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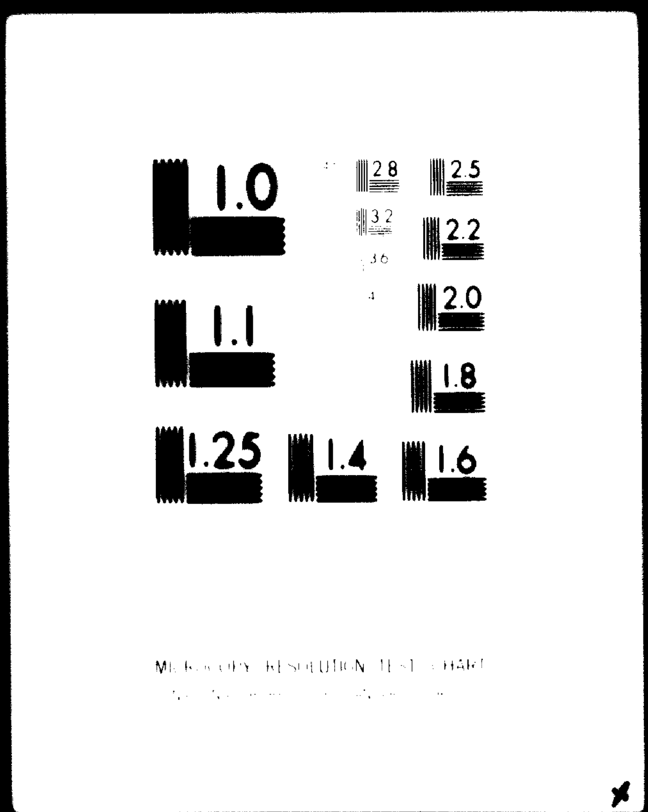

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The results of this mission are the subject of this report, and we will succinctly discuss its content.

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1 - In fact the cement plant was well built and uses high quality equipment. It is capable of producing 330 t. daily of clinker which corresponds, under normal operations and given local conditions, to 90,000 t. annually of clinker, or, following the addition of gypsum, an average of 95,000 t. of cement.

2 - In point of fact, it was only able to produce 45,000 to 55,000 t. with an intermediate year approaching 70,000 t. This stagnation is significant and disturbing, especially since it was accompanied by similar stagnation in quality which remained highly insufficient.

This reflects the inadequacy of the technical staff and perhaps the sense of organization and authority of the general management whose staff changed too often in the past. On the other hand the new general management has become aware of technical needs, and this has already produced a slight but impressive financial recovery. The difficulties which have just been mentioned, however, persist ; technical recovery has not yet been achieved, and an effort at training personnel remains to be made.

3 - The matter of quality remains fundamental for the future of the firm in the competitive climate to be encountered to-morrow. As it happens, it is impossible to manufacture good clinker starting with bad raw materials. Uniform, carefully proportioned materials are essential and irreplaceable in obtaining good cement.

4 - The supply of good raw materials is a matter of the quarry involved.

As it happens, the quarry was neglected by the builder and seems to have been opened without any extensive studies. In addition, although very near Sokoto there is a major limestone source with favorable prospects, at the present time, contrary to widespread opinion, there are no known deposits of good limestone which can be used in the manufacture of cement.

Given the quarry's present condition, the carbonate content may be considered to be too frequently below the acceptable limit.

Finding and using to-morrow's materials is one of the essential tasks to be carried out in succession, and a detailed chapter is devoted to this problem in this report (homogeneous or heterogenous quarry with correction materials to be exploited at another location, reserves and so forth).

5 - Not only is the raw meal's carbonate content too close to the limit, but it is uneven, since the homogenisation unit at the plant is not operative. Of that, the equipment, insufficiently changed over by the contractor at the time of the conversion from the wet to dry process, is more responsible than the personnel. As it happens, the homogenisation process, always difficult, is a major step and will be of equal importance to-morrow if, as is likely, it will be necessary to work with correction materials. Concerning this, the report gives recommendations for an improvement program.

6 - Other imperfections influencing equipment efficiency concern the raw material dryer, kiln operation and the cement grinder which is too often out of adjustment. These imperfections are less important than defects in materials and homogenisation, since they are easier to solve.

7 - Essential for production without any hitches, the maintenance program must be improved by instituting visible regular maintenance and by the stocking of better chosen replacement parts.

8 - Improved productivit must also be applied to management and administration. There is an excessive number of operating personnel in virtually all areas. As has been said, the number of high technical staff and supervisory personnel must be added to with individuals of known capability. Analytic bookkeeping must be set up, and this will contribute considerably to supervising costs and the proper operation of each shop.

9 - We have specified technical coefficients of consumption and efficiency which can be achieved using present equipment but at the cost of training and disciplining personnel which must be carried out without any delay. Even so, however, results will show a deficit in that the plant, although able to more than meet its direct manufacturing costs, will only be able to provide for some of its amortization and financial expenses.

At that time, even taking into account a possible increase in the cost of supplies to uniformly obtain better raw materials, the financial burden of the new installation must be easily met.

Even when output will reach nearly the capacity of the two kilns there must even appear a margin to help with the amortisation deficit of the first plant. However, it is worth saying this result can only be given as an indication, since the corresponding capital expenditure has only been too briefly evaluated.

10 - The margins created, however, will never make it possible to repay the indebtedness acquired as of this day and which is excessive. As it happens, this indebtedness is certain to grow for the present plant alone by the amount of investments corresponding to reorganization of its operations (prospecting for correction limestone, adjustment of the homogenisation, various improvements and personnel training).

As it is, it is unquestionable these various investments, which it is virtually impossible to detail due to the unpredictable nature of geological prospecting, will total several hundred thousand N Pounds.

11 - From this must follow the financial reorganization of the company in order that, with its new structure, it will be able to operate profitably. This means a considerable reduction in capital, the partial or total wiping out of the present indebtedness and a new call for funds.

The rate at which debts are to be wiped out will be determined by the amount of costs healthy, technical perfected administration will allow it to cover.

12 - The question of an increase in capacity mentioned earlier does not arise as concerns obtaining these results, since, brought about under present conditions, there is an excellent chance it would be disastroue. No plant, no matter how large, can survive with the two present handicaps : merchandise of quality inferior to that of competitors possibly available on the same market at the same price ; and insufficient operational ratio of installed equipment whereas the investments were planned for amortization with much higher output.

To summarize, reorganization is essential before any increase in capacity.

Moreover, practical factors presently forbid this. On the one hand, it is a question of locating the suitable raw materials in terms of quantity, quality and price, and, on the other, of finding the necessary electric power.

The time to solve these problems corresponds closely to that needed in training the personnel and carrying out the market study, always keeping in mind the fact that larger, better sales can only be obtained if quality is guaranteed.

13 - To summarise, it is no more a question of giving up the idea of operating the Sokoto cement works than allowing it to continue to make the same mistakes, which could only gradually lead it into an untenable position.

Action can and must be undertaken immediately in 3 directions :

- a reduction of superfluous operating expenses which have gradually proliferated (excess number of personnel, waste, unproductiveness, too distant customers and improvement in cost factors) It would seem, in this respect, the present general management is worthy of confidence.

- the development of an informed, dynamic technical staff, in specific organizing production, supervising it and training personnel.

- the financial support needed to rectify conditions already existing in a certain number of faltering areas already mentioned earlier (quarry, homogenisation, replacement parts and so forth) and insufficiently studied at the beginning.

The examination already carried out gives reason to think that, if these steps are taken, it will be one or two years before the company can develop its output and markets and reestablish a new financial balance in a better setting which more advanced technical and financial studies will be able to define.

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This leaves us the pleasant duty of thanking all those who, in Nigeria, helped us perform our mission and who, with as much patience as objectivity, provided us with the elements for work, which, without them, would not have been possible. Unfortunately, we can only mention the most important individuals among them :

IN SOKOTO

- Among government officials :

  His Excellency ARGUNGU, Minister of Finances

  The General Secretaries of the Ministry of Finances (Mr. Suleiman LIMAN) and the Ministry of Natural Resources (Mr. ALCALI)

  The Director of the Plan, Mr. [illegible]ENN

  The Directors of the Ministry of Natural Resources, Messrs. Hassan ABUBAKAR and Umaru NDAKAKO

  The Director of the ECN, Mr. IBRAHIM

- Among the CCNN personnel :

  The General Manager, Mr. LUKMAN, who devoted so much time to us and shared his experience and thinking with us

  Mr. YAHAYA, Administrative Secretary

  Mr. ENAJI, Director of Personnel

  All Division Chiefs, both Nigerian and European (Messrs. BEULKE and BARRETT)

IN KADUNA

Mr. YAKUBU, Deputy General Manager of the NNDC

Mr. Mohamed DABO, Sales Manager of the CCNN

The Personnel of the Geological Survey and Marketing Board

And, naturally, the UNIDO representative, Mr. BLAINEY, who so gladly facilitated our contacts and solved material questions.

ABOUT THE SYMBOLS AND MEASURES

1° - In the text, we use the metric tons - t = metric ton.

2° - For the currency, we use the Nigeria pound, £ N, with decimalisation ; anyway, this decimalisation will be legal January 1st, 1973.

3° - For chemical analysis, the following symbols are internationaly adopted :

S	for	SiO^2
A	for	Al^2O^3
F	for	Fe^2O^3
C	for	CaO

So, C_3S means Tricalcic silicate $(CaO)_3\ SiO_2$

C_4F means Tetracalcic alumino-feinte $(CaO)_4 . Al_2O_3 . Fe_2O_3$

LSF means Lime Saturation Factor

MS means Silica modul

4° - For statiscal matters, we use symbols m and σ for the averages and real typical difference of the population, and symbols m' and σ' for the averages and typical differences of the samples extracted from this population.

CHAPTER I

DESCRIPTION OF THE PLANT

I - BACKGROUND

As we said in the Introduction, the history of the Sokoto plant is rather complicated. Originally, it was designed to be operated using the semidry process with a granulator directly feeding the kiln with granules.

Subsequently, to take into account foreseeable drying difficulties due to the water content of the raw materials, the project was modified, and the plant was constructed to be operated using the wet process with a calcinator.

As soon as the plant was started up in 1965, however, it turned out to be impossible to operate it due to : the excessively high water content in the raw slurry ; and decantation phenomena.

Thus, without attempting a virtually impossible adjustment, the engineers then decided to convert to the dry process. Naturally, the cost of this conversion, resulting from the insufficient preliminary studies, had to be borne by the supplier.

This explains :

- that the converted section was built at lower cost than the unit constructed in 1965 ;

- that the plant's lay out is not the same as it would have been had it been originally designed to use the dry process ;

- and, lastly, that the characteristics of certain units (the kiln, in specific) are unconventional for an installation of this type. In specific, the kiln diameter (3.4m) is instead that of a kiln normally designed for 140 to 150,000 T. of clinker using the dry process. This kiln is very short, however, since it was equipped with a preheater, the calcinator. Similarly, the homogenization silos do not have the conventional dimensions associated with the dry process.

The wet process plant was designed to produce 100,000 t. of cement annually.

The newly installed equipment was modified to existing equipment and at the time of the conversion to the dry process output of 125,000 t. annually was announced.

II - FLOW SHEET

On the reduced flow sheet attached we have entered the characteristics of each major equipment unit, characteristics which appear on the documents provided by the suppliers or which we consider to be reasonable.

On the much more detailed flow sheet (Appendix I) appear the circuits for the :

- materials
- fuel oil
- hot gas leaving the kiln and then the dryer

A - Circuit for the materials

Following blasting, the raw materials are loaded by mechanical shovels on dumpers which feed the crusher.

On leaving the crusher installation, the crushed product is sent either for storage or directly to the dryer.

On leaving the dryer, the rock is sent either to storage or directly to the grinder.

The raw meal, following sifting on leaving the grinder, is brought by a Fuller pump to the storage and homogenization silo.

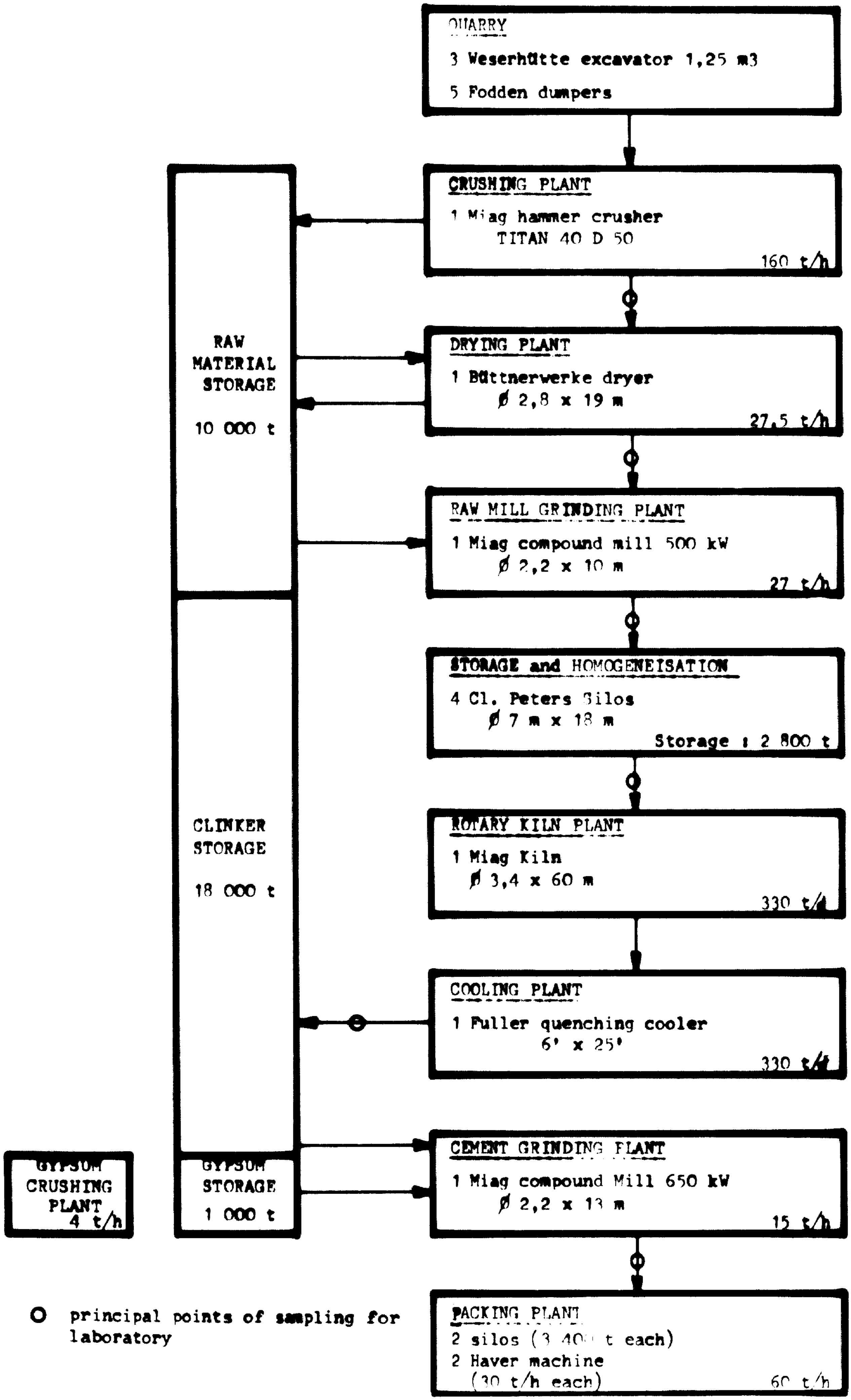
The meal, drawn from the silo, is brought by a Fuller pump to a reserve hopper from which the kiln is fed by means of a constant level buffer hopper and a POLYSIUS variable-speed chamber.

The meal is placed in the fume jacket preceding the cyclone collectors. Thus, it is centrifuged and preheated before reaching the kiln.

On leaving the kiln, the clinker is cooled in a quenching cooler and brought to the storage bay by a conveyor belt followed by a bucket conveyer.

The cement grinder hoppers are filled with clinker and gypsum by a travelling crane. Two adjustabl e, vibrating extractors draw off the clinker and gypsum to feed the grinder. The grinder is ventilated and its tube mill is cooled by sprinkling.

SOKOTO CEMENT FACTORY - FLOW SHEET



A Fuller pump sends the cement to the 2 silos tapped by fluidization.

The packing station makes it possible to simultaneously load the bags onto trucks.

B - Fuel oil circuit

The fuel oil, which comes from the Port Harcourt refinery, is heated and brought into the kiln by a mechanical vaporization burner. Lightweight fuel oil is used when the installation is started up in the dryer furnace and kiln.

C - Fume and dust circuit

The hot gas leaving the kiln following centrifugation is removed by a fan which can theoretically handle gas at temperatures of up to 600° C and is sent through a long conduit to the dryer operating in line with the kiln with all the drawbacks this implies.

After passing through the dryer, the cooled gas is centrifuged two times and removed by the chimney.

Dust collected at the bottom of the first cyclone collector after the dryer is returned to the kiln.

This results in : the dust coming from the kiln being recovered in the dryer installation and returned to the raw materials going to the raw material silos ; and the dust produced by the dryer being recovered in the "kiln cyclone collectors" and returned to the kiln feed.

Consequently, the raw material/clinker ratio is very difficult to obtain without accurate measurements (in any event, very difficult especially in the gas at a temperature of 500° C leaving the kiln) of the dust concentration in the gas (cf. attached diagram).

The clinker/raw material ratio is influenced :

- by the ignition loss of raw materials which has varied from 0.63 to 0.67 , or 5 percent ; here, a check can be performed by analyses.

- by the presence of "parasitic" materials, those from the quarry introduced into the system by the dryer.

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TECHNO-ECONOMIC SURVEY OF THE CEMENT FACTORY AT SOKOTO (NIGERIA)

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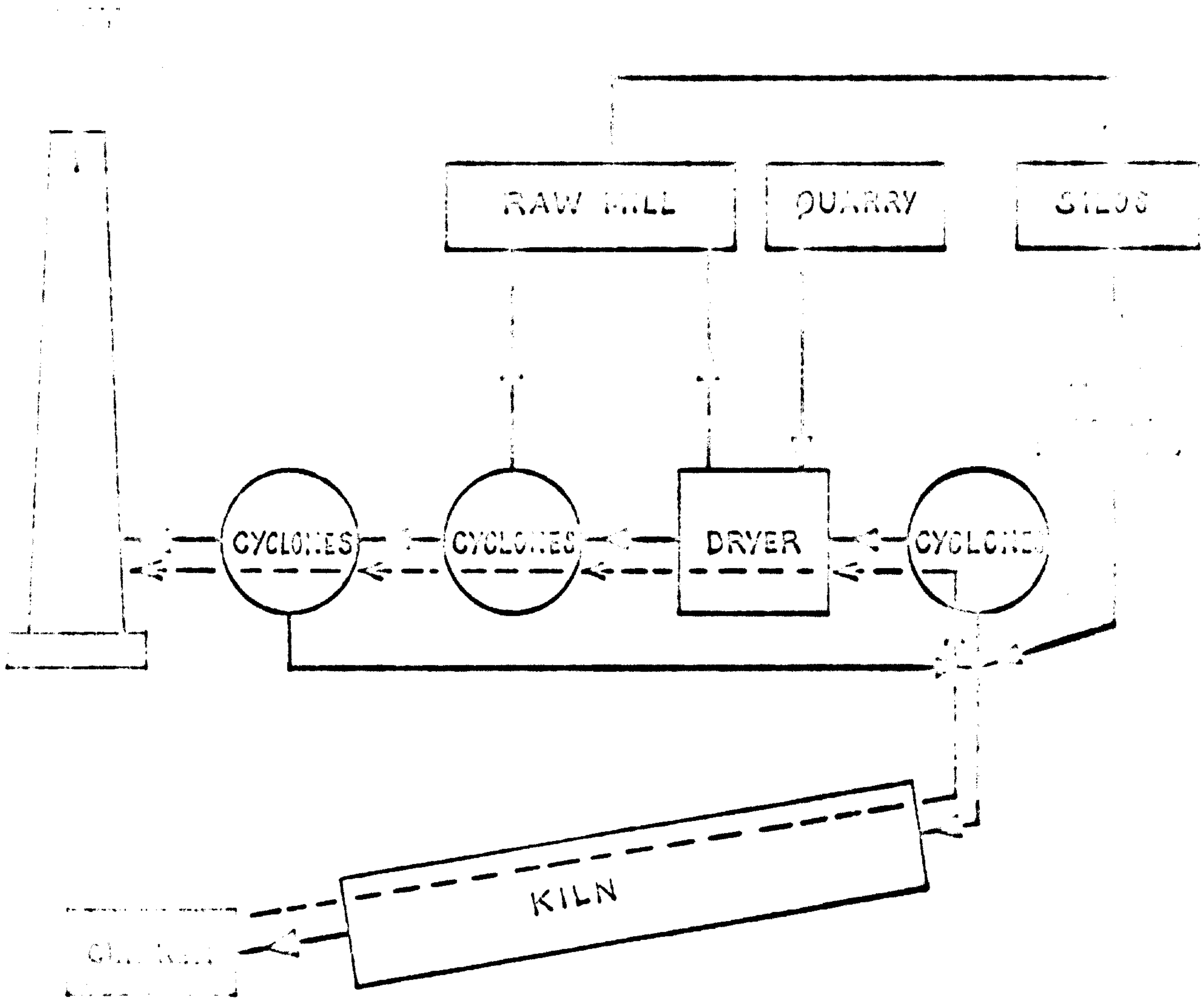
SOCIETE D'ETUDES POUR LE DEVELOPPEMENT ECONOMIQUE ET SOCIAL
With the technical collaboration of the
SOCIETE DES CIMENTS LAFARGE



—— FLOW OF MATERIAL OR DUST

- - - - FLOW OF GAS

- by the loss of dust coming from the kiln which can be returned to the grinder system by the dryer and by the cyclone separators at the dryer output.

