile strength testing);

Length-variation measuring equipment;

Equipment for one and two day resistance measurement;

Sound-proof clinker grinder for laboratory use;

Two stainless-steel hood exhausters (acid fumes);

Device for the preparation of demineralized water;

Assorted physical and chemical indicators for this laboratory;

Stock of spare parts.

The approximate monetary value of this equipment is 1 million French francs.

Annex III

PREPARATION OF A DATA BANK AND ITS USE

COURSE OF TRAINING

Name of the trainee: Mrs. H. Erkan

Total duration: One month (four weeks)

Places of training:

At Paris, at the Study and Research Centre for the Hydraulic Binder Industry (CERILH)

Duration: Three weeks

Subject: Organization and operation of laboratories

Two weeks:
- Laboratory equipment;
- Objectives, use of the equipment;
- The role of CERILH vis-à-vis laboratories concerned with cement industry problems.

One week:
- Clinker constituents;
- Cements;
- The phenomenon of setting (explanation, kinetics); on this occasion, a meeting with Mrs. Regourd at CERILH and Mrs. Conjeaud of the Research Laboratory of the Lafarge Group at Trappes.

At the plant

Duration: One week
Subject: The logic of the production process; relations between a plant laboratory and the central laboratory.

At Viviers - central laboratory of the Lafarge Group

Duration: Two weeks
Subject: Role of the central laboratory vis-à-vis a plant laboratory; organisation, operation and equipment of the control laboratory.

<u>In Paris</u>

Duration: One week at CERILH

Subject: Supplementary information; consolidation of the results of the training; conclusions.

Visit to the Solid-State Physics Laboratory at Orsay;

Visit to the installations of the Atomic Energy Commission at Saclay;

Visit to the Central Laboratory for Bridges and Highways.

Duration: Two weeks

Subject: General information

Annex IV

ROAD CONGRESS ORGANIZED BY THE PERMANENT INTERNATIONAL ASSOCIATION OF ROAD CONGRESSES (PIARC), MEXICO CITY, 1975

This Fifteenth Congress, which was of great interest because of both the nature of the subjects discussed and the high calibre of the speakers, was held in Mexico City from 12 to 18 October 1975 and brought together 2,300 delegates.

The texts distributed before the Congress provided a rather clear picture of the road-building policies of the different countries repreesented.

The major trends emerging from the papers read at the meeting were the following:

Paper of Mr. Odier (France), Wednesday, 15 October 1975: Low-cost roads and low-traffic roads

The paper dealt with the concern to build in a way that will not have adverse effects for the future; logical selection of the routing based on optimization of factors as regards geology, geography, traffic, the environment and the economy; choice of stable ground; if argillaceous ground cannot be avoided, stabilization using lime or cement or both together, rather than blacktopping products; little or no foundation; a surface of sand and bituminous emulsion, hence low cost and roads which are easy to build with a minimum of resources, and easy to maintain; options for the future are left open, but the assumption is light traffic, limited loads and little danger of frost. This approach is very logical, and it is hard to envisage alternative solutions (cement replacing blacktopping for this kind of road), unless it were possible to produce a quality-surfaced soil-cement with rudimentary material; nevertheless, a layer of blacktop material would have to be used for temporary repairs.

Paper of Mr. Giannini (Italy), Tuesday, 14 October 1975: Non-rigid carriageways

This paper focused on three key objectives towards which blacktop producers will direct their efforts in close co-operation with firms most interested in the use of these products:

The forming of ruts is one of the major shortcomings of blacktopped surfaces and of foundations stabilized with black materials as well. The permitted axle load for trucks (10 tons) makes roads of this kind very vulnerable. As a practical consequence, while it is possible to renew the surface, this is not true of the foundation. Accordingly, there is a need to move towards non-deformable, cement-treated gravelly sand foundations. This is an interesting trend.

To reduce surface rutting, two approaches are under study: either hard asphalt or asphalt mattress (non-woven polyester fabric with a non-rigid latex additive) if the increase in hardness leads to a risk of cracking.

The lowering of the cost of the surface course by the replacement of the road carpet by coatings resistant to compression and creep.

The blacktop advocates have not yet had their last word and are seeking the most economical solutions in terms of investment, while realizing that foundations of cement-treated gravelly sand will be required. Nevertheless, the fatigue-resistance of the latter has still to be calculated. A study programme should be initiated in this field; it is already apparent that cement-treated gravelly sand is more fatigue-resistant than gravelly sand containing slag (hydraulic bond qualities).

Paper of Mr. Saccasyn (Belgium), Monday, 13 October 1975: Rigid carriageways

There are signs of greater interest in rigid (concrete) carriageways, but only as regards motorways and heavily travelled roads.

(a) The Setra solution - rigid bonding between the surface course and the shoulders of the road to avoid lateral pumping - is a technique used throughout the world; there is particular emphasis on very good lateral drainage, very good stabilization of the soil, which must be able to contain any upward movement of the clay strata, and a foundation of cement-treated gravelly sand; if the ground has been well stabilized, a slight cracking of the foundation is not serious, but it must have good fatigue-resistance (subjection to alternating pressure); there are no new developments as regards the surface course outside the United States.

(b) A new United States approach: Recent economic studies carried out by the Portland Cement Association (PCA) on different concrete surface solutions have led to the proposal of a solution which results in manpower economies (wages are steadily rising) and is of great interest to cement producers: very good drainage; cement stabilization of the ground, if required; no foundation, with direct single-layer emplacement (slip-forming) of slabs of 30-40 cm thickness; virtual elimination of pumping; good freezing and thawing resistance. This solution, whioh is economically justifiable in the United States, would probably not yet pay in Europe, but thought should be given to it as supplies of good-quality gravelly sand are continuously shrinking.

(c) There is another trend in the United States in the area of road renovation. A slab of slightly reinforced concrete measuring 20 cm in thickness is laid across the entire width of a four-lane road and its shoulders. The carriageways are separated by a prefabrioated hollow central wall consisting of movable concrete sections which, although keyed together, can be disassembled and reassembled. Telephone and power lines, etc., can be run through the central cavity.

PCA has demonstrated a large number of walls, including noise-resistant concrete walls. This is a wide open field in which there is a large potential market for concrete, particularly light-weight concrete for use in noise-resistant walls.

(d) There is increasing interest in prefabricated concrete components for use in urban road-building (paper by Mr. Batsch, Director of the Central Laboratory for Bridges and Highways, Paris). Another, brilliant, paper was read by Mr. Pasquet, Director of the National Sohool of Bridges and Highways in Paris, on methods for reducing skidding on roads and the correlations that have been found to exist between means and effects, i.e. accident statistics (studding on non-rigid carriageways with hard aggregates, studding on rigid carriageways before hardening of the surface concrete with hard aggregates, grooving before or after hardening of the concrete, gluing of hard aggregates to hardened concrete or non-rigid carriageways, etc.).

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