These last two factors are very difficult to measure.

III - ELECTRIC POWER

Power is provided at 33 KV by the Sokoto ECN power station. An appended note outlines the present and future problems of this power station which, moreover, is located a long way away.

Two series transformers step down the voltage :

- one from 33.000 to 11,000 volts
- the other from 11,000 to 6,000 volts

The two grinders are operated from 6,600 volts and the rest of the plant is fed with operating power by means of two 1200 KVA transformers which step down the power to 400 volts.

In conclusion, this plant, built with high-quality equipment (1), would appear to be fully viable, but we will see later on that it is difficult to operate and that certain problems (in specific homogenisation) remain to be solved.

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(1) The major suppliers build good equipment.

The main supplier was MIAG. The others included : SIEMENS, Claudius PETERS, BUTTNER WERKE and so forth.

IV - PLANT COST AND FINANCING

It is rather difficult to accurately determine the initial cost of the Sokoto plant proper, in other words leaving out the Guiseu storage facilities and additions which came after the plant was placed in operation.

However, we can take to be accurate the figure for assets appearing on the 31st May 1967 balance sheet, the date of the CCNN takeover.

This figure was £ 4,448,570, not taking into account £ 363,152 corresponding not to equipment but to the negative balance of preproduction spending and income as of 31st May 1967.

The detailed breakdown of the £ 4,448,570 is given in the attached table in order to permit a rapid evaluation of expenses which would correspond to a twofold increase in plant size. Revaluation of the DM at the end of 1969 has not been taken into account.

Financing was provided by a capital of £ 1,500,000 in £ 1 stock, of which 80 percent was provided by the NNDC and 20 percent by Ferrostaal.

In addition, NNDC had advanced £ 70,000 from a current and draft account and promissory notes to the contractor written in DM, covering a figure of £ 2,583,840 (at the exchange rate in effect at that time of DM 11,2 for £ 1). A bank overdraft covered the balance.

SOKOTO FACTORY

COST OF EQUIPMENT

I -	Quarry	179 453	
	Crusher	118 051	
	Raw material store	45 328	342 832
II -	Dryer and hot gas lines	368 543	
	Raw mill	183 383	
	Raw material pump house	58 257	
	Raw material silos and homogenisation	189 860	
	Cyclones preheat	134 108	
	Kiln	854 108	
	Oil firing plan	67 478	1 861 697
III -	Gypsum crushers	12 230	
	Cement mill	217 291	
	Cement silo plant	95 154	
	Cement bagging	58 920	
	Compressed air	7 003	390 598
IV -	Switch and transformer plant	132 877	
	Laboratory equipment	17 035	
	Water supply	42 212	
	Workshop equipment	43 741	
	Office equipment	4 456	
	Weight bridge	2 713	
	Outside lighting	8 432	
	Fire brigade and first aid station	9 370	
	Emergency power sets	11 468	
	Lorries and trailers	78 146	350 450
V -	Spare Parts		111 088
VI -	Roofing of equipment		199 613
VII -	Land and buildings of the factory		548 087
	Staff house and club		100 675
VIII-	Miscellaneous: staff cars, radio, furniture , fixtures, etc. ..		41 323
	Unidentified (about 10%)		502 307
			4 448 670

For doubling the factory , item I is sufficient , but it would be necessary to buy items II and III, about 140 000 £ from IV and 130 000 from VI and spare parts, that is to say about 2 600 000 £ , with contingencies and growth of prices , the total would probably reach 3 000 000 £ .

CHAPTER II

1 - PLANT OPERATING RESULTS

We have taken the main operating results from the log kept daily by the laboratory since the first month the plant was taken over by the CCMN, in other words June 1967. Earlier, the Ferrostahl Company had operated the plant for one and one half months to perfect its functioning and perform dry process acceptance tests.

As a criterion of regularity, we use the operation of the kiln and its accessories which, until now, unquestionably constituted the weak point and bottleneck. Kiln operating days were divided into three categories :

- virtually without incident (continuous days or with stoppages of less than 1 hour)
- with incidents (stoppages exceeding more than 1 hour)
- complete stoppage

In Appendix II appears an even more detailed breakdown. As much as possible, for complete stoppages we tried to indicate the technical reason. In most instances, however, the former personnel who were present were no longer working at the plant and, as such, information is incomplete and sometimes, to a certain degree, inaccurate for the earliest incidents.

From the beginning, plant operations can be summarized as follows:

- the period from June 1967 to April 1968 seems to have been a period of breaking in and apprenticeship with equipment adjustments and trials and errors. Operations were irregular and output very poor.

- the period from May 1968 to March 1969 saw financial crises frequently interrupting operations and leading to a search for new liquid assets. Production was very chaotic with a complete stoppage of three months and no judgement can be made concerning the plant.

- during the period from April 1969 to February 1970 the equipment seemed to be broken in and more familiar to the personnel who, in turn, gradually succeeded in training themselves. During this period of time, the best plant results were obtained with 4 months of seemingly normal production (at least in terms of quantity), these being the months of April, July and August 1969 and January 1970.

- between February 1970 and April 1971, production once again became more irregular, and uninterrupted days of operation became less frequent. In addition, the lack of replacement parts prolonged the stoppages. In addition, though, stoppages of several hours during the day became more common. This may be related either to more extensive wear of the equipment or a change and lowering in the quality of staff personnel or both reasons at the same time.

Quantitative Output

We will not spend any time discussing the production of clinker as it appears in the daily operating log and which we have reproduced in Appendix II.

In point of fact, this output is determined from the quantity of raw materials multiplied by a coefficient which has varied over time between 0.65, a value clearly too high and maintained until the end of 1969, and 0.55, probably too low. It is still being adjusted and will perhaps stabilize between 0.55 and 0.60.

Thus, we will go on the quantity of cement actually sold which is surely the quantity known most accurately, since a weighing operation is performed at the time of bagging and the loaded trucks are weighed, although these recorded figures do not always coincide, but deviations do not exceed 5 percent.

This quantity differs from that of the produced clinker by the addition of gypsum totalling 5 percent by weight as well as due to bad clinker which, on several occasions, was manufactured, rejected and only recovered and reground in a mixture in small quantities.

Moreover, the removal of the clinker from stock and its grinding were generally performed during stoppages for technical reasons or kiln breakdown. Thus, cement output to be indicated cannot be strictly compared with the kiln operating hours given earlier.

for each 3months
A: Number of days of continuous work
C: Number of days of complete stops
B: Number of working hours of the kiln
Number of hours
1700
1600
1400
1300
1200
1000
900
700
600
500
C
B
A
1194
832
731
535
1709
1445
1223
1050
1168
1208
1968
1970
II
III
IV
I
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5

RUN OF THE FACTORY FROM THE BEGINNING

TABLE 1

Year	A	B	C	D	Reasons of the complete stops
1967					
June	0	13	17	262	
July	10	3	22	190	
August	17	2	12	431	
September	1	3	26	68,5	
October	9	5	17	274,5	
November	7	3	20	197	
December	2	2	27	63,5	
1968					
January	8	5	18	281	unitherm (fuel preheater)
February	13	8	8	420	
March	18	4	9	493	
April	16	2	12	406,5	vibratory conveyors
May	0	0	31	0	
June	15	4	11	425	
July	5	1	25	125	) no supplies by lack of money
August	0	0	31	0	)
September	0	0	30	0	) financial reorganization
October	0	0	31	0	)
November	0	13	17	293	)
December	18	2	12	438	belt conveyor and raw mill
1969					
January	13	3	15	353,2	) cranes failure
February	0	0	28	0	) and primary air blower
March	7	5	19	231	
April	27	2	1	660	
May	4	4	25	135,3	) raw mill bearings
June	12	1	17	297	)
July	22	3	6	581,3	
August	24	5	2	662,6	
September	17	3	10	465	
October	17	3	11	453,7	
November	25	1	4	618	
December	13	5	13	374,3	
1970					
January	22	9	0	677,7	
February	11	1	16	270,3	rebricking
March	10	3	18	276,6	bad clinker - hop gas fan
April	12	9	9	397,8	vibratory feeder
May	17	9	5	481,7	power failure
June	5	5	20	170	roller dryer - hot gas fan
July	16	4	11	442,5	power failure - hot gas fan breakdown
August	5	6	20	200,7	power failure
September	13	11	6	505,7	) rebricking
October	9	5	17	274,5	)
November	6	4	20	204,3	rebricking - fuel heating disposal
December	20	6	5	575	roof collapse - hop gas fan preheater explosion
1971					
January	11	12	8	435,4	Fuller cooler - power failure
February	14	8	6	416,2	lack of water
March	7	14	10	356,4	roller dryer
April	9	7	14	337	roller dryer - Fuller cooler raw material compression

A = days of continuous or pratically continuous work

B = days with some noticeable stoppage

C = days of complete stop

D = working hours of the Kiln / month

CEMENT OUTPUT
(TONS)

	1967		1968		1969		1970		1971	
	bagged	sold	bagged	sold	bagged	sold	bagged	sold	bagged	sold
January			4.686	4.050	4.006	4.[illegible]	7.111	7.120	4.405	6.244
February	(tests)		6.253	6.106	5.794	5.825	4.710	4.631	5.407	4.260
March	206)	during	7.186	7.143	6.657	6.663	1.957	2.101	5.267	5.700
	)	test								
April	1.211)	period 4.980	6.317	6.450	7.575	7.831	5.387	5.373	5.000 as of 23rd April	
May	3.513)		2.268	2.196	4.684	4.690	5.840	5.840		
June	2.125)		3.585	3.501	3.513	3.520	4.595	4.906		
July	2.532)		2.774	3.001	6.000	6.398	1.084	1.083		
August	3.010)		2.427	2.337	8.751	8.690	3.047	2.870		
		16.429								
September	2.059)		6[illegible]	533	7.712	7.860	5.812	5.795		
October	1.983)		806	886	7.[illegible]	7.024	5.480	5.496		
November	2.869)		790	792	6.[illegible]	6.001	4.786	4.780		
December	2.071)		3.706	2.154	5.104	4.[illegible]	4.947	4.960		
		21.330	41.213	50.[illegible]	70.714	70.[illegible]	54.715	54.864		

Added in the form of a fiscal year going from 1st June to 31st May of the following year, these results are as follows :

Fiscal year 1967 - 1968 : 42,265 tons
1968 - 1969 : 43,518 tons
1969 - 1970 : 69,140 tons
1970 - 1971 : 57,000 tons (51,000 as of 23rd April 71 + the estimated production for 38 days).

As the examination of kiln operations has shown, it was the period from July 1969 to January 1970 which was the most productive with 6,880 t. monthly for 7 months.

From July to October, 30,000 t. were produced or 7,500 t. monthly for 4 months in a row.

Using the same arrangement clinker output for the same period would have totalled 54,707 t. in 7 months (7,800 t. monthly) or 31,590 t. in 4 months (7,900 t. monthly).

This emphasizes the use of an excessively high clinker/raw material conversion coefficient at that time (0.65), especially since the cement adds 5 percent gypsum to the weight of the clinker.

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II - ANALYSIS OF QUALITY

The quality of the products has been examined at various stages of production : raw material, clinker, cement.

A - QUALITY OF RAW MATERIAL

The chemical properties of the final product are determined by those of the raw material except for the adding of gypsum.

a - Gauging and Correcting Raw Material

The gauging of raw material is made only at the mill. After that, there is no other correction in order to ameliorate composition or regularity of the material. This composition is determined at the delivery of the mill by hourly samples of which the only carbonate tenent is gauged by chemical analysis. The silica, alumina and iron, which are also likely to vary, are note gauged.

The considerable variations in quality observed at this stage of production are slightly reduced when the materials enter the kiln, thus the is no use for the homogenization facilities which would be clearly out of service.

For this reason, the chemical properties of the raw material are highly variable.

1- Period from June 1970 to February 1971

The table below gives the monthly averages of the CO_3Ca content of the raw material from June 1970 to February 1971 (1).

Month	June 1970	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan. 1971	Feb 1971
Raw material leaving crusher	72.7	73.1	75.9	74.9	-	75.4	75	74.6	74
Entering kiln	72.2	72.5	75.2	74.8	-	74.8	74.4	75	74.3

(1) Figures recorded in SOKOTO

...

This corresponds to the following averages :

Raw mill leaving crusher 74.4
Entering kiln 74.1

These two averages which are significant only for providing orders of magnitude reveal that the gauging of the raw material is apparently quite inadequate (1).

2 - February 1971

The graph 3 appended to the present page gives the daily averages for the month of February 1971 for the CO_3Ca content of the raw material leaving the crusher and entering the kiln.

These daily averages vary, in a month, between 72,9 % et 75,1 % of CO_3Ca at the exit of the crusher and between 73,3 et 75,8 % of CO_3Ca at the entry of the kiln, that is to say variations of 2,2 % an 2,5 %. The extend of these variations must be ± 0,3 %, as it is the case in a well regulated plant.

3 - Hourly Variations

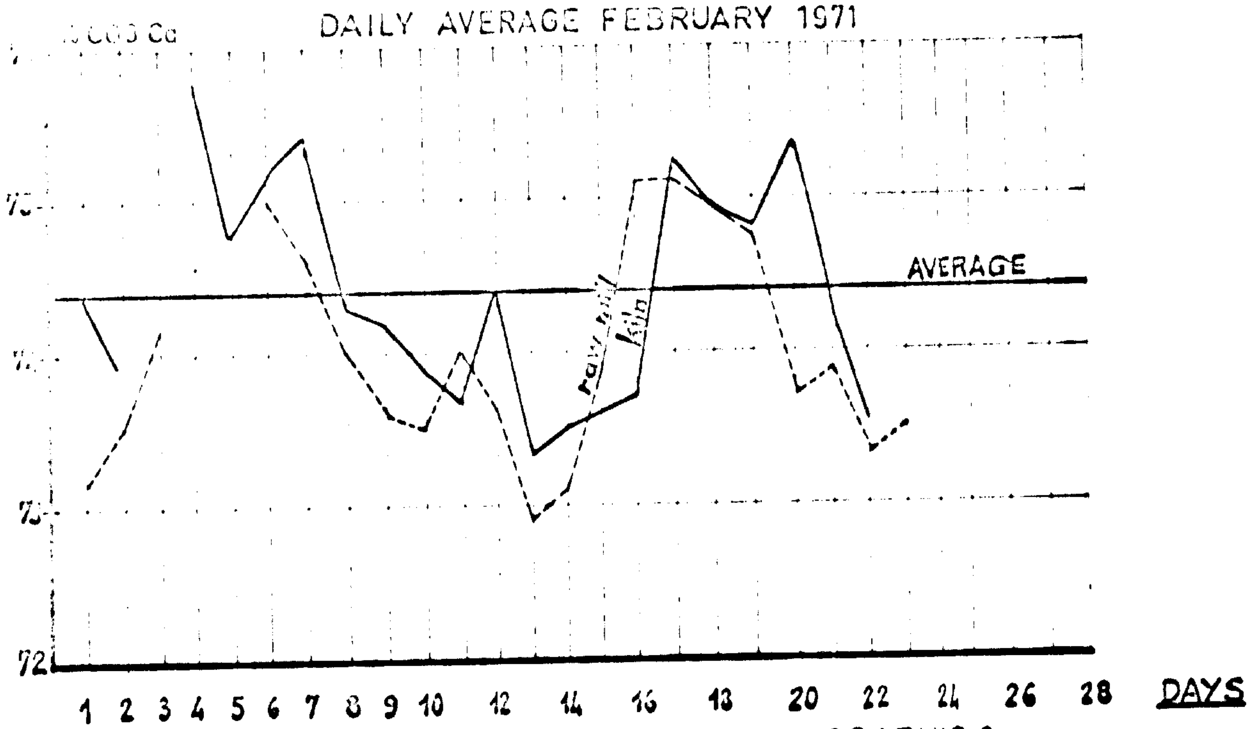
In order to appreciate the regularity of a raw material, it is necessary to examine non only monthly and daily averages, (these averages give a first idea) but also the hourly variations that reflect instantaneous variations of the CO_3Ca content.

The table below and graph 4 show the average CO_3Ca content (m') of the hourly samples and the corresponding daily variance σ' between February 12 and 21 1971.

		12/2 1971	13/2	14/2	15/2	16/2	17/2	18/2	19/2	20/2	21/2
Raw mill	m'	73,6	72,9	73,0	73,8	75,2	75,0	74,9	74,7	73,7	73,9
	σ'	0,81	1,44	1,68	2,03	0,61	0,75	0,87	0,70	1,22	1,00
Kiln	m'	74,3	73,3	73,5	73,5	73,8	75,1	74,9	74,7	75,3	74,2
	σ'	1,05	0,67	0,83	1,40	0,74	0,67	0,46	0,44	0,49	0,69

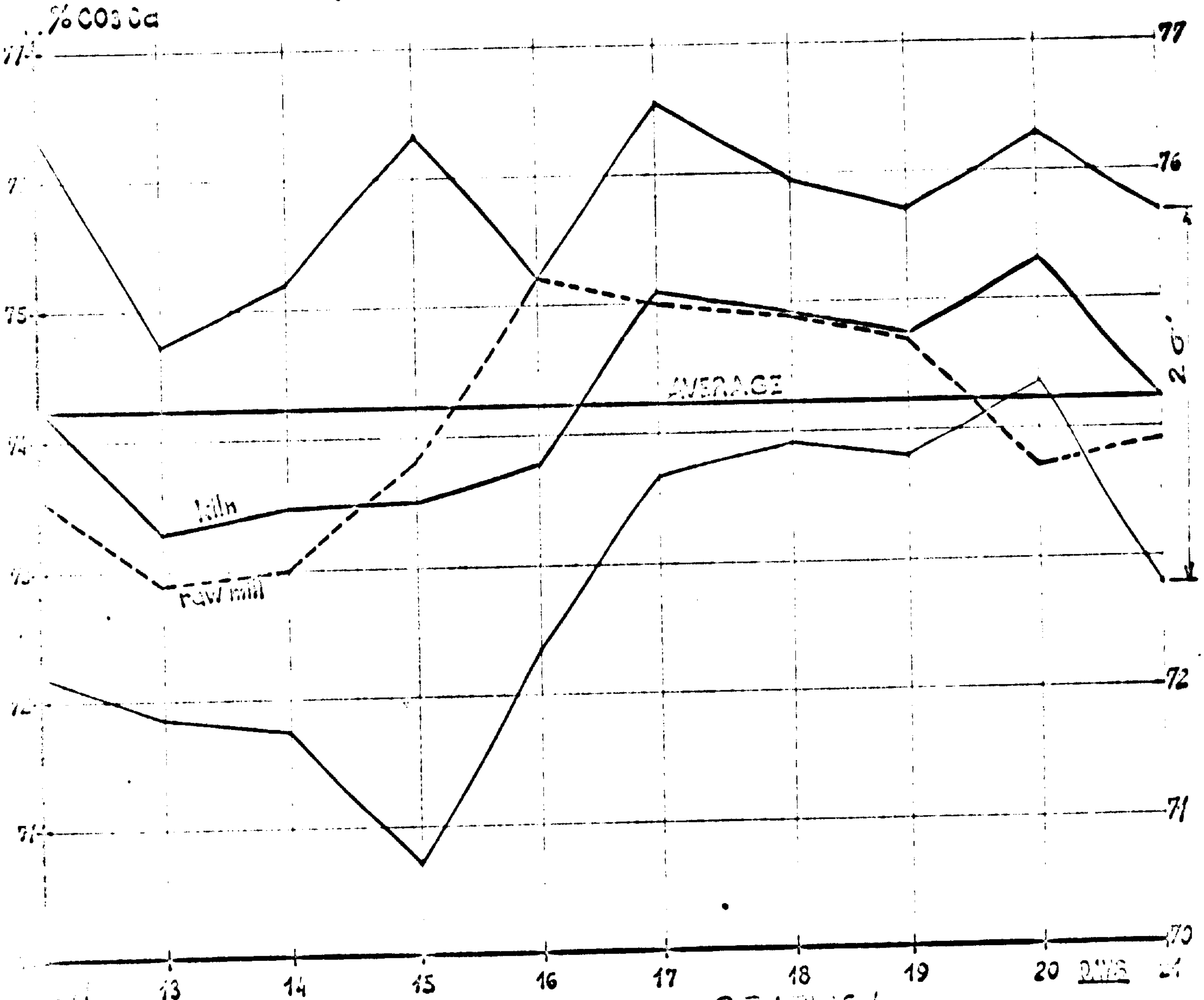
...

(1) See Chapter IV paragraph B on chemical gauging.



GRAPHIC 3

PER CENT OF CO3 Ca RAW MILL - KILN
(FROM 12.2.71 TO 21.2.71)



From all the samples N taken during 10 days the following figures are obtained :

	Raw Mill	Kiln
N'	243	264
m'	74.2	74.2
[illegible]	1.40	1.02

The average figure for the ten days gives the percentages of CO_3Ca fairly well identical to those obtained for the monthly averages from June 1970 to February 1971 (1).

	Raw Mill		Kiln	
	June 1970 to Feb. 1971	Feb. 12 to Feb. 21/71	June 1970 to Feb. 1971	Feb. 12 to Feb. 21/71
m'	74.4	74.2	74.1	74.2
[illegible]	(2)	1.40	(2)	1.02

This table shows that :

1° there was no change in the CO_3Ca content of the raw mill since June 1970, thus the raw mill remains apparently undergauged. (3)

2° the typical difference is very high, this fact thus confirming the wide variations already indicated. Within a well adjusted factory having prehomogenization facilities the percentage of CO_3 varies from $\pm$ 0.25 and the LSF of $\pm$ 1.

...

(1) These are daily averages.

(2) The typical difference has not been calculated for the 9 months for all the corresponding figures were not available (in the range of 3 to 4000 results).

(3) See Chapter IV paragraph B on chemical gauging.

b - Influence of the Clay Phase on the Composition of Raw Mill

In order to determine the hourly variations in the composition of the raw mill, comprehensive analyses have been performed in France on hourly samples taken in SOKOTO during our visit of the factory. (1)

The average figures obtained for these samples are as follows :

N = 11	S	A	F	C	Mgo	CO_3Ca
m'	13.0	3.8	2.0	43.5	1.2	77.7
[illegible]	0.74	0.18	0.19	1.04	0.08	

Which corresponds to :

LSF = 1.03

MS = 2.2

A/F = 1.85

This average raw mill is thus overgauged, but the variances show considerable irregularity in the composition in particular for lime and silicium, which thus results in major variations in the LSF : between 0.87 and 1.13.

The graph 5 appended gives the variations in the percentage of CO_3Ca and CaO for these hourly samples taken during the night hours from 5 PM to 4 AM during our visit of the factory.

The difference between the Lafarge and CCNN analyses stem from the method of analysis. The CCNN measures all the carbonates whereas Lafarge measures the total lime content (lime in the form of silicates, phosphates... and lime in the form of carbonates).

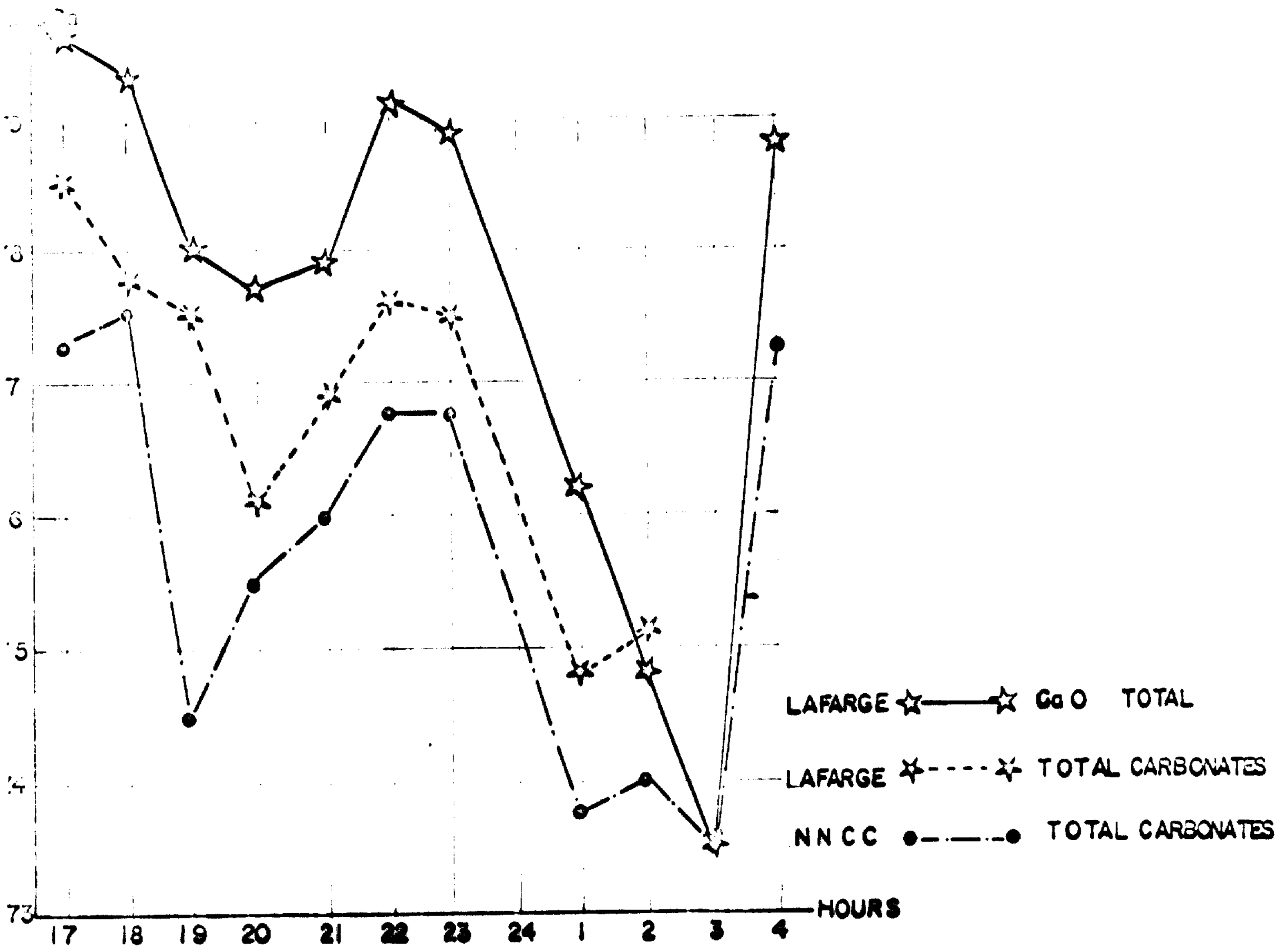
The method used by the CCNN results in systematic under-estimation of the percentage of lime within the raw mill. (2)

...

(1) We give in appendix the total results of analysis made in France.

(2) The problem of method of analysis is dealt with in a special paragraph (cf. chemical gauging : § B Ch. IV).

VARIATIONS OF THE PER CENT OF CO_3Ca OF THE RAW MIX FROM 17h TO 4h AVRIL 71



c - Instantaneous Variations in the Raw Material

In order to determine with greater accuracy the extent of the instantaneous variations in the raw mill when entering the kiln, a serie of samples have been taken at an interval of several minutes on April 17 between 5.30 PM and 6.50 PM.

These samples have been analyzed by the Central Laboratory of CIMENTS LAFARGE.

The table below gives the averages and typical differences of the components of the samples : (N = 15)

N = 15	S	A	F	CO_3Ca (1)	Mgo	TiO2	K_2O
m'	14.0	4.0	2.2	76.0	1.4	0.15	0.18
σ'	0.42	0.13	0.08	0.80	0.10	0.00	0.03

LSF = 0.93
MS = 2.2
A/F = 1.8

This table reveals thus the extent of the variations in the CO3Ca and the silicium during such a short lapse of time, as has already been observed. These variations are illustrated by the graph IV appended : within one hour and twenty minutes the percentage of CO3Ca varied between 77.15 and 74.85, thus more than ± 1 %. The silicium varied between 14.75 and 13.25.

Graph 6 appended also shows the variations in the LSF, which is especially the result of the variations of the CO3Ca and SiO_2. The LSF varies between 0.99 and 0.90. It should be noted that the curve of variations in the LSF is more or less the same as the curve for variation in the CO3Ca content : it would thus appear that the silicium and the lime vary in not a completely independent manner.

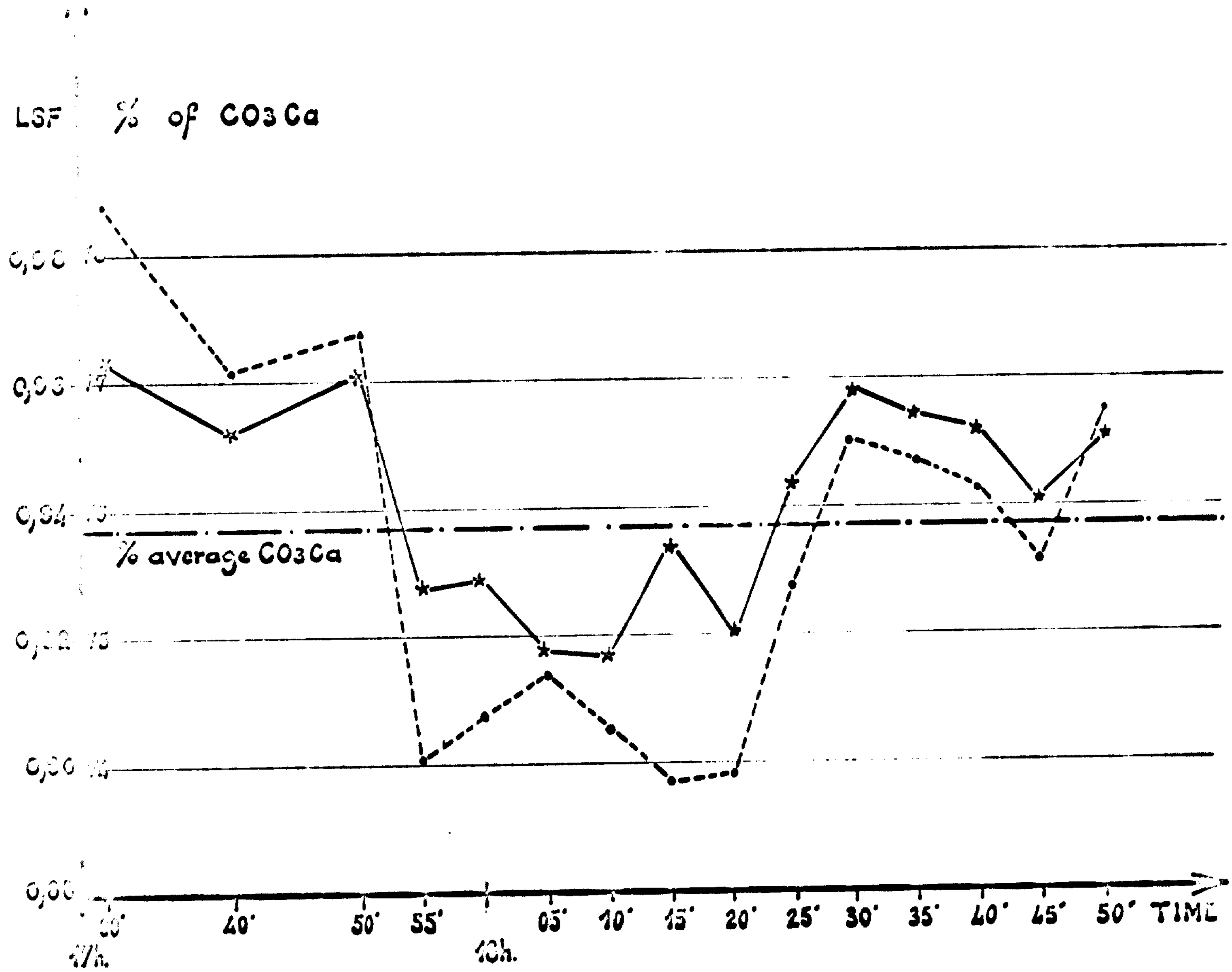
...

(1) Calculated on the basis of the total CaO

RAW MIX AT THE KILN

VARIATIONS OF THE LSF AND PER CENT OF CO3Ca

(SAMPLES TAKEN EACH 5 OR 10 MINUTES THE 17 OF APRIL 71)



% CO3Ca

LSF

GRAPHIQUE .6.

SOKOTO - CHEMICAL ANALYSIS OF AVERAGE DAILY SAMPLES OF CLIKER - DECEMBER 1970

	Loss 1 gr	S	A	F	C	MgO	TOTAL	$\frac{S}{A+F}$	A/F	LSF
4.12.70	[illegible]	21.8	8.2	4.05	63.5	2.14	99.71	1.79	2.05	0.87
9.12.70	0.02	22.74	4.4	4.5	66.2	3.19	101.03	2.55	1.0	0.52
10.12.70	0.33	21.64	5.3	4.5	63.4	2.4	97.27	2.21	1.2	0.51
13.12.70	0.08	[illegible]	4.4	3.6	65.2	3.4	58.68	2.75	1.22	0.94
15.12.70	[illegible]	22.00	5.6	4.05	65.5	3.5	101.05	[illegible]	1.4	0.92
16.12.70	0.31	[illegible]	5.6	3.2	67.5	2.5	100.41	2.42	1.75	0.99
20.12.70	0.42	21.36	6.2	3.2	65.5	3.5	100.18	2.27	1.94	0.94
21.12.70	0.05	22.30	5.4	3.6	64.6	2.63	98.58	2.48	1.50	0.92
23.12.70	0.43	21.60	5.7	3.6	65.2	3.3	99.83	2.32	1.53	0.94
24.12.70	0.50	21.04	6.3	3.6	65.5	2.64	99.58	2.13	1.75	0.95
27.12.70	0.69	22.12	5.7	3.2	64.6	2.42	99.73	2.49	1.78	0.91
28.12.70	0.24	22.12	5.8	3.2	65.6	[illegible]	98.96	2.46	1.81	0.92

As an initial approximation, it should be possible (to be verified) to gauge the raw material by measuring only the CO3Ca content or that of CaO, provided that these data are supplemented quite frequently by several complete analyses to make sure that the CaO content is representative of the real quality of the raw material.

Systematic quality controls performed on the raw material bear only on the content of carbonates. For this reason, besides the several analyses of the rax material made in the factory and except for the analyses which we have performed on several samples, data is available on the other elements : S, A, F and MgO only through the analysis of clinker and cement.

The table on the opposite page consolidates the analyses of average daily samples of clinker for the month of December 1970. It should be noted that the contents of magnesium vary between 2.0 % and 3.5 %, which is far from being negligeable, although it is below the allowable limit within the British Standards.

In the table below are shown the minimum and maximum values for lime, silicium, alumina and iron for the month of December 197

Component	Minimum	Maximum
CaO	63.4	67.5
SiO_2	21.04	22.72
Al_2O_3	4.4	8.2
Fe_2O_3	3.2	4.5

The extent of the variations in lime and silicium has already been pointed out and are further confirmed in this table.

...

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

TECHNO-ECONOMIC SURVEY
OF THE CEMENT FACTORY AT SOKOTO (NIGERIA)

SOCIETE D'ETUDES POUR LE DEVELOPPEMENT ECONOMIQUE ET SOCIAL

With the technical collaboration of the

SOCIETE DES CIMENTS LAFARGE

d - **Phosphates with the raw material**

In conclusion, it should be noted that tere is a presence of P_2O_5 in the raw materials. Out of 13 samples taken from the factory hall, the average content of this element is P_2O_5 = 0.32 (1). This content comes within the generally accepted limits.

It may well be that the P_2O_5 plays an essential role in the formation of chalk-stones on the blades of the hot gas fan. This formation can give desastrous effects).

The analysis of these concretions has provided the following results :

S	A	F	C	MgO	SO_3	CO_2	H_2O+MVW
26.45	8.35	4.55	31.15	2.40	1.15	20.00	3.75

K_2O	Na_2O	P_2O_5	Cl	TiO_2	Total
0.73	0.06	4.90	0.035	0.45	100.37

Analysis by the X defraction has revealed the presence within these components of calcite TF, quartz tf and a hydrated phosphate compound of iron and aluminium ($Fe\ Al_2\ (PO_4)_2\ (CH)_2\ 8\ H_2O$ - metavauxite).

e - **Conclusions on Raw Material**

It may be that there is a certain interdependance between the variations in the lime and silicium. This interdependence is however inadequate for controlling the quality of the raw mill by limiting oneself only to the measurement of the percentage of CO_3Ca. In order to produce a regular quality raw mill, it would be necessary to gauge the four main elements (S, A, F and C) to carry out the correcting allowing to obtain a raw mill with always the same LSF.

...

(1) Nurse R.W. 1952 "Action du phosphate sur la constitution et le durcissement du ciment Portland".

Guye F. 1954 "Influence du phosphate sur le ciment Portland.

SOKOTO : POTENTIAL COMPOSITION OF CLINKER - DECEMBER 1970

	C_3S	C_2S	C_3A	C_4AF	$\frac{S}{A+F}$	A/F	LSF	Free lime
4.12.70	33.14	37.5	14.71	12.31	1.79	2.05	0.87	1.0
9.12.70	57.9	21.5	4.0	13.7	2.55	1.0	0.92	0.45
10.12.70	50.2	24.2	6.4	18.7	2.21	1.2	0.51	0.45
13.12.70	63.54	15.14	5.54	10.9	2.75	1.22	0.94	0.05
15.12.70	53.50	18.9	7.8	12.3	2.20	1.4	0.52	0.05
16.12.70	68.7	9.2	0.4	10.8	2.42	1.75	0.99	0.30
2[illegible].12.70	56.8	18.4	[illegible]	10.9	2.27	1.94	0.94	0.0
21.12.70	51.70	24.9	8.2	10.9	2.48	1.50	0.92	0.0
23.12.70	57.46	18.58	9.0	10.5	2.32	1.58	0.94	0.0
24.12.70	58.4	16.3	10.6	10.9	2.13	1.75	0.95	0.2
27.12.70	56.3	24.7	9.7	9.73	2.49	1.78	0.91	0.0
28.12.70	56.3	20.9	10.0	9.73	2.46	1.81	0.92	0.0

B - QUALITY OF THE CLINKER

The study of the quality of the raw mill has led to the analysis of the chemical properties of clinker as well. It has been pointed out that the extent of the variations in the chemical composition is of importance and it brings on variations in the potential composition.

The table on the preceding page shows the potential compositions obtained from the daily analyses of the averages of samples for the month of December 1[illegible]7[illegible]

Minimum and maximum contents are as follows :

	Minimum	Maximum
C_3S	33.1[illegible]	68.7
C_2S	[illegible].20	37.8
C_3A	[illegible]	1[illegible].71
C_4AF	[illegible].73	13.7

The irregularities in the composition of the raw mill which have been noted are found in the potential composition of clinker.

In order to supplement this data, a microscopic analysis has been made of the sections with clinker from SOKOTO. A detailed report of this study is given in the appendix. The conclusions are as follows :

A clinker which is known to be poor in quality, produced prior to July 197[illegible], has proved to be very heterogeneous and undergauged. There is a considerable amount of C_2S, that is [illegible] to 50 %, and the clinker is quite porous.

A clinker which is known to be of good quality, produced in April 1971 reveals a normal alitic phase although a bit low (C_3S = 50 %). The large size of the crystals (dia. = 5 to 1[illegible]) indicates that it remained a long time in the kiln.

The belitic phase is normal (C_2S = 25 %). The crystals are well distributed.

...

In both cases, there is a large percentage of magnesia (2 to 3 %) the isolated and grouped crystals with a dia. of 5 to 2 are in the form of periclase. It should be recalled that periclase can ~~[illegible]~~ in the long run be the source of considerable swelling which may lead to the destruction of the structures. It is moreover in order to combat this harmful effect of magnesia that the Americans have developed the quenching cooler. This reveals the importance of steeping.

It should be noted that in both cases a major liquid phase has allowed for baking at a relatively low temperature, below 1450° C (l series in strip in C_2S).

In both cases, there is a rather slow cooling which results in the formation of fine crystals. This crystalization which is due to poor steeping results in a low development of resistance strength at early stages.

a - Milling

In order to complete the study of the characteristics of clinker, milling tests have been performed. They were carried out by comparing with clinkers from the whole CIMENTS LAFARGE group (1). Graph 7 appended shows the results of this testing which was conducted in the following manner : 5 kg of clinker are placed into a laboratory mill. The number of rotations of the mill is recorded and periodically for certain number of rotations (1000, 1500, 2000, etc.) the [illegible] of the product obtained is measured.

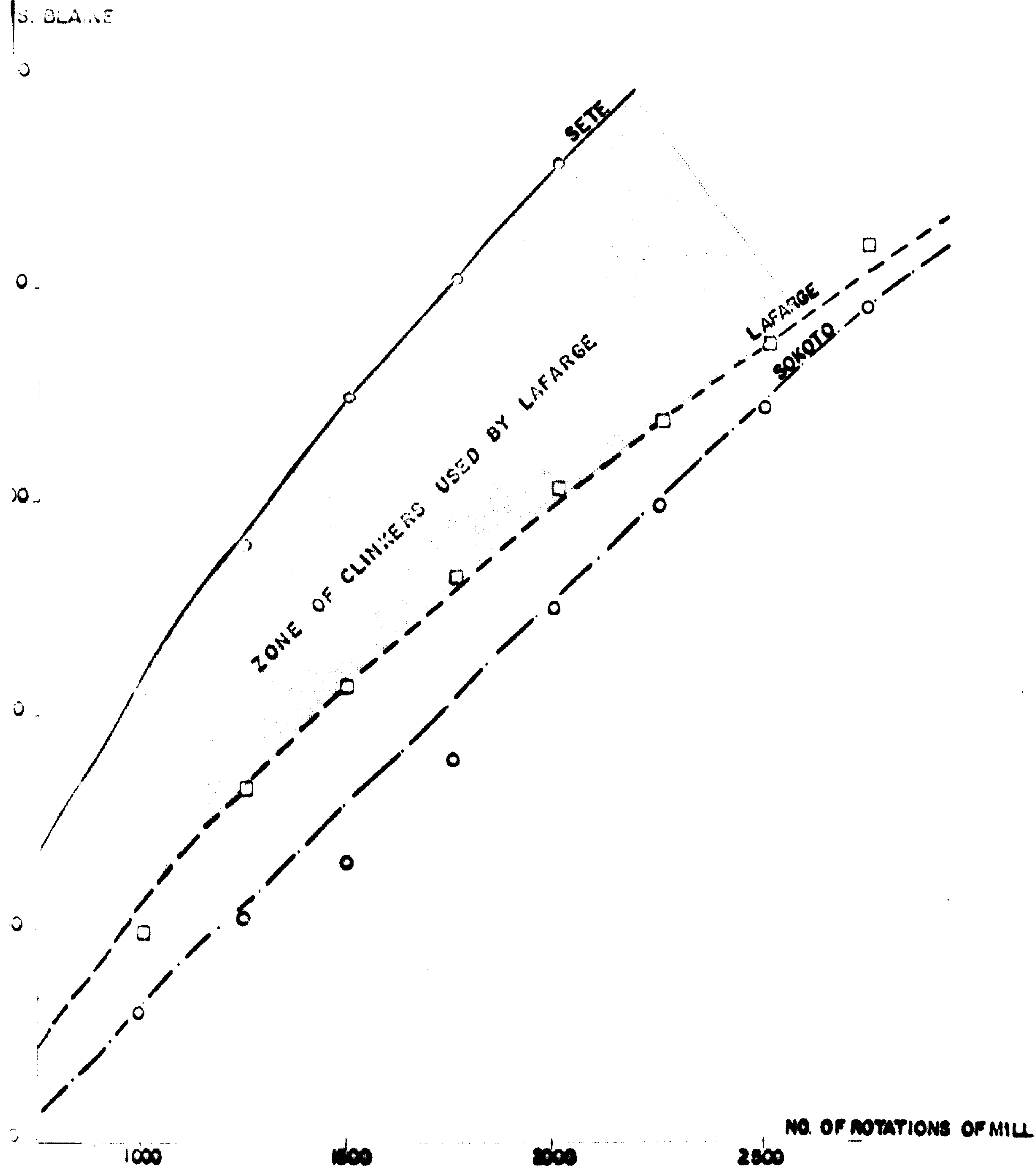
It is concluded from this testing that the clinker from SOKOTO is harder than any other Lafarge clinker. This anomaly arises from the overbaking which produces a clinker which is extremely hard to mill. Normal baking and steeping would considerably improve the milling possibilities for this clinker.

...

(1) France - Canada - North Africa

....

A COMPARISON OF THE BROYABILITY OF THE CLINKERS OF SOKOTO & LAFARGE



b - **Conclusions on Clinker**

The irregularities noted on the raw mill can be applied to those of clinker. The irregularities became even worse due to the absence of steeping and the variations in the kiln feeding which results in too much baking.

An improvement in steeping and baking would result in two advantages : the milling would be improved and the risks due to magnesia would be reduced.

C - QUALITY OF CEMENT

The quality and the mechanical strength of the cement have been examined.

As far as finess of quality is concerned, the monthly averages, both for the samples taken when leaving the cement mill and during packing, are irregular and the typical differences quite wide. This variation in quality is a disadvantage to the user for it influences the cement hydration speed.

It should moreover be noted that the quality of the milled product is quite good which, in view of the crystalline form of the clinker and at times its potential composition, is necessary for obtaining early strength. Clinker with a slightly higher C_3S content and one which is especially more regular would undoubtedly make it possible to reduce the milling process which would save electricity.

The mechanical strength is controlled on mortar. The averages and typicals differences have been calculated for each month, thereby making it possible to make the following comments :

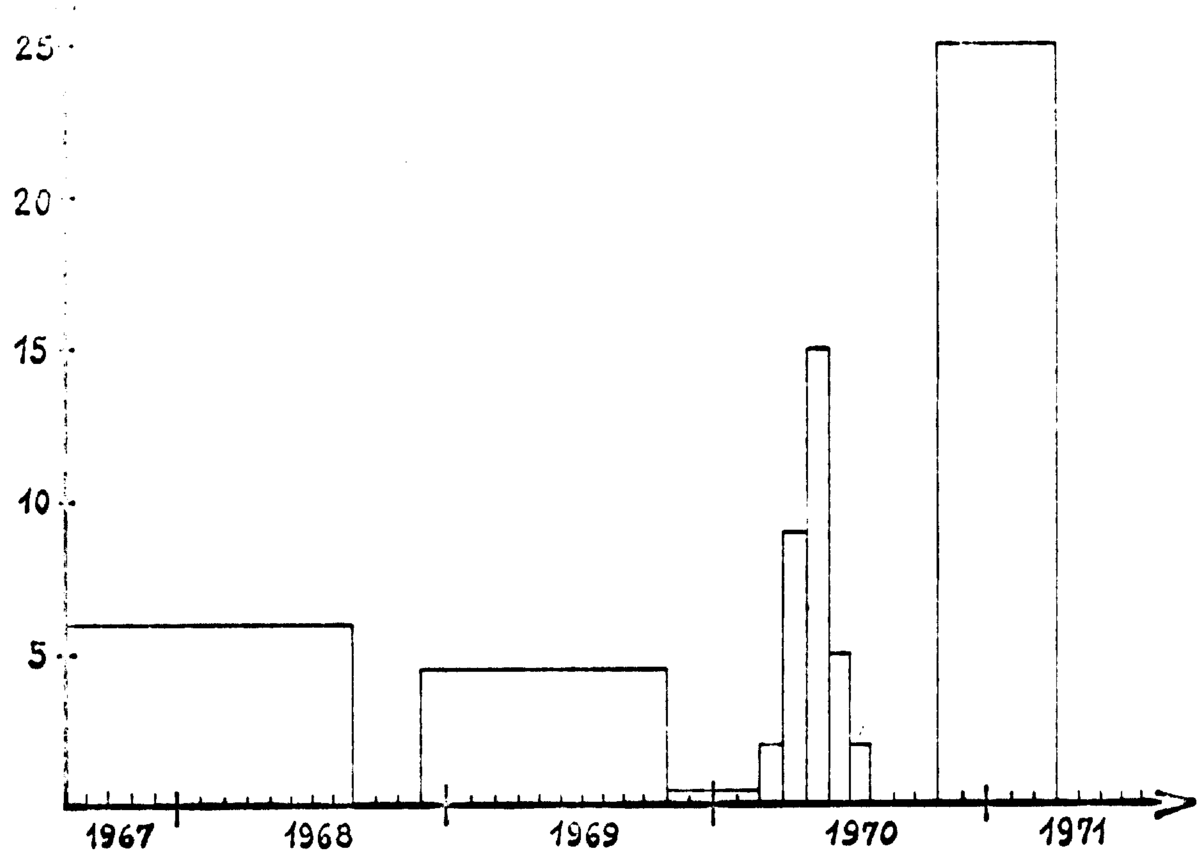
- The mechanical strength varies considerably.
- The mechanical strength after three and seven days is sometimes below the standards (see graphs 8 and 9 appended).

These results are confirmed by the tests which were performed at CERILH (Centre d'Etudes et de Recherche de l'Industrie des Liants Hydrauliques).

...

NUMBER OF CLINKER OR CEMENT ANALYSES

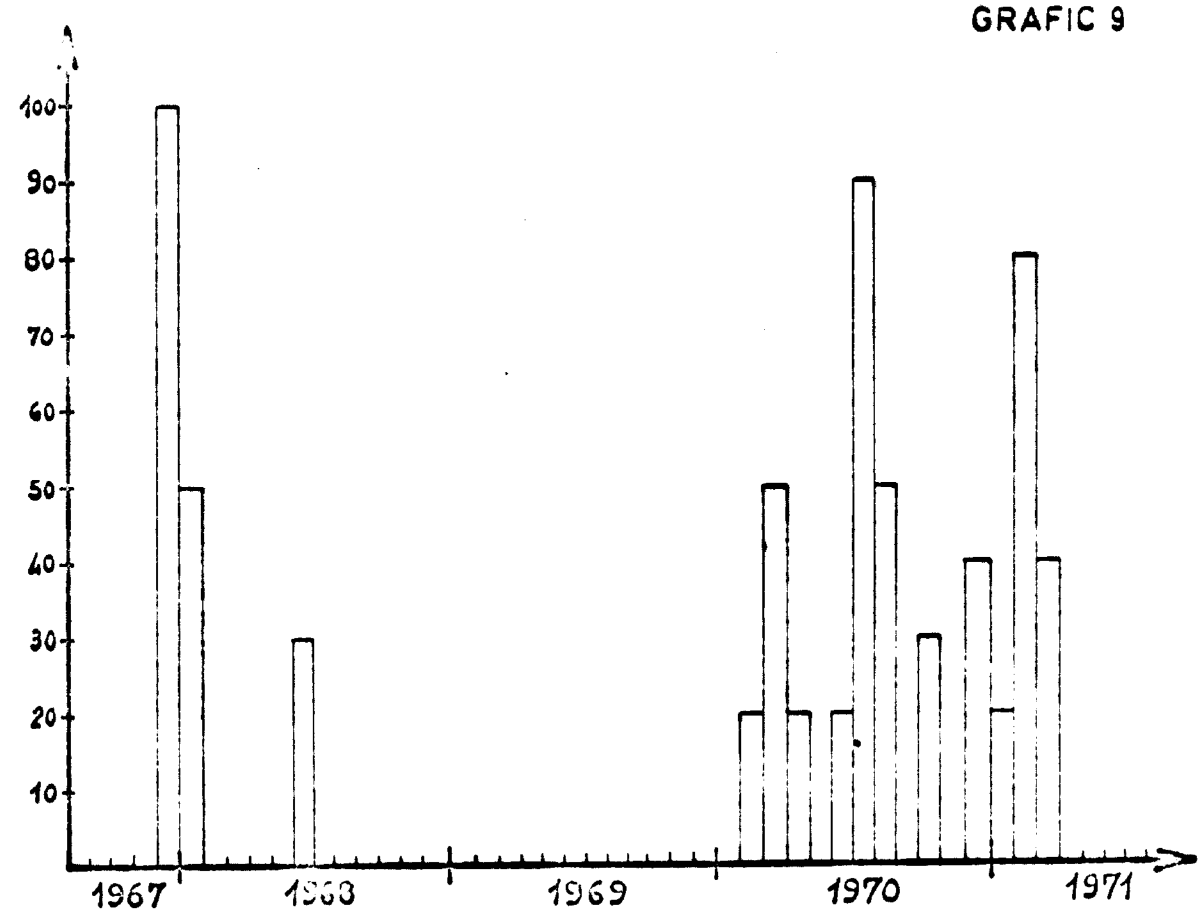
GRAFIC 8



Surfaces are proportional to the number of complete analyses made each month

% MECANICAL STRENGTHS INFERIORS TO BSS NORMES

GRAFIC 9



Surfaces are proportional to the percentage of results of 3 days strength inferior to BSS norm ([illegible] percentage is [illegible])

CEMENT MILL

SPECIFIC SURFACE BLAINE cm2/gr -

	September	October	November	December	January 197
m'	3426	3269	3286	3[illegible]53	2946
σ'	734	132	290	801	405
N	26	14	13	28	16

STRENGTH (lb/sq.in.)

1 day m'		138	1382	1087	1321
σ'			463	289	305
3 days m'	4301	3633	2642	2315	2953
σ'	438	780	776	597	440
7 days m'	5704	4894	3560	3357	3510
σ'	571	901	947	801	1399
N	26	14	13	27	15

BRITISH STANDARD SPECIFICATION

3 days 2200 lb/sq.in.

7 days 3400 lb/sq.in.

...

PACKING PLANT

SPECIFIC SURFACE BLAINE cm2/gr 1970 - January 1971

	September	October	November	December	January 1971
m'	3986	3394	3358	3446	3469
σ'	187	218	180	256	576
N	17	23	22	22	17

STRENGTH (lb/sq.in.)

	September	October	November	December	January 1971
1 day					
m'			1846	1170	1181
σ'			426	376	219
3 days					
m'	3553	2885	3531	2453	2444
σ'	8[illegible]7	1045	709	791	499
7 days					
m'	5151	4082	4754	3541	3790
σ'	940	1202	847	1046	715
N	21	23	23	22	14

BRITISH STANDARD SPECIFICATION :

3 days 2200 lb/sq.in.

7 days 3400 lb/sq.in.

...

a - **Tests on Strength of the material :**

Cement from SOKOTO tested according to BSS standards on mortar with BSS sand from Great Britain).

Compressive Strength			
Cement from Sokoto	1 day 150 psi	3 days 1750 psi	7 days 2900 psi
BSS 12-1958 standards		2200 psi	3400 psi

Testing time : starting : 3.55
finishing : 5.20

No stiffness was observed.

b - **Physical tests**

Solid volume = 3.21 ; Specific surface Blaine = 3770 gr/cm2
This test which was performed on any sample has only an indicative value. A series of samples along with statistical processing of results would be necessary to determine the quality of the cement.

However, it turns out that the sample tested has a lower mechanical strength than required by the British Standards. In view of the solid volume and the specific surface Blaine which is large it would appear that there is a retarding admix in the cement. (Is this the result of the action of the clay of the gypsum additive or that of the P_2O_5 ?)

The chemical composition and potential composition are not examined in detail herein for they have been dealt with in reference to the raw mill and the clinker.

However, the complete analysis made in the CERILH is given in the tables below and in appendix :

...

SUMMARY

S	A	F	C	MgO	
21.85	6.05	3.40	61.45	2.40	
TiO_2	K_2O	Na_2O	P_2O_5	SO_3	CO_2+MV
0.32	0.27	0.04	0.68	1.85	0.85

The following should be noted :

1° the presence of a large quantity of P_2O_5 which has delayed the development of the mechanical strength.

2° the large MgO content. In order to check the effect after a long period of this magnesia the cement has been tested for expansion by means of autoclave and on the basis of the ASTM standards. This test showed an expansion of 0.77 % while the maximum tolerance in the standards is 0.8 %.

The harmful effects of these two elements on the properties of cement have already been discussed at length.

c - Gypsum Additive

For the month of December 1970, the chemical analyses of cement provide the results on the SO_3 content :

2	3	9	13	15	16	17	20
2.60	2.18	2.20	2.00	2.40	2.50	2.20	2.30
21	22	23	24	25	27	28	29
2.40	2.44	2.20	2.30	2.00	2.25	1.84	1.99

It appears that in the course of the same month, the SO_3 contents varied between 1.84 and 2.60 ‰.

Under these conditions the quality of the product can only be very irregular and the users of this product should be aware of the variations in the setting times.

...

d - **Conclusions on the Cement**

The characteristics of the cement from Sokoto are very irregular and sometimes under the British Standards thereby affecting the setting, handling and the strength of the product. To these must be added the risks of expansion after a long period. The same irregularities exist in the cement as in the clinker and the raw mill.

These major irregularities finally run the risk of having effects on the behaviour of consumers who may thus prefer other competitive cement to cement from SOKOTO.

One could imagine that the results -as well for the quantity than for the quality- would be improving from the beginning in 1967. In fact, the precedent analysis show that this was not the case. This appears to proceed either of insufficient technical knowledges for detect the reasons and promote the necessary instructions, either of the general discipline in order to make these instructions applied.

Perhaps the two reasons have joined in the past ; for the present time, the first hypothesis seems the more probable as the action of the actual general manager appears to be well orientated.

III - FINANCIAL BALANCE SHEET

The length of time required for adjustments and inadequate initial output could only reflect heavily on financial results.

These losses can be specified by analysing the balance sheets from the first fiscal year of operation (1st June 1967 to 31st May 1968) until the last fiscal year for which information was made available to us.

These results have been assembled in Table 1, preceding it with the results for earlier months. The latter show a loss of ₤N 363,182 which, in point of fact, was listed among the assets, since these were setting up expenses, and appears under the "quarry" entry.

In this table, operating expenses include manufacturing costs, and administrative and sales expenses as well as the excise duty collected by the federal government totalling :

- 33,666 ₤ for 1967-68
- 45,130 ₤ for 1968-69
- 72.935 ₤ for 1969-70

As required, sales expenditures include the costs of client delivery in the form of very large transportation expenses whose size is estimated in Table 2 using the annual reports somewhat arbitarily. It can be seen these were quite high (from ₤ 3.5 to ₤ 4 per t.) and constitute a sizeable share of the deficit, since this nearly represents the difference between manufacturing expenses and income. Thus, an observation which should be taken into account in establishing the company's new commercial policy is that excessive delivery costs should be eliminated through the use of a single, ex-factory price.

The information in the fifth column in the table takes into account other factors which are present apart from cement sales.

These include sales of assets, outside services, the product on capitalisation and stock variations taken into account in the balance sheet and which figure in production expenses.

Thus, the agreement with the figures in the balance sheet is reestablished.

TABLE I

Exercise	sales in £	manufacturing costs in £	difference (negative)	adjusting to the balance sheet (always positive)	losses balance sheet	exchange losses (reevaluation DM)	depreciation	total losses in balance sheet
Before 1.1.67	none	319.805	319.805	)	363.152	-	none	363.152
January to May 67	105.007	189.310	84.303	40.956)				
1967-68	719.871	846.698	126.827	36.392	90.475	-	498.100	588.575
1968-69	616.792	795.469	178.677	19.957	158.720	6.889	469.711	635.320
1969-70	1.080.462	1.267.807	187.345	114.998	72.347	190.620	250.911	513.878
			492.849	171.307	321.542	197.309	1.218722	1.737773

TABLE 2

	1967 - 68	1968 - 69	1969 - 70
Sales, £	719.871	616.792	1.080.462
Tons sold	42.265	42.518	69.140
Price £ / t.	17	14,4	15,6
Difference to 13,5 £	3,5	0,9	2,1
Sales if price was 13,5 £	570.577	573.993	933.390
Difference in sales (attributed to transport invoices paid)	149.294	42.800	147.070
Real cost of transport (in balance sheet)	294.614	209.704	364.134
Loss for transport operation	145.320	166.900	217.064
Loss per ton (£)	3,45	3,9	3,15

Depreciation has been listed separately since it does not figure in financial losses and could appear in a provisional "postponed depreciation " account. However, the supplier credit has been paid, and this was done from public funds, since the company is unable to make available the corresponding amounts. To be noted is the nearly 50 percent reduction in 1969-70 in depreciation reserves. It would clearly seem that here the change was from excess to flagrant insufficiency.

Due to the long stoppage at the end of 1968, the corresponding fiscal year is not significant. The 1969-70 fiscal year is not significant either due to the loss attributed to the exchange rate of ₦ 190,620 which appears under the Ferrostahl annual payments entry due to revaluation of the DM in 1969, an event for which the company cannot be held responsible.

The 1969-70 fiscal year includes ₦ 95,470 in stripping work at the quarry and ₦ 100,352 for the purchase of spare parts, expenditures which can probably not be entirely charged off to this fiscal year alone.

The deficits listed in Table 1 were covered as follows :

As concerns the payment of installments corresponding to the supplier credit for equipment, by loans :

- either contracted at 8.5 percent from the ICSA, the financial agency of the 6 Northern states, for a total of ₦ 503,259,

- or contracted directly with the 6 states and paid in fact by the federal ministry of finances which substracted the amount from its allocations to these states. Total : ₦ 1,053,157. The same procedure will probably be used for 1970-71 payments or ₦ 493,184. At that time, this will leave total installments to be paid amounting to ₦ 1,278,700 with the interest as of 1st June 1971.

As concerns operating deficits, by various financial means such as :

- advances from the NNDC account totalling nearly ₦ 300,000
- bank loan of ₦ N 200,000
- current supplier advance of approximately ₦ N 230,000 a portion of these advances is now being repaid.

There is no question the company's results would never allow it to rid itself of these financial handicaps for which, moreover, it cannot be held fully responsible.

Thus, it is essential to reduce and consolidate the indebtedness. In Chapter VI we will give an idea of what can be done to this end.

CHAPTER III

RAW MATERIALS AND RECOMMENDATIONS

I - GEOLOGICAL BACKGROUND

A - Geographical location

The state of Sokoto takes up the north-west corner of Nigeria. It extends west, north and north-east as far as the borders of the Republics of Dahomey and Niger. The western part of the state, stretching over a uniform region of some 45 000 sq. km. is made of sedimentary cretaceous and tertiary rocks lying on Precambiran granits.

B - Geological Past

At the beginning of the Cretaceous period, sands and clays resulting from the erosion of the Precambiran shelf were deposited on the north-west part of the province of Sokoto. In the middle of the Cretaceous period, a slight movement of the earth's crust gives these deposits a slight slope towards the east and north-east and then sedimentation of the same kind continues.

A shallow sea which extended over what is now the Republic of Niger then covers these deposits. Deposits of the same kind continue to settle in sea into which also settle some calcareous deposits as well as some gypsum deposits in the lagoons on the edge of this sea.

At the time of the Eocene period, the sea deepens and deposits with greater calcareous content appear. However, the settling conditions varied considerably and the depositing was intermittent.

At the end of the Eocene period a slight movement of the earth's crust gives all these layers a slope towards the east and north-east. This movement is accompanied by the withdrawal of the sea.

After this withdrawal, continental deposits continue to move in with materials from erosion of the materials previously described and of the Precambiran shelf.

...

C - Present deposits

The present deposits are as follows (beginning with the most recent) :

POST EOCENE	Gwandu clay and Grit group		Coarse sandstones and continental clays
	Discordance		
EOCENE	Sokoto group	calcareous bed Dange bed	calcareous and clay shale
UPPER CRETACEOUS	Rima group	Wurno bed	detrital sandstones and clays
		Mosasaurus shales	shales and limestones
		Taloka bed	detrital sandstones and clays
	Discordance		
UPPER CRETACEOUS	Gundumi grit and clay group	Gundumi bed	coarse sandstones and continental clays (continental intercalary)

In this whole, the limestones noted in the Mosasaurus deposits form only nodules and small balls without any economic importance. The only plainly limestone level is the calcareous bed of the Sokoto group.

On the regional scale, the pattern of sedimentary rocks in the province of Sokoto is quite simple. The deposits are located in the south-eastern part of a synclinal the center of which is in Niger just north of Niamey.

No geological fault has complicated this pattern. The dip is low, 2 to 4 m per kilometer. In the vicinity of the town of Sokoto the layers are directed 20° east and inclined towards the west.

Erosion shaved up the calcareous bed which forms a "cuesta" which passes through Sokoto in a south-west/north-east direction.

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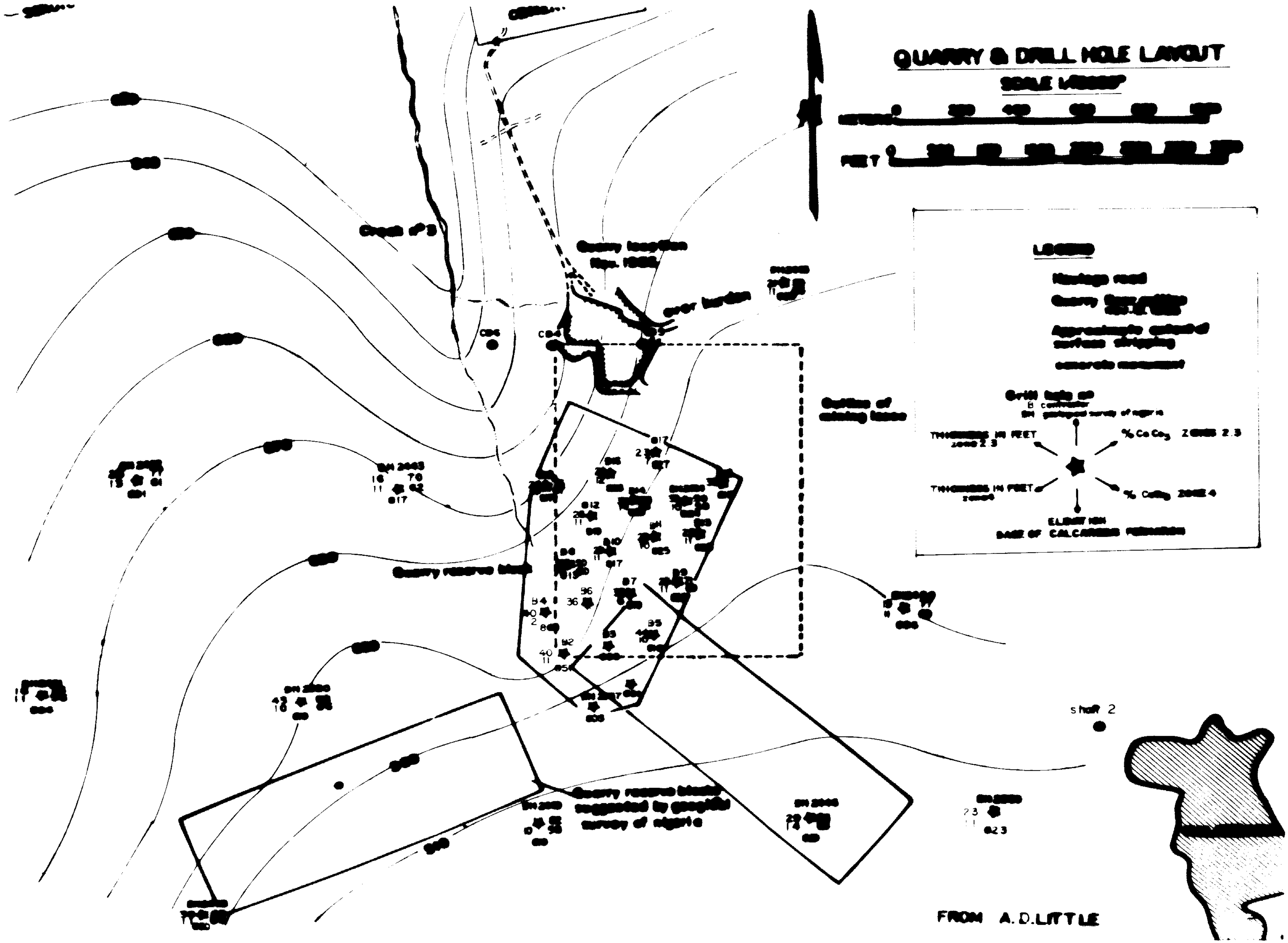


FROM A.D.LITTLE

II - BASIC MATERIALS OF SOKOTO

A - Deposit

All the documents received on the survey of the Sokoto deposit have been examined and the data contained therein have been completed by observations made within the context of the present mission as well as by laboratory tests.

a - Location of the Quarry (General Vicinity Map - Figure X)

The quarry of the Sokoto factory is located about 300 m south of the cement factory. The quarry was opened in a hollow area of the plateau stretching out along the southern bank of the Sokoto river.

The present deposits are composed of :

- reddish brown alluvial sands	0 to 1 m)	overburden
- laterite and ironstone	7 to 12 m)	
- greenish white clay shale	0,5 to 5 m)	
- limestone series : limestone blocks, very hard calcareous nodules, chalky calcareous formations, white marls, grey clay	10 to 12 m)	Partly worked deposit
- Dange blue clay		

The quarry is worked on two faces :

- the upper face : overburden composed of sand, laterite and lamellar clay. This overburden is to be discarded ;
- the lower face which supplies the cement factory with a part of the calcareous deposit which is worked.

At the present time, the quarry is being worked towards the east.

b - Survey of the deposit

The localizing of the deposit for the Sokoto cement factory was performed in three stages :

- Regional study by the Geological Survey of Nigeria
- More detailed study of the vicinity of the town of Kalambaina located to the west of Sokoto, by the Geological Survey of Nigeria
- Study made by the Contractor of the factory and covering a smaller area west of the town of Kalambaina.

...

The chronological progress of this research work was outlined in the March 1971 report produced by ARTHUR D. LITTLE (1).

The first research investigations on the regional scale were carried out in 1959, together with 43 exploratory borings and 500 analyses. These works revealed in the calcareous bed the existence of an area richer and mainly thicker in limestone, west of Sokoto (2) beside the town of Kalambaina. The results of these initial investigations are however very inaccurate due to the poor recovery of boring samples (on an average 72 % in the calcareous deposits).

An additional investigation was conducted in 1960 near the town of Kalambaina and involved 11 borings and 3 pits (3). The average recovery of the cores of the second campaign was only about 69 % and for this reason the results are also very inaccurate. On the other hand, among the three digged pits the only one completed, N° 2, allowed to identify the geological cross section.

The most important result of this additional investigation within a small area is a change in the interpretation of the results of the first survey campaign.

In the course of the first survey campaign, the variations in the thickness of the calcareous deposit and the presence of clay and marls between the blocks had been interpreted as the result of erosion before the appearance of laterites.

Taking into account the observations made in the course of the second survey campaign, the geologist in charge of the mission interpreted the presence of limestone rocks covered with clay as the result of dissolution of the calcareous deposits. Thus the dissolution would be greater near the outcrops and in particular on the slopes of the valleys, where the topography cuts through the calcareous level, which corresponds with the field observations.

...

(1) ARTHUR D. LITTLE Inc. Technical and Economic Evaluation of the Sokoto Cement Factory - March 1967 - Ministry of Trade Industry Norther Nigeria Military Government.

(2) GSN Report 1182 - The Sokoto Limestone Investigation 1959-1960, M. P. JONES, Senior Geologist, and J. P. BELL, Mining Geologist.

(3) GSN Report 1184 - The Sokoto Limestone Investigation : a supplementary report on the Kalambaina area.

The Contractor then undertook the survey of an area of 105 acres west of Kalambaina by means of 18 borings (1533 ft of drilled boring holes).

As observed by A.D. LITTLE, this area covers only 2/3 of the CCNN concession of land.

In addition, from these 18 borings holes which should have allowed for satisfactory identification of the deposit, only 4 were used for chemical analyses. In any case, the percentage of recovery of the cores extracted during this last campaign was only 74 %. It is consequently difficult to obtain from it any valid information on the chemical composition of the deposit ; and that, all the more so since the quarry was in fact opened more than 100 m north of the investigation area.

Finally, due to the poor quality of the survey work performed on the calcareous layers of Sokoto, very little information was in fact provided.

On the regional scale, it is fairly certain that there is no formation of compact limestone within a radius of 20 km around Sokoto.

As far as the deposit is concerned, the results are the same : the boring holes samples revealed that the calcareous series are a mixture of limestone, marls and clays, but the average chemical characteristics of the series are unknown and the chemical characteristics of the deposit even less so.

c - Characteristics of the Deposit (Figure XI)

The observations and sample analysis performed in the context of the present mission have made it possible to distinguish the following characteristics :

1 - Surface Formation

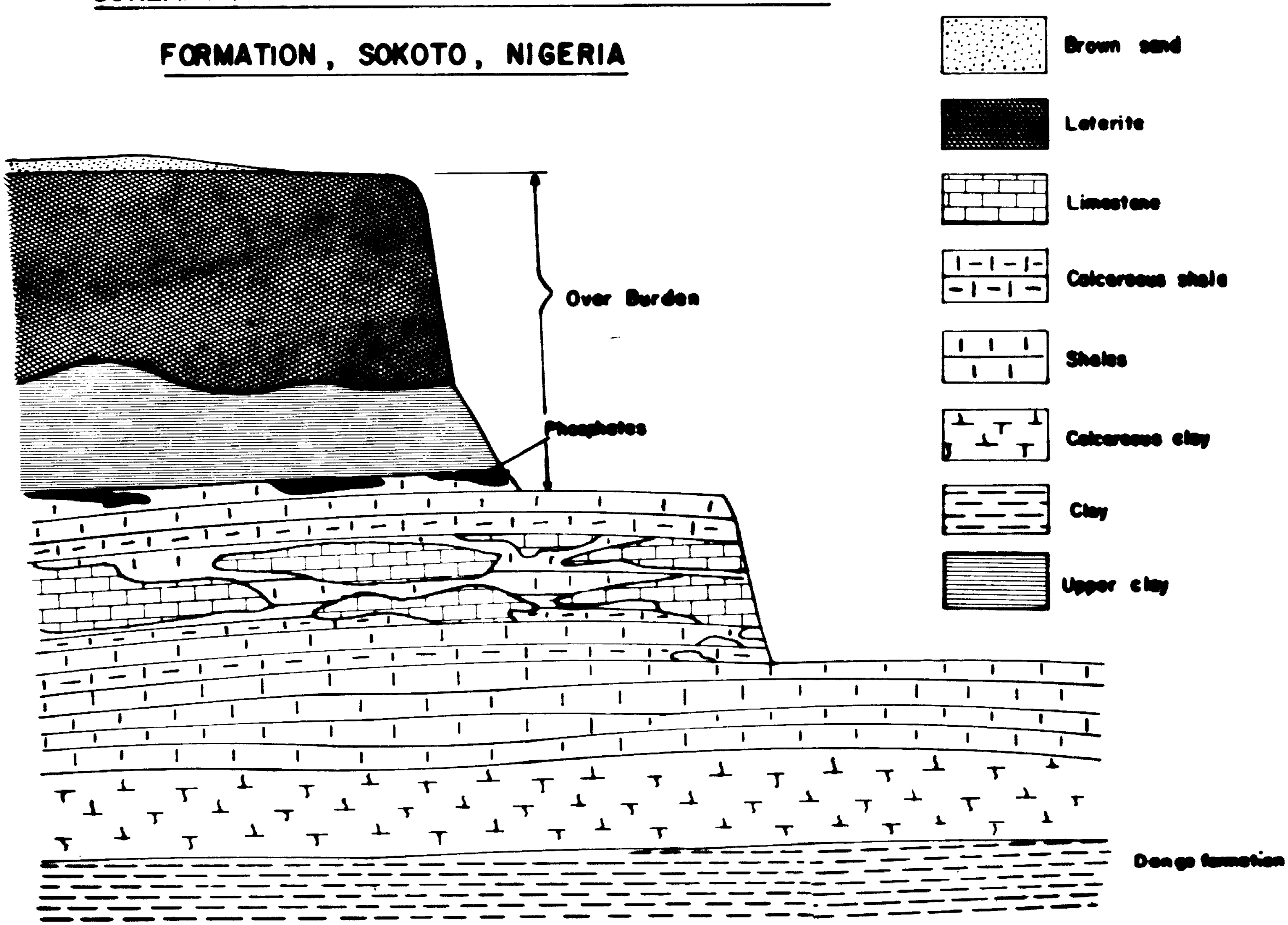
The surface is composed of red brown sands the thickness of which varies from 0 to 2 m.

The analysis of a sample has produced the following results :

S	A	F	C	MgO	TiO_2	K_2O
90.10	4.40	3.25	0.45	0.00	0.40	0.05

...

SCHEMATIC CROSS-SECTION OF THE CALCAREOUS FORMATION, SOKOTO, NIGERIA



2 - Laterite and ironstone

Laterite and ironstone combinations which appear in the quarry are very compact. Their thickness varies from 7 to 12 m. They are definitely thicker on the north face near the small thalweg.

Analyses of two samples, one from the lower part of the ironstone, the other from the middle part and the last two from the upper part have provided the following results :

Sample		S	A	F	C	MgO	CO_2+H_2O+VM
Lower	64	16.40	11.45	58.40	1.00	0.15	11.75
Middle	65	18.40	9.15	61.15	0.40	0.05	9.60
Upper	68	53.40	4.25	35.20	0.30	0.10	5.40
	69	53.00	1.60	40.55	0.50	0.15	3.30

3 - Clay shales

The formation of white clay shale with greenish shades which are found beneath laterites are the base of the overburden. Its thickness varies inversely with that of the laterites, i.e. between 0.5 and 5.0 m. A phosphate level which is intermittent lies at the base of these clay shales.

Chemical analysis of two samples of clay has revealed the following results :

Sample	S	A	F	C	MgO	TiO_2	K^2O
S 9	56.95	14.30	8.45	1.65	4.95	1.03	0.35
S 66	53.40	16.65	7.80	1.80	5.10	0.97	0.63

4 - Calcareous formation

1) Geology

This formation is covered on the top by a level of phosphate limestone appearing intermittently and which has been mentioned previously.

On the basis of the Nigerian Geological Survey Department observations, it is possible to distinguish two layers in the calcareous formation :

- at the top just under the clay shales, the limestone series
- at the bottom, the lower calcareous clay shales.

This distinction is analysed below and corresponds to the observations of the present mission.

...

- Limestone series

This term, in a wider sense, is applied to the part of the formation in which the limestone is more abundant. The limestone exists in the form of intermittent large blocks, white, chalky and friable, measuring 0.50 to 2.00 m in height. These limestone blocks are covered with a mass of chalky white to soft beige marls with numerous fossile imprints. In places, 0.20 to 0.05 m thick beds of grey clay are found in contact with limestone blocks and seem to have slid with the blocks they cover.

In various places very hard recrystallized limestone nodules, several centimeters in diameter, can be found.

The limestone block area is, generally speaking, separated from the clay shales which cover the blocks with 1 to 2 m of white chalky marls.

These series are particularly intermittent and, as stated in the first GSN report, it is impossible to make a correlation between the boring holes. Thus the information obtained from each boring hole has, as far as quantity is concerned, only a punctual value.

This intermittent nature of the formations, along with the phenomena of dissolution has not sufficiently been taken into consideration in the course of the investigations which followed the regional survey.

The whole limestone series have a depth of 7 to 8 m.

- Lower Calcareous clay shales

At present, the floor of the quarry is located at the top of this level which is not quarried.

On the basis of the observations of the present mission made in the quarry and which are confirmed by the interpretations of the GSN and the ARTHUR D. LITTLE geologist, this layer is outstanding for its regularity and lithology.

These series are composed of chalky fawn beige marls with greenish effects. The interpretation of the cross section of the pit digged in the series has made it possible to conclude that progressively the shales change to clays which then become sandy when in contact with the lower formation.

The lower series are about 3.5 m thick.

...

2) Geochemistry

- Limestone series

Analyses of various types of rocks constituting this series have led to the following results :

Formation	Sample	S	A	F	C	MgO	TiO_2	K_2O	P_2O_5
Clays covering limestones	3 4	54.8	15.9	7.85	2.75	4.40	0.85	0.65	0.19
Chalky white shales	5	11.7	3.7	1.40	44.65	1.10	0.16	0.12	0.16
Chalky white limestone	6	0.7	0.2	0.3	54.7	0.2	0.00	0.00	0.06
Decomposing limestone	2 7	4.2	1.2	0.85	51.4	0.40	0.04	0.2	
Limestone nodules	8	0.15	0.05	0.2	55.35	0.1	0.00	0.00	

These analyses reveal the heterogeneity of the deposit since, within one formation, the lime content varies between 2.75 and 55.35, that of silica between 0.15 and 54.8, that of alumina between 0.05 and 15.9 and that of iron oxyde between 0.20 and 7.85.

At present, the entire limestone series are quarried. An average of 6 samples taken from the entire height of the working face provided the following results (major elements) (see details in the table on the following page) :

S	A	F	C	MgO	CO_3Ca (1)
13.9	3.8	1.8	41.9	1.55	74.8

...

(1) This is actually lime expressed as CO_3Ca. The same applies to contents of CO_3Ca dealt with in this chapter.

Which corresponds to :

LSF = 0.93
MS = 2.5
A/F = 2.1

These figures call for two comments :

- These series are slightly poor in lime content, but this fact may arise from the representativity of the sampling. This fact is of major importance and should be kept in mind for plant operation.

- The heterogeneity of the formation is again revealed by the wide variation of the content of its components.

	Maximum	Minimum
S	22.70	8.35
A	6.65	2.10
F	3.10	1.00
C	47.40	33.10
MgO	2.30	1.10

In order to attempt to identify the average chemical composition of the quarried formation, two series of samples have been taken in the raw materials storage hall.

At present, the material coming from the quarry is stored in the factory hall in 2 clearly separated piles so as to have theoretically a pile of material with a low CO_3Ca content and another with a high CO_3Ca content.

Samplings of the low CO_3Ca content pile have provided the following averages (11 samples of several kg) :

N = 11	S	A	F	C	MgO	TiO_2	K_2O	CO_3Ca
m'	16.0	4.4	2.9	40.1	1.5	0.18	0.17	71.6
σ	0.45	0.14	0.15	0.34	0.07	0.01	0.01	

Which corresponds to :

LSF = 0.77
MS = 2.17
A/F = 1.48

...

Samplings of the high CO_3Ca content pile have provided the following averages (24 samples of . several kg) :

N = 24	S	A	F	C	MgO	TiO_2	K_2O	CO_3Ca
m'	13.5	3.9	1.9	42.7	1.3	0.16	0.16	76.3
σ'	1.08	0.31	0.18	1.10	0.14	0.14	0.02	

Which corresponds to :

LSF = 0.98
MS = 2.32
A/F = 2.0

For all these samplings, the heterogeneity of the products should be noted. This heterogeneity is apparent through the variances exceeding 1 for silicium and lime content.

The average chemical features of the quarried formation may thus be estimated without considerable risk of error to be :

S	A	F	C	CO_3Ca
14.5	4.0	2.5	41.5	74.0

The presence of P_2O_5 should in addition be noted in the limestone formation, which may have consequential effects on the clinker. Out of the 13 samples from the factory hall and on which analyses have been performed, the average result obtained is : P_2O_5 = 0.32.

This P_2O_5 content is within the allowable limits but has harmful secondary effects such as the depositing of material on the blades of the hot gas fan, which led to the unbalancing and then the explosion of this equipment.

The distribution of the P_2O_5 in the worked formation and the way of eliminating it should have to be examined in a special detailed study.

- <u>Lower calcareous clay shales</u>

Chemical analyses of this formation were performed on samples obtained from the pit digged in the floor of the quarry.

...

The 1.5 m thick upper part which is under the floor of the quarry has the following characteristics (sample 56) :

S	A	F	C	MgO	TiO_2	K_2O	CO_3Ca
16.15	4.20	1.90	39.55	2.10	0.17	0.20	70.63

The 2 m thick lower part which forms the base of this formation has the following features (samples 54-55) :

S	A	F	C	MgO	TiO_2	K_2O	CO_3Ca
28.1	9.3	3.5	27.8	2.4	0.4	0.5	49.6

- Dange formation

Two samples have been taken in this formation : one in the sandy brown clays which form about 1 m of transitional zone between the limestone formation and the Dange blue clays ; the other in this latter formation. The results of analysis of these samples are as follows :

Sample	S	A	F	C	MgO	TiO_2	K_2O	CO_3Ca
Brown clay 53	55.0	13.65	7.10	4.50	4.95	0.80	0.90	8.03
Blue clay 52	57.85	19.95	6.40	1.40	2.45	1.15	1.35	2.50

d - Conclusions on the characteristics of the deposit

Upon examination of available data, it appears that there is not enough information on the Sokoto deposit.

At present, there is even none who can tell in advance what the characteristics of the extracted material will be nor all the more what the overall characteristics of the deposit are :
is the average CO_3Ca content of this deposit greater or smaller than the usual content of cement raw mixes ?

Boring holes made by the GSN were very far from the quarry. From among the boring holes made by FERROSTAL, only several were actually analyzed.

...

In any case the data provided by these boring holes have only an indicative value in view of the low percentage of cores recovered i.e. between 69 % and 72 %. Consequently, the deposit remains to be investigated and this is most essential. The methods to be used, either pits or drillings, should allow for all the material to be sampled and analyzed.

Although the characteristics of the deposit are not known in detail, observations made within the present mission point to the fact that this deposit is very heterogeneous.

Utilization of the limestone series in the cement factory will thus demand as much homogeneity as possible so as to be able to obtain a product having regular chemical characteristics from highly heterogeneous materials.

B - Utilization in cement factory

At present, the entire limestone series are being worked. A distinction is, however, made between the high CO_3Ca content product and the low CO_3Ca content product.

In fact, the "high CO_3Ca content" product sampled shows a very slight excessive CO_3Ca content compared with that of a raw mix of cement factory. Its characteristics are as follows :

S	A	F	C	MgO	CO_3Ca
13.5	3.9	1.9	42.7	1.3	76.3

Which corresponds to :

LSF = 0.97 - slightly high
MS = 2.32 - slightly low, but acceptable
A/F = 2.0 - slightly high

Upon adjustement of the clay content this product could be used as raw mix in the cement factory and would produce a cement with an approximate potential composition of as follows (in percentage) :

C_3S	C_2S	C_3A	C_4AF	Total
63	15	12	10	100

thus, a product of excellent quality. ...

These results have been confirmed by the clinkerization test performed in the Central Laboratory of Ciments Lafarge in Viviers (see Appendix).

It should, however, be kept in mind that the characteristics of this product have been defined with quite rudimentary means and thus our sampling may be tainted with errors. Moreover it is very important to state that, in view of the heterogeneity of the deposit, it is impossible to guarantee constant characteristics. It is felt herein that at times the so-called "high CO_3Ca content" product is very slightly richer in lime than necessary for the cement factory raw mix and at other times this product is definitely too low in lime content.

Correcting a material having a slightly too high CaO content for a cement raw mix does not raise any problem. The Sokoto quarry containts sufficient clays and shales. The same is not true for correcting a product with a slightly too low CaO content. In this case, rich limestone will be required. But no rich limestone has been found in the deposit. Thus, under the present conditions the factory cannot at all correct its raw mix, thereby making the preparation of a regular product impossible.

The necessity of obtaining a regular raw mix of good quality thus makes it indispensable to have limestone available for correction either within the quarry or otherwise (1).

A detailed investigation of the quarry should make it possible to locate areas rich in CO_3Ca and areas poor in CO_3Ca.

Provided that the differences between these areas are large enough, it would be possible to have material to correct the raw mix.

Should it not be possible to locate high CO_3Ca content areas, when quarrying the entire depth of the limestone series, it should be possible to enrich a part of this level, in view of the fact that the limestone masses and blocks are generally surrounded by two layers of marls. However, the removal of marls surrounding the limestones would increase the waste rocks.

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(1) Practically speaking and for evident economic reasons, a ground raw mix cannot be eliminated whenever its lime content is too low.

INTRODUCTION AND SUMMARY

For a long time, the presence of limestone has been observed at three or four points in Northern Nigeria, but especially in the Northwest. The construction of a cement plant is part of a program for the manufacture of basic materials whose principle is no longer to be questioned as soon as satisfactory resources are available.

These resources, located near Sokoto and discovered in 1911, were extensively studied by the Geological Survey in 1959-61, and the conclusions were promising. During the first 6 months of 1961, the Rockefeller Brothers Fund requested, asked for a feasibility report an American engineering firm with an office in Lagos (Stanley Engineering). This study adopted a 100,000 t. program using the semidry process and Enugu coal. Capitalization was estimated at £ N 2,500,000, and the report concluded there would be no question about the profitability of such a project.

Consequently, in October 1961 the Government of Northern Nigeria authorized the construction of this cement plant and approved a contract between the company it set up for this purpose, the Cement Company of Northern Nigeria (CCNN) and the German engineering firm, Ferrostaal, a contract followed by a second one for administrative aid during the first years of operation.

In point of fact, the CCNN is an 80 percent owned subsidiary of the New Nigeria Development Co., a financing organization of the Government of the North, and is 20 percent owned by Ferrostaal. Since April 1st, 1968, the NNDC has been the emanation of the six states which succeeded the Government of the North.

The Sokoto cement plant was designed by Ferrostaal with a capacity of 100,000 t. using a wet process with a granulator and using fuel oil for fuel. Construction was completed at the end of 1965 following excessively brief technical and economic studies, especially as concerned quarry materials.

Tests proved disastrous due to excessive absorption of water by the clay, swelling of the latter obstructing the conduits and the resulting unacceptable consumption of calories in the kiln with a fall in the corresponding capacity.

Another solution would be to find high CO_3Ca content limestone in the vicinity of Sokoto. In the Malbasa deposit some one hundred kilometers north of Sokoto there are such layers although they are also quite irregular. Similar deposits should be investigated in the vicinity of Sokoto. Such investigation work could be assigned to the GSN which is highly qualified for solving this type of problem.

C - Reserve stocks

Calculation of raw materials reserves for the Sokoto factory is significant only as far as the quantity of overburden to remove in order to make these reserves available is also evaluated. As a matter of fact, leaving aside the ratio limestone/overburden, it is possible to consider that the reserves are unlimited, since a large part of the formation has the chemical composition required for producing clinker.

At the start, the GSN identified an area of 32.77 million square feet corresponding to 109 million short tons of limestone reserves with a ratio limestone/overburden of 1/1. This area is located beyond the CCNN concession of land.

In fact, the quarry was opened outside the area designated by the GSN and it has turned out that the ratio between the overburden and the limestone was in the vicinity of 1.6. For the present, quarrying leaving in place the lower calcareous clay shales, the ratio should be about 1.5. In any case, in view of the necessity of enriching the limestone series by leaving in place the lower calcareous clay shales, it is felt herein that, at best, within the area designated by the GSN, with a similar quarrying method as that used at present at Sokoto, the ratio between the overburden and the limestone should still remain at 1.3 to 1.4.

On this hypothesis, the reserves of the present concession are estimated to be between 6 and 6.5 - 10 tons of clinker, by assuming that the limestone formation can be quarried to a depth of about 7 m and that the overburden is 10 m thick. Only the results of a detailed investigation could provide precisely these figures. These reserves correspond to 100 000 t of annual production during 60 years or 200 000 t of annual production during 30 years.

In any case, there are large possibilities of increasing the reserves by extending the concession.

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D - Quarrying operations

Quarrying operations are composed of two parts : removal of overburden and extraction of marls and limestones.

a - Removal of overburden

Up until a recent date, overburden removal was performed by an outside sub-contractor. For about a year, this operation has been carried out by the factory with its own equipment.

At present, the overburden to be removed is a mass of some 10 meters deep. It includes sands, laterites, clay shales and several detached patches of limestone with phosphate.

The sands and upper part of laterites are removed by means of a bulldozer. The hardness and compactness of the laterite and iron-stone require blasting so that this material can be removed by means of a shovel and then loaded into dump trucks.

The deposit of waste rocks is located north/north-west of the quarry about 300 m away from the working face. In the future, when ever the quarrying operations will be sufficiently advanced, it will be possible to place the overburden material on the floor of the quarry behind the working face.

b - Extraction of limestones and marls

The extraction of limestones and marls goes down 7.0 m to 7.5 m in depth, with the lower clay shales being left in place.

These materials are removed by means of a shovel and loaded into trucks which deliver the material to the factory.

On the basis of the areas from which these materials have been extracted, we have noted that the factory attempts to obtain two types of products : one with high CO_3Ca content and another with low CO_3Ca content.

The material extracted from the quarry is normally sent to the crusher and then to the factory hall. However, during the dry season, part of the material extracted from the quarry is stored within the factory, before crushing, for the production needs during the rainy season, at which time the quarry is not easily accessible.

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c - Quarry equipment and haulage facilities

Quarry equipment currently includes :

- 3 Weser-Hutte TW12 1.5 cu. m. diesel shovels
- 1 compressor and 1 wagon drill
- 5 Fodden trucks in more or less satisfactory condition
- 1 bulldozer.

When the factory was opened, 6 new Zettelmeyer Type A6 85 HP dump trucks were purchased and after the first year of service they were completely worn out and their motors were used to replace that of the bulldozer.

The operations were then carried out with 9 Fodden trucks purchased second-hand and 2 new trucks. At present, out of the 9 second-hand trucks, 3 are in serviceable condition as well as the 2 new trucks.

Two other Fodden trucks have been ordered.

It thus appears that the quarry is adequately equipped for the timebeing. However, the equipment is not carefully used. It is partly almost worn out and in no case could handle an increase in production.

d - Drainage of the quarry

Water seeps into the quarry from two hydrostatic levels : at the base of the laterites and the limestones.

At the end of the dry season, there still remained several inflows of water from the laterites, but these should be especially abundant at the end of the rainy season when the water empties from the ironstones.

Inflows of water from the limestone layers are more abundant. They are located in the cracked area of the central part of the limestone formation, the part with the highest limestone content.

This water is collected in ditches of which one is located at the foot of the working face being quarried. The water is then drained out of the quarry by means of a pumping station. At present, although considerable effort has been made, the floor of the quarry is very irregular and sometimes sloped in the opposite direction thus making it difficult to drain water, in particular during the rainy season. A highly valid project plans to reverse this slope so as to allow quarrying in any season.

...

III - ADDITIVES

The only additive used at Sokoto is gypsum of which theoretically 5 % are added to the clinker.

After various tests, the gypsum currently used comes mostly from Malbasa and partly from the vicinity of Sokoto. The gypsum in both cases is extracted from the same geological level in which it is found in small beds 0.5 to 2 cm thick, in various layers within clay layers. Thus, the product used contains a considerable amount of impurities and it should perhaps be washed to remove some of these impurities.

Analysis of three samples of gypsum has provided the following results :

Samples	S and insolubles	A	F	C	MgO	SO_3	CO_2	K_2O	Na_2O
36	20.20	4.00	3.50	22.95	0.80	27.85	0.50	0.35	0.12
37	19.70	3.80	5.15	22.35	0.70	27.75	0.60	0.36	0.11
70	17.90	3.30	3.80	23.75	0.55	29.85	1.85	0.36	0.10

These analyses reveal the poor quality of the gypsum used and the large portion of clayey gangue previously referred to and which results in abnormally high silica, alumina and iron oxide contents and low SO_3 content (1). The clayey gangue has a harmful effect on cement (shrinkage, cracking, poor resistance).

Without purchasing imported gypsum which is very expensive, the quality of the product delivered to the factory should be better controlled and the factory should be more demanding as far as quality is concerned so as to have a minimum of clayey quangue.

...

(1) The theoritical maximum SO_3 content in gypsum is 46.5. Fine quality gypsum has a SO_3 content of 40 and poor quality gypsum has a SO_3 content of 35.

IV - CONCLUSIONS ON RAW MATERIALS

Most of the difficulties facing the Sokoto factory since its start up come from the raw materials.

At the very start, the Geological Survey of Nigeria warned the Contractor who built the factory as to the risk of opening the quarry in the area quarried at the present time. The GSN foresaw that this area would be poor in limestone and also suggested, in view of the heterogeneity of the deposit, that a survey of the formation be carried out with a 90 % recovery of the cores.

Since this advice was not heeded from the very start, the factory has had some difficulties producing a raw mix rich enough in CO_3Ca. This fact had been frequently noted and the raw mix was often sent to the rotary Kiln with too little CO_3Ca content.

However, the chemical characteristics of the limestone series are on the average adequate for producing raw mix for the factory with satisfactory quality. The irregular CO_3Ca content results from inadequate knowledge of the deposit and from its heterogeneity In order to solve this problem, it is necessary to have a high CO_3Ca content correction material.

It would be possible to obtain a higher lime content product either by enriching the formation currently quarried or by orienting the quarrying activities towards the areas with higher limes content, or by finding elsewhere limestone with a very high lime content.

The enriching of the limestone series would increase the proportion of the overburden and would thus result in an increase in costs.

Orientation of the quarrying to areas with limestone having a higher lime content is impossible at present due to the fact that the deposit has not been sufficiently investigated. A detailed reconnaissance survey of the deposit thus appears to be necessary.

Utilisation of an outside source of limestone with a high CaO content would require a regional study.

The heterogeneity of the raw materials which contain products with highly varied chemical characteristics would require a more efficient homogeneization method than the one used at the present time.

...

During quarrying and haulage, the materials are somewhat homogenized, but the product delivered to the crusher is still very heterogeneous.

As a result of the inadequacy of the homogenization facilities, a large part of these heterogeneous materials arrive in the kiln, which leads to cement burning difficulties and produces clinker of variable quality which impedes the cement grinder from operating at maximum capacity.

Provided that modifications, it is herein proposed for the preparation of the raw mix and its homogeneization be made, the raw materials of Sokoto can be used for the production of Portland cement for which they are perfectly adaptable.

CHAPTER IV

PROCESS AND RECOMMENDATIONS

In this chapter we will first examine present operating conditions of the equipment and will progressively indicate our recommendations to improve plant operations.

Then we will study present manufacturing operations and improvements which can be made. From them we will deduce the potential the plant would have were it located in Europe.

I - EXAMINATION OF PRESENT CONDITIONS OF EQUIPMENT RUNNING AND RECOMMENDATIONS

A - Raw material drying

An important observation is to be made concerning the dryer. In point of fact, any stoppage of this unit exceeding 1 hour stops the kiln.

From 19 March 1970 to 1 February 1971, equivalent to approximately 178 days of kiln operation, 19 kiln stoppages were due to the dryer. These were the result of various causes including :

- breakdowns in the equipment used to handle dry products
- breakdowns due to one of the rotary dryer's carrier rollers

It is unfortunate the chimney which seems to have been designed to remove the fumes from the kiln without passing through the dryer, should the latter or an auxiliary unit break down, is not in service. It would make it possible to avoid kiln stoppages due to the dryer. Thus, it must be used, and for this purpose it has to be equipped with cyclone collectors or connected to the normal circuit used to remove fumes from the dryer using pipes passing through this unit.

In the latter instance, special attention must be given to the operating conditions of the kiln exhaust fan (gas temperature and power drawn).

Operation of the hot gas fan is interferred with by deposits appearing on the blades. It will be difficult to avoid these deposits and resulting unbalanced conditions.

Thus, special attention must be given to monitoring the operation of this unit and having the necessary replacement parts on hand.

In specific, it is necessary to :

- verify that the measuring units and gas temperature signalling devices are in good condition
- systematically organize outside and inside inspection of the fan and periodically clean the blades
- take samples of the deposits for purposes of analysis to keep track of changes in the phenomenon and possibly determine those elements which might lead to discovering its causes.

B - Raw grinding

It is equipped with a separator for closed-circuit operation, but it functions in an open circuit since the finished product leaving the grinder is rather fine and grinder volume is sufficient.

It is unfortunate the screen at the grinder's output was not placed directly between it and the Fuller pump, thus making it necessary to continually use the elevator originally designed to operate in a closed circuit leading to useless wear of this unit and equally useless consumption of kWh.

C - Homogenization

Homogenization of raw materials is a problem which has been poorly solved in Sokoto although Ferrostaal supplied an installation for homogenization by fluidization of the Airmerge type (system developed in the USA by the Fuller Company).

Let us first review the operating theory of this installation.

Each homogenisation silo is equipped with porous surfaces divided into 4 quadrants.

The fluidisation air is divided between a so-called active quadrant and the three other so-called inactive quadrants.

A large quantity of air is sent over the "active" quadrant, whereas a small quantity of air is distributed over the three other "inactive" quadrants. The matter above the "active" quadrant is more fluidised and thus less dense than that over the other quadrants and it rises higher coming down on the remainder of the matter.

The dense matter of the "inactive" quadrants in turn slips under the highly fluidized matter of the "active" quadrants. This leads to a sort of vertical, continuous boiling creating an effective mixture and providing homogenization of the materials.

Using the air distribution valve, the "active" quadrant is periodically changed, making each of the four quadrants active in turn.

The "high pressure" active air compressor must be capable of delivering this air at 1.2 to 1.4 bar, the pressure needed at the start of the operation to change the matter to an emulsion ; once the emulsion exists (normal operation), pressure of 1 bar is adequate.

The so-called "low pressure" "inactive" air compressor must deliver its air at 1 bar at the outset followed by 0.7 bar (normal operation).

The Fuller Company claims the Airmerge reduces deviations (of $CaCO_3$ concentration for example) by a factor of 10 (1). In point of fact, industrially we have never encountered as high an improvement as that announced by the Fuller Company.

However, sometimes (2) a reduction by a factor of 7 is obtained, and, normally, it should be necessary to obtain a reduction by a factor of at least 5.

Maximum efficiency, however, can only be obtained if the equipment is in perfect condition and if it is operated under good conditions.

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(1) In other words, if the homogenisation silo is fed with a product whose concentration varies by $\pm$ 2 points around the value of 78, the homogenised product will have a concentration of 78 $\pm$ 0.2.

(2) In point of fact, this reduction in the variations is very closely a function of the heterogeneity of the materials entering the homogenisation process.

We feel the difficulties encountered by the plant in this shop originated in :

1 - contradictions between documents provided by the constructors. The homogenization system was set up according to the plans of Claudius Peters N° PO 324 116 E. With this installation and existing equipment it cannot operate according to the plans of Miag Z 39 264 (and the note from Miag V 645-53 of June 1966). In specific, the high-pressure "active" air which, theoretically, must be sent to but a single quadrant is sent towards 3 quadrants and the "inactive" air, which should be sent to 3 quadrants, is only sent to 1 quadrant. Schematically :

Air blown over	This should give us		Actual installation	
	Pressure		Pressure	
One quadrant	"active" air 1.6 bar	20 m3/mn	"inactive" air 0.6 bar	20 m3/mn
The other 3 quadrants	"inactive" air 0.6 bar	6 m3/mn	"active" air 1.6 bar	6 m3/mn

2 - an unclear definition of the method to be employed in effectively using the homogenization process.

3 - the need to hand operate the air distribution valves. This maneuver must be performed every 15 minutes for a silo undergoing the homogenization process. For storage silos or for tapped silos, it is desirable that the air distribution valve be operated every 30 minutes ; however, this is less important than for the silo undergoing homogenization. As it is, it is very difficult to get operators to systematically repeat the same gesture every 15 minutes. To avoid this dull work, motor-driven valves have been installed for the fluidization of cement silos (where they are less indispensable). Valves of the same type have been installed on raw material silos, but these are not motor operated (1) (a proof that the changeover to the dry process at the plant was performed at less cost than the initial construction in 1965).

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(1) This operation will successively require the immobilization of each silo, and this will considerably interfere with the manufacturing process

The economic report shows that things cannot be otherwise given the competitive climate created by cement plants in the South which enjoy considerably better manufacturing conditions. Apart from virtually identical costs of manual labor and electricity, this leaves two factors :

- the price of fuel oil which is 2 to 3 times higher than in the South,
- the size effect (for example, a plant which is 5 times larger has production costs which are 40 % lower) which is unfavorable to the North.

As it happens, Sokoto is also handicapped by its distance from to-day's major consumer markets and especially by the 130 miles separating it from the railroad. Moreover, it has already been pointed out that a large share of the deficit is due to plant sharing in the costs of shipping the cement to far-distant customers.

Thus, major efforts are to be made in commercial and gouvernmental areas which can be summarized as follows :

- regional sales are to be improved and a single price used, with customers paying for shipping. This will produce a slight shrinkage in the market, more theoretical than real, however, and the brief market study given in the report indicates that this will leave enough to operate the plant at full capacity;
- the sales network is to be reorganized, especially by comparing the profitability of direct storage with that of commercial representatives firms. The same applies to the profitability of the transportation service as compared with specialized companies.

An attempt must be made to negociate better conditions for fuel oil shipping, for the amount of the fixed allowance in the supply of electricity and, if possible, for the excise duty.

There is good reason to believe that, with such arrangements, factory operations will begin to break even. In point of fact, the economic study shows that with 90.000 t of output it is possible to produce more than £ 300,000 in amortization. However, the business is still unable to provide for its survival, and other solutions must be examined.

Possible diversifications as well as the use of groundnut shells cannot provide the basic answer and can only constitute additional approaches sometimes difficult to put to work (the case of groundnut shells is covered in a special appendix).

The true solution is to be found in the increase in capacity, and the small amount of information given concerning the probable 1975 market shows there could be a twofold expansion.

4 - porous surfaces of dimensions probably too small to permit effective fluidization (and even if the porous surfaces were sufficiently large, the silo's usable homogenizable would only be on the order of 9 to 10m. whereas these silos are 18m. high) (1). The fill height/diameter ratio must be on the order of 1.2 to 1.5 to obtain proper homogenization.

At the present time, new operating difficulties probably come from :

- fouling of the porous surfaces making them ineffective : the entire installation should be cleaned ;

- overfilling of the silos which are now only used for storing the materials

- air distribution valve leakage

Given these conditions, the homogenization installation is not used, and the silos are used virtually solely for storage purposes. This leads to nonuniformities in the composition of the raw materials which compromise the uniform operation of the rest of the installation following this point and which reappear in the clinker and then in the cement.

To rectify this situation, it is necessary :

1 - For experimental purposes :

- to modify the installation at one silo to be able to blow the required amount of air by volume and pressure over a quadrant, the other three beeing simultaneously supplied with "inactive air"

- at the same time completely overhaul the installation at this silo and ascertain that the porous surfaces are clean and in good condition

- determine for a fill height of 8 to 9 m the homogenization quality for this silo : variations in $CaCo_3$ content must be reduced by a factor of at least 5.

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(1) It should be remembered these silos were designed for wet process plant functioning.

2 - If homogenisation is inadequate, it will be necessary to increase the amount of porous surface area (1) and thus modify (2) the bottom of the 4 silos.

Thus, it will be possible to solve the homogenisation problem. One other problem, however, will appear, that of the amount of volume available for storage purposes, since virtually 3 silos out of the 4 will be taken up by one of the phases (filling, homogenization, analysis, correction), and it will then be practically impossible to fill them by more than 50 percent.

To solve both the homogenization and storage problems (to use their entire height) several silos could be modified by placing a homogenisation stage in the top of each with the bottom being used for storage purposes.

In any event, it is likely it will be necessary to increase plant maneuver possibilities by building a fifth silo (to be reserved for homogenisation purposes) to permit the proper preparation of the raw material. To avoid this investment, homogenisation and possible correction operations for the tanks must be performed very quickly by the laboratory ; as it happens, the length of these operations is heavily influenced by the quality of the raw material leaving the grinder and by its sampling.

Moreover, the capacity of the fifth silo could be larger than that of the presently existing silos.

In conclusion, the solution to the homogenization problems will require :

- either rather lengthy experimentation leading to investments whose utility will have been thoroughly studied, and, in particular, sufficiently large samples of industrially ground raw materials must be studied at the laboratory and at a pilot plant ;

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(1) For 1 installation of the same type, we would have had a total blown air flow of 21 m3/mn (14 m3/mn of active air at 1.2 to 1.4 bar and 7 m3/mn of inactive air at 1 bar) distributed over 4 quadrants each having a minimum of 6 m2 of porous surface area (instead of 2 m2 per quadrant in Sokoto ; (cf. the Miag Z 39 264-1 drawing).

(2) This operation will successively require the immobilisation of each silo which will considerably interfere with the manufacturing process.

- or, new investments which can be already decided on (1) and which, in any event, will be useful to plant functioning but which might perhaps have been minimized.

In our opinion, the first of these two solutions is preferable, since it will make it possible :

- to accurately determine requirements,
- to specify the characteristics (air flow, porous surface area, necessary homogenization time, dimensions and so forth) of the required installation,
- and thus to optimize the equipment and the cost of the additional investment.

Future plant expansion is to be taken into consideration in this study.

The homogenization elevator which should be used solely for correction purposes operates without interruption or else the bottom of the elevator becomes filled with raw meal and cannot be started without emptying this bottom.

This raw meal can come from two sources :

- leaks in the by-pass shutters of the air slides (silo emptying)
- or more likely (since it piles up to several meters high), the decantation of dust coming from the dusty air travelling from the silos toward the dust removal mechanism through the air slides.

Reducing the pressure at various points in the dust removal circuits, by closing off certain parts of the installation, will point to the origin of the dust thus collected and indicate the modification to be performed on the dust removal circuit.

Subsequently, if this elevator is used frequently for tank corrections, the bottom of the elevator will not have enough time to become filled up between two operations (naturally, it will be necessary to check it).

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(1) - an increase in the porous surface area of the bottom of each silo
- construction of a fifth silo
- installation of additional compressors

D - Rotary kiln and burning

The kiln's dimensions (length 60m., diameter 3.4m., length/diameter ratio 17.6) are unconventional (1) for a dry process burning installation with one stage using 2 heat exchanger cyclone collectors. This is a consequence of the fact the plant was initially built to operate using the wet process with a calcinator.

On first glance, this leads to high fume temperature and thus high heat consumption due to the fact that exchange operations in the kiln are insufficient and that the material reaching the burning zone is more poorly prepared.

On the other hand, fortunately, the diameter of the kiln in the burning zone is quite sufficient for burning the planned volumes.

A sizeable imbalance (a difference of 100° C between the temperatures of the gasses entering the cyclone collectors) is seen between the exchanger cyclone collectors and the kiln output due to the unsymmetrical use of raw meal (2). This problem can be cured.

The high temperature of the fumes (on the order of 560° C following the cyclone collector stage) is favorable, moreover, since the fumes are used to dry the raw material before grinding ; as it happens, this material is very humid (commonly 14 to 18 percent water).

Dust is removed from the entire gas circuit using cyclone collectors (3) some of which were clogged. As concerns efficiency and power consumption, electrostatic dust removal equipment would have been preferable, but the cost of the investment would have been higher.

The kiln is operated through control of :

- fuel flow
- kiln rotation speed
- the speed of the rotary kiln feed lock chamber
- the flow of primary air

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(1) With one stage of cyclone collectors, the length/diameter ratio is more commonly on the order of 30.

(2) Calibration differences can also explain part of this difference.

(3) The temperature at the bottom of the cyclone collectors, an indication of proper removal of the recovered dust, must be monitored.

As it happens, the control of the kiln rotation speed and the feed are not synchronised. Given these conditions, any disruption of the burning process, corrected by the kiln speed, leads to problems with the burning whose repercussions are still felt a long time afterwards (pumping phenomena caused by the irregular arrival of the raw material in the burning zone in turn due to constant feed of the kiln despite variations in kiln speed).

It would be desirable to develop and use a table making it possible to continually adapt the speed of the lock chamber supplying raw material to the kiln to the kiln rotation speed.

It would be much better if an automatic mechanism continually synchronised those 2 speeds in order that the kiln operator no longer has to worry about this operating parameter.

At the end of November 1970 the fuel oil reheater (1) exploded. A temporary heating system (the fuel oil circulation pipes had been located parallel to the kiln at a distance from the burning zone of approximately 1 cm) is in operation, but the fuel oil is only brought to a temperature of 60 to 70° (under the most favorable heating conditions : during the dry period) which is inadequate (2) for obtaining good vaporisation of the fuel oil. The temperature previously desired was on the order of 100° C.

Approximately one third of the Rotary Kiln Control Stand equipment no longer operates. Consequently, some major parameters for proper kiln operation (for example, pressure in the first cooler chamber, secondary air temperature) are no longer available to the kiln operator.

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(1) In Appendix appear the characteristics of the fuel oil used ; we would like to draw attention to the asphalt probably contained in this fuel oil.

(2) We believe that at the time this report will appear, the fuel oil reheater system will have been repaired and that, consequently, the fuel oil used will be at an appropriate temperature for good mechanical vaporization.

Kiln operation is thus disrupted :

- by the lack of incoming meal due to the fact the reserve hopper is not fluidized (although it is the job of one worker to monitor this important point) ;

- by the formation of rings and balls : the major cause of the formation of rings in the kiln is uneven operation (both irregularities in the raw material as well as irregularities in kiln operation and heating).

On the other hand, there do not seem to be too many problems due to caking in circuits preceding the kiln or clogging of the cyclone collectors (the portion preceding the kiln was in remarkably clean condition).

An inspection hole (with a radius of approximately 30 cm) in the heating floor makes it possible to see what is going on in the cooler. At the time of our visit, it was open virtually all the time introducing cold air into the upper part of the cooler, highly undesirable for proper thermal operation of the kiln.

Lastly, as concerns operations it would be preferable to determine the density of the clinker (1) from samples taken at the kiln output and not from those taken from the bucket conveyor in order to reduce the response time.

Cooler

The pressure indicator in the cooler's first chamber does not operate any more than the secondary air temperature meter. This is unfortunate for quenching efficiency and proper functioning (2) of the cooler, especially since the operators do not seem to have any precise instructions to change the speed of the grating as a function of kiln operating incidence.

This speed must be modified to kiln operating conditions (normal functioning or crust removal) and must be marked on the daily output reports (or recorded).

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(1) Or free CaO.

(2) One minor detail : the cooler traps are often emptied without any concern for the removal capacity of the bucket conveyor, thus leading to the buckets overflowing when they receive too much material in too short a period of time (the equipment operators should be asked not to open wide the traps under the cooler in order to limit the flow of the fine clinker).

The volume of air blown over the cooler must be modified to the speed of the grating and kiln output. In case of insufficient volume for the grating speed, the clinker is not longer quenched (1) but, in addition, distortion in the frame of the cooler is a possibility. This has already occured several times (it must be pointed out the quenching cooler is a device which is very sensitive to operating mistakes).

E - Cement grinding

a) Volume

This grinder has already produced 15 to 16 t/h (2).

In April 1971, the volume produced by this equipment was insufficient in view of its characteristics (dimensions, power, ventilation). The main sources of this insufficient volume were :

- the lack of clinker quenching,
- insufficient CaO content (LSF too small)
- adjustment of grating openings and charges in grinding elements to be changed, all causes which were worsened by the difficulty in adapting the grinder charge to clinker of variable quality (and hardness).

How can this failing be rectified ?

The raising partitions remove the clinker very easily, and this explains that the first compartment always seems to be empty of any material and rings very clear.

The clinker must leave the first compartment very well prepared, and, for this purpose, some of the openings in the gratings at the output from the first compartment must be closed (3) in order for the clinker to stay long enough in the first chamber to improve grinder output (4).

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(1) As it is, in Chapter II (cement quality) we saw that quenching is especially important in Sokoto.

(2) From 1st September 1970 to 8th November 1970 the plant sold 12,000 t. of cement without drawing on the stock which was very low and on the same order of size at both the beginning and end of this period. The grinder operated for 798 hours, corresponding to a volume of at least 15 t/h and even 16 t/h if stock errors are small.

(3) By welding steel billets some of which will perhaps have to be eliminated subsequently if the first compartment becomes packed too quickly.

(4) It will perhaps also be necessary to shorten the first compartment.

For the same reason, it will perhaps also be necessary to modify the partition between the second and third compartments.

Simultaneously, we will see whether or not it is possible to further ventilate the grinder, since clogging of the openings of the gratings between the first and second compartments will lead to an additional loss of charge (we will base ourselves on the fineness of the finished product recovered during dust removal which must be of the same order as that of the desired finished product).

We feel it is desirable to increase the volume of the grinder through better adjustments and through modifying the quality of the clinker.

Thus, we should be able to return to the 15 to 16 t/h already obtained earlier and the grinder will no longer be a plant bottleneck.

However, if need be, use can be made of the separator installed at the raw material grinder although it is not in service. Use of this separator will provide an increase in production on the order of 10 to 15 percent but will necessitate a new adjustment of the charges and openings since use of a separator considerably modifies the granular distribution of the cement and thus all of its characteristics, especially mechanical strength.

b) Use

However, even if the grinder is properly adjusted, in addition to the quality of the finished product, the other operating conditions must be closely monitored (1) :

- volume (rather long measurements on the order of a minimum of 2 to 3 mn)

- consumed power

- charges in grinding elements

if good equipment efficiency is to be obtained.

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(1) This is not presently the case.

In specific, it is necessary :

- to organize the systematic reloading and sorting of the three compartments. In specific, in April 1971, the balls and cylpebs charges in the three compartments had not been sorted for a long time. Notably, the first compartment had too many balls reduced to too small diameters by wear.

Systematic daily or weekly reloading of the first compartment can be performed by feeding in through the grinder's feed chute a certain number of large balls (an estimate of hourly operating consumption is to be made over a period of three months. From this, can be determined the number of balls 90mm in diameter to be added systematically each week, as a function of the number of hours of operation, in the first compartment).

- to regularly (1) determine (using the existing kWh and number of operating hours meters) average consumed power.

This is an excellent way of monitoring grinder efficiency.

c) Moisture in the grinder

At the time of our visit, the gypsum bin in the bay was empty. We hope it was filled before the rainy season, since major efficiency losses (due to clogging) can be the result of the moisture in the gypsum (or clinker).

For the same reason, it is desirable to very likely cover the bucket conveyor transporting the clinker due to the heavy summer rains (exposed length, approximately 20 m.).

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(1) These recommendations also apply to the raw material grinder, but it is necessary to observe that the raw material grinder normally consumes far fewer grinder elements than the cement grinder.

F - Shipments

All of the cement is shipped in 6-ply bags, no matter how much distance is to be covered and whatever the means of transportation used is, consisting of trucks followed by the railroad or trucks alone. Other, less expensive shipping methods (4-ply bags, bulk) are to be studied and probably adopted.

It would appear the scale is not kept calibrated sufficiently accurately. Since the scale indicating clinker tonnage produced by the kiln is inoperative, plant output and thus the output of various units is evaluated afterwards by the volume of cement shipped following the indispensable stock adjustments.

Thus, for this purpose, but also to avoid disputes, it is important to adhere to Nigerian laws, periodically calibrate the scale and regularly check the accuracy of the weight of shipments.

Systematic comparison of the weighing slips for fuel oil trucks, before and after unloading, with those of the plant delivering the fuel oil, should permit locating any possible variations in respect to an official scale on which these trucks might be weighed from time to time.

Without consulting, the contractor immediately undertook a conversion to the dry process of the equipment and at his own expense, whence the savings in the corresponding conversion which could only lead to operating difficulties.

Moreover, it would not appear that sufficient effort was made both in the choice of foreign staff and in the training of local personnel working at the plant.

Thus, given such conditions, it is not surprising the results obtained with the start of operations in the middle of 1967 were rather mediocre on the whole ; particularly mediocre as concerns quality, and the considerable shortage of cement during the past few years in Nigeria covered over this deficiency which was very dangerous for the future.

The results were also mediocre in terms of quantity, the planned dry process capacity of 125,000 t. never having been approached, since the average for the 4 years of operation was 53,500 t.

Such low output could only lead to major financial losses and, in specific, the inability to develop the funds for amortisation which would have made it possible to make the installment payments agreed on with the general contractor, payments which originally totaled £N 475,000 per year with interest. Even more, the CCNN's obligations to provide the 6 northern states with certain quotas burdened the company with extremely high transportation costs which could not be completely covered in the sale price thus leading to an additional operating deficit.

Thus, this led to a major hindrance for the 6 northern states which, in 1968, inherited the indebtedness and, in specific, the payment of the installments, since, in addition, the federal government which guaranteed the service subtracted the amount from the annual subsidies it normally awarded these states. Thus, the latter, worried about a situation they could see was hardly improving, became concerned about the plant's future and asked the UNIDO to engage in a complete examination of the undertaking in order to shed light on the policies to be adopted.

This examination was assigned to the Société d'Etudes pour le Développement Economique et Social (SEDES in Paris) which obtained the technical aid of the Société des Ciments Lafarge. This mission was carried out in Nigeria during April 1971 and was then analysed in France during the next three months. In particular, delivery of samples gathered on the spot caused a delay of several weeks.

II - EXAMINATION OF PRESENT CONDITIONS OF LABORATORY OPERATION AND RECOMMENDATIONS

A - Building and equipment

Laboratory operating conditions are poor :

- the building is in poor condition : very large cracks due to settling of terrain. It is not air conditioned.

- excessive vibration transmitted to the scales considerably alters the accuracy of weighing operations.

- the sand used for mechanical strength tests is not standardized sand. The substitute sand used must be subjected to at least 10 times as many tests as have been performed in the past before being used.

- the methods used for storing the prisms employed in strength testing are insufficient. The temperature of water used for storing the samples is unregulated and frequently exceeds 30° C, thus fictitiously increasing mechanical strength values (1).

Laboratory equipment must be modified. In specific, the following should be obtained :

- a damp cabinet for the storage of test prisms before immersion

- vessels kept at a constant temperature by a regulation making it possible to perform BSS standards tests under better conditions.

- a gas analysis unit of the Orsat type (the Hermann Moritz unit is more complicated) making it possible to ascertain that the kiln outlet fumes do not contain too much O_2 and thus that there is not too much excess air which increased heat consumption uselessly.

---

(1) Systematic experiments have demonstrated that, for concrete with a concentration of 300 kg/m3 mixed with a water/cement ratio of 0.66, the increase in mechanical strength when going from 18° C (normal storage temperature) to 30° C is on the order of 500 psi.

B - Chemical Analysis

Since the mechanical strength of a cement primarily depends on the CaO, it is this substance which will interest us first of all.

In general, the magnesia behaves as an inert substance, but in certain cases it can be dangeroue (cf. Chapter II - II/C) ; thus, it must be analysed separately.

The method used in Sokoto to analyse the raw material, a volumetric method, in reality first measures the total amount of carbonates in the material : calcium carbonate and magnesium carbonate. Then, by a separate analysis, the amount of $MgCO_3$ is obtained and the amount of $CaCO_3$ by a different method.

Normally, the laboratory only analyse s the amount of total carbonates ; we have never seen the $MgCO_3$ and $CaCO_3$ in raw materials analysed successively.

Moreover, in the laboratory records we found no analytic results for the $CaCO_3$ and $MgCO_3$ analyses of the same raw material.

Since the results of these ordinary analysee, performed by operators at continuous stations, were expressed solely in terms of calcium carbonate, the measured result for CaO exceeds the actual value, since the 2 to 3 percent of larger amount of magnesium carbonate was ignored.

In addition, this method does not make it possible to determine the amount of lime which might be present in the raw material in any form other than carbonates, such as silicates or phosphates.

In studying these various points, we took a seriee of samples which we had analysed by the three chemistry technicians in the laboratory responsible for continually monitoring the quality of the raw material. These samples were then analysed using the same method along with fluoroscopy at the central laboratory of CIMENTS LAFARGE at Viviers.

The results of these tests appear in the following table :

Sample	SOKOTO			LAFARGE		
	Operator 1	Operator 2	Operator 3	Volumetric Analysis	Fluoroscopy	
					CaO	MgO
114	77,50	77,50	77,75	79,10	44,95	1.15
112	77,75	77,25	77,75	-	44,95	1.10
100	74,75	75,00	74,75	75,80	43,10	1.25
105	74,50	73,75	73,00	74,90	42,90	1.25
109	72,50	72,50	72,00	73,90	42,00	1.20
117	77,25	77,50	77,25	79,00	44,65	1.20
116	77,25	77,50	77,50	79,10	44,75	1.20
108	77,50	77,75	77,75	79,00	44,55	1.15

We should note :

- that the dispersion between the various Sokoto operators is low

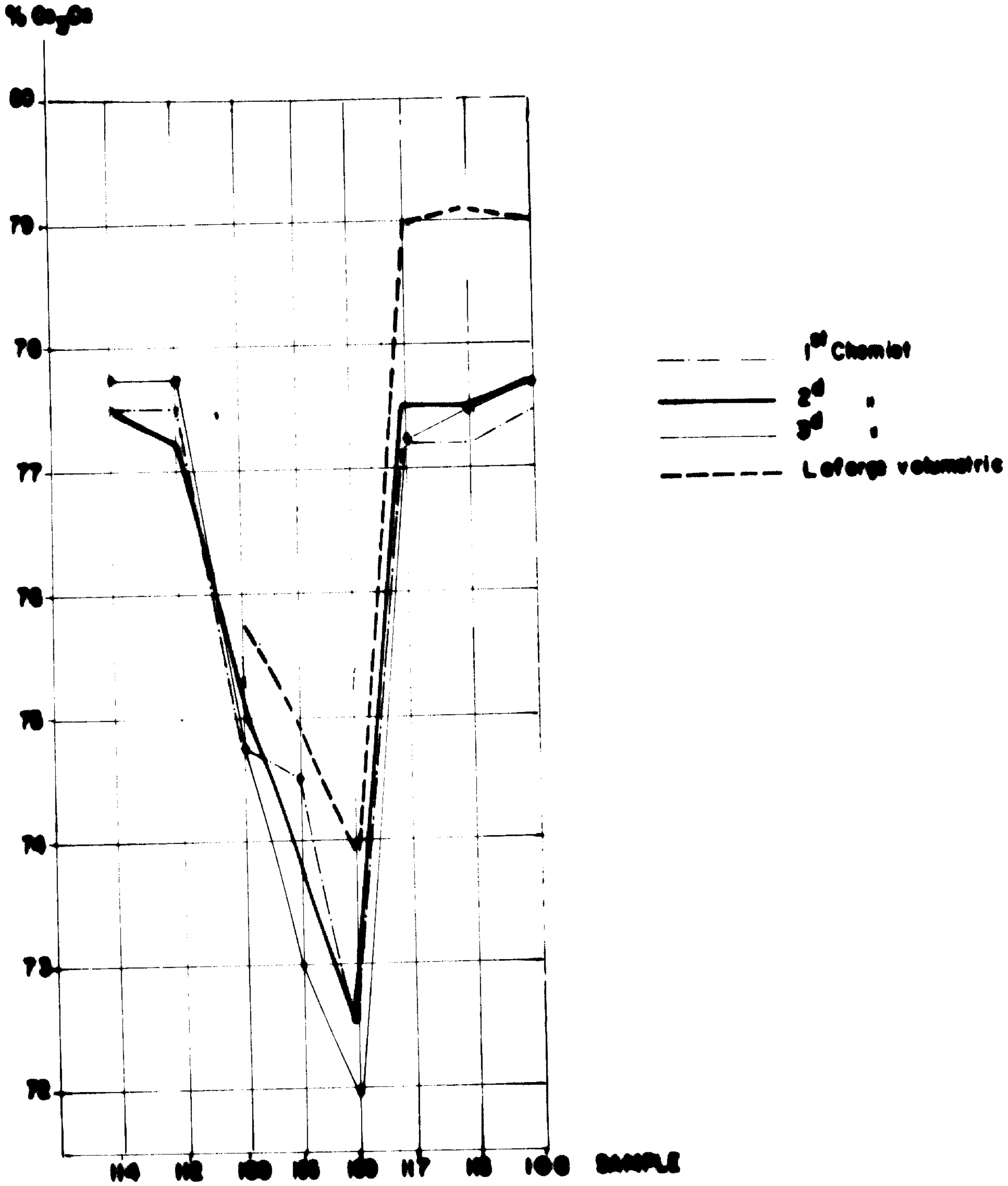
- that the results of the Lafarge volumetric analyses are higher than those obtained in Sokoto. The difference between the two varies between 1.05 and 1.75. This systematic error (1) may be the result of inadequate calibration at the Sokoto laboratory. The contradictory analysis of the same sample performed by several laboratories, would, in the future, make it possible to avoid such systematic errors or deviations.

The difference between the Lafarge volumetric and fluoroscopic analyses is due to the uncombined lime in the form of carbonate : this lime is combined in the form of silicates and phosphates.

It is on the order of 2 percent CaO or 3.5 per cent $CaCO_3$ if we refer to the fluoroscopy analyses carried out in obtaining Graph V and those performed on the 8 samples above.

(1) If they are constant, the systematic errors are much less of a nuisance for the manufacturing process than random deviations.

COMPARAISON BETWEEN SOKOTO AND LAFARGE ANALYSES



As for the entire deposit, the MgO content would be on the order of 1.4 percent or 2.3 percent $MgCO_3$. It can be seen the unanalyzed CaO of the raw material is more or less compensated for by the $MgCO_3$ (1).

The complete analyses are made by gravimetry using a method more than 40 years old. Too commonly, the analysis total is different from 100, thus demonstrating the analyses are erroneous (cf. the December 1970 table showing clinker analyses, Chapter II, II/B)

In conclusion, the laboratory must try to better determine the values of the raw material leaving the crusher and the raw material leaving the grinder. Thus, it is necessary to systematically perform the complete analysis of the raw material much more often than that of the cement (the latter is the consequence of the former).

In specific, for the same raw material it is necessary to frequently determine :

- the $CaCO_3$ and $MgCO_3$ contents
- the CaO content determined from the $CaCO_3$
- the MgO determined from the $MgCO_3$
- the total CaO content

and determine from this the procedure to be followed when only the $CaCO_3$ + $MgCO_3$ or $CaCO_3$ alone are known.

Only this method will make it possible to place in the kiln raw materials having a correct CaO content.

---

(1) In point of fact, the amount of $MgCO_3$ measured in the raw material leaving the grinder is less than the $MgCO_3$ leaving the crusher, since the $MgCO_3$ is partly decarbonated in the dryer where it is in contact with gas at 500° C.

C - Sampling

Proper sampling of the products is perhaps the most difficult problem to resolve in the manufacture of cement ; the Sokoto plant is not an exception to the rule.

Sampling at the crusher output is difficult to achieve due to the material's granulometry. It is necessary to sample several tens of kg. to determine the average analysis to a good approximation. This is rarely performed in Europe ; in Sokoto, they are very far from this.

The sampling system using several levels in the homogenization silos is not used. This is unfortunate.

Sampling of the clinker at the output of the kiln for purposes of operating it is made from the bucket conveyor. The response time, if a kiln operator's action is required, is too long.

Sampling at the cement grinder's output does not correctly represent the finished product, since the fines produced by dust removal from the ventilation circuit are sampled haphazardly , depending on whether the dust removal discharge occurs at the time the sample is taken.

Given the present status of the installation, it is simpler to agree to only sample the cement at the grinder's output, and for this purpose it is necessary to keep the dust removal valve closed while the cement sample is being taken.

Thus, samples of similar origin are compared (the systematic difference between the Blaine finenesses of the product sold to customers and that of the ground product sampled at the grinder's output is due to the sampling method).

Naturally, it is necessary to frequently check that the dust collected in the dust removal device is always of the same fineness.

In operating the cement grinder, it is preferable to determine the specific Blaine surfaces from these samples rather than from the rejects on a screen.

In point of fact, the specific Blaine surface better "integrates" the granulometric composition of the cement and its hydration potential than rejects on a screen.

Lastly, the plant normally prepares average samples from cement samples taken over a 24 hour period and studies them.

For the manufacturing process, it is necessary to use both average samples and instantaneous samples (in specific, in grinding the raw material).

On the other hand, in determining the quality of the finished product it is desirable to use instantaneous samples since, in the final analysis, customers work successively with "instantaneous samples"and not with average cements.

D - Quality checking

Effort to be made in those areas preceding the kiln will be highly worthwhile, since the quality of the raw material and its uniformity are essential factors in the manufacture of uniform, good-quality clinker and thus of good cement.

In other words, once the raw material (ready for the kiln) has been stored before reaching the kiln, it is difficult to repair measuring errors and effectively modify the characteristics of the cement which depends on its chemical composition (good burning is essential and the proper addition of gypsum is necessary, but the latter must be applied to good clinker produced using good raw materials).

Thus, it is necessary to concentrate most laboratory effort on the preparation of the raw material, even if this means fewer controls (if there is a lack of personnel) of the clinker or cement produced.

a) Raw mix quality

Given present conditions, the laboratory must produce the raw material of the highest possible concentration compatible with :

- quarry characteristics

- burning characteristics

Subsequently, as soon as the personnel has been trained, the plant must be operated at the lime saturation factor (1) which takes into account the various capacities of the siliceous, aluminous and ferric phases of the raw material for holding lime.

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(1) LSF = lime saturation factor

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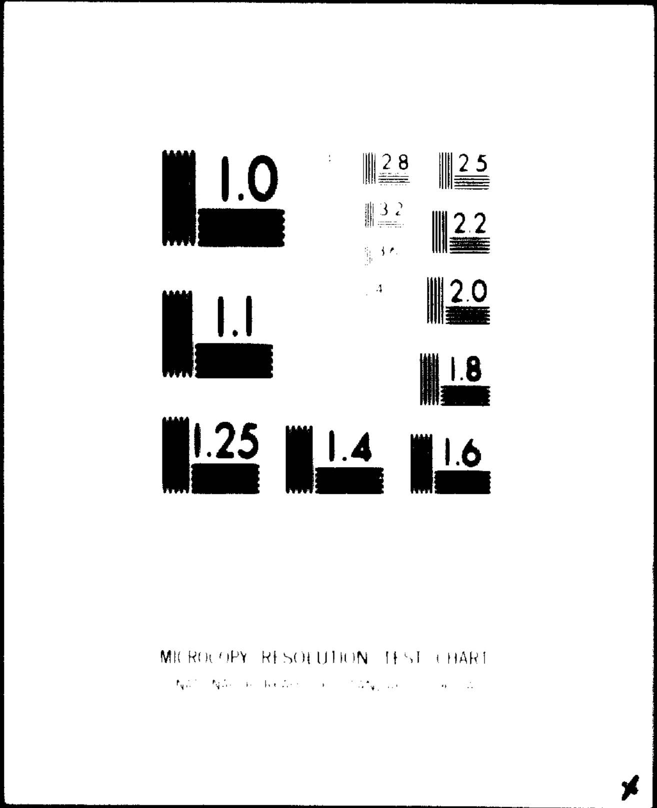

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IV - TECHNICAL COEFFICIENTS

Plant operation is irregular (long kiln stoppages, shorter cement grinder stoppages, but nevertheless of highly variable length depending on the month). This leads to highly irregular consumption of power, fuel oil and various consumable materials (balls and bricks).

Consequently, only averages for rather long periods of time are meaningful, especially since errors (inevitable when measuring the stocks) can completely falsify the results of a given month and cause maximum or minimum figures to appear which have not truly been obtained.

At the end of each paragraph we estimate those coefficients which should be obtained when the plant is best adjusted, when the renewed control and reorganization currently underway have borne their fruit, and, lastly, when the set of improvements mentioned earlier has been instituted.

CLINKER / RAW MATERIAL RATIO

The output of a kiln at a cement plant, not equipped with a scale to weigh manufactured clinker (1), is estimated :

- daily, by multiplying the amount of raw material consumed during the day by the clinker/raw material ratio (2)

- monthly using the same procedure, but also by calculations performed using actual (or so estimated) stock of clinker and cement as a base. The calculations make it possible to estimate changes in the clinker/raw material ratio.

In point of fact, this ratio combines :

- the ignition loss of the raw material (essentially CO_2 lost by the carbonates and removed in the fumes)

- all losses in the form of dust (kiln chimney, cooler chimney, various handling operations, and, possibly, leakage and so forth)

- all possible measuring errors and so forth

---

(1) The one installed in Sokoto is inoperative and would have given "satisfactory" results during a very short period of time. It would appear it was neither sufficiently reliable nor accurate.

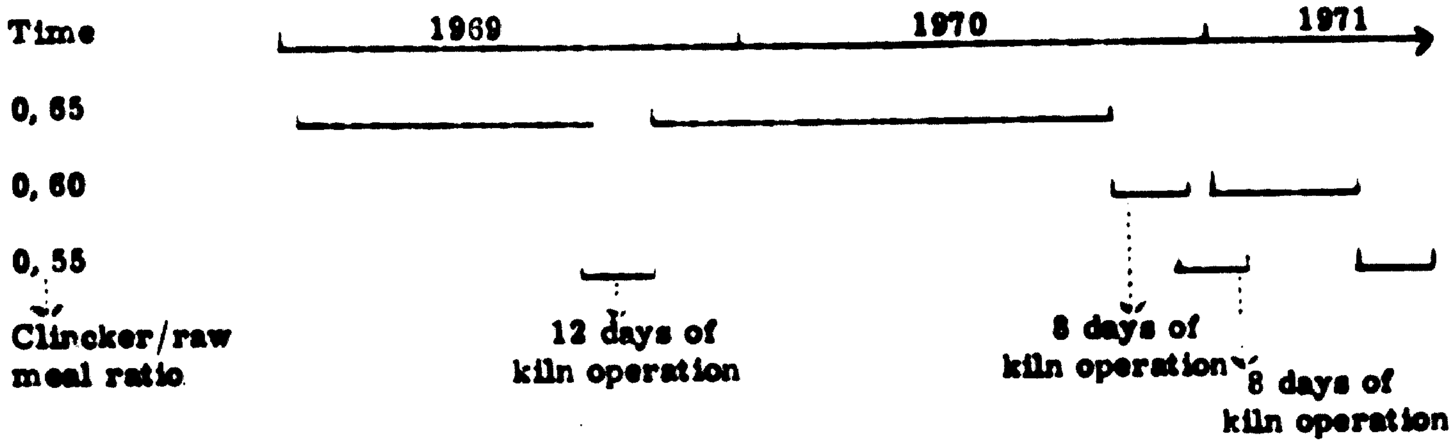
(2) See Chapter I-II, paragraph C.

We believe this training must be carried out using active methods :

Have the workers discover by simple experience :

- the operating principle of the major pieces of equipment that they

The ratio used in the calculations changed according to the diagram below :



Using a high clinker/raw material ratio it is easy to obtain erroneous outputs 10 to 15 percent high.

We believe that 0, 57 should be used in the calculations. This figure is the clinker/raw material ratio for a 10 month period :

$$\frac{\text{produced clinker}}{\text{raw material used}} = \frac{47,238 \text{ t}}{82,863} = 0.57$$

thus, there is a good chance of minimizing stock errors.

A - FUEL OIL

At the end of May 1967, during the acceptance tests which lasted three days, the announced heat consumption for a clinker/raw material ratio of 0, 65 was 1, 050 th/t. Operating records and documents for that period to which we had access did not allow us to confirm this conclusion.

In Marc 1971 we observed 1, 180 th/t.

During the last 10 months, the plant consumed :

- according to kiln meter readings : 5, 826, 000 l.

- according to stock and received shipments records (Mobil Oil bills, fuel oil at 40° C) : 3, 015, 000 l.

4/ - available space and copy equipment for documents, since the trained personnel will like to be able to refer to the documents they will have helped produce or have understood.

5/ - lastly, that the plant's executives express their interest :

(entries, in the books are not always coherent, but, on the whole, this figure agrees with Mobil Oil fuel oil bills paid without any terms of payment).

Estimates of temperatures, stocks and possible meter variations explain these differences.

We will use this last figure.

The lower heat value of this fuel oil is :

9, 814 mth/kg (cf. Appendix)
or 17, 665 BTU/lb

for a density of 0.950 at 40°C.

During the last 6 months, with the 0.57 clinker/raw material ratio the plant should have consumed 121 kg of fuel oil per t of clinker, giving a heat consumption of :

121 x 9, 814 = 1, 186 th/t.

In point of fact, due to possible irregularity in fuel oil consumption, it would appear prudent to use a slightly lower value for the effective heat value, for example 9, 600 to 9, 700 mth/kg.

We feel the well-known causes of excessive heat consumption at this plant are to be found :

- in poor consumption due to the temperature of the insufficiently heated fuel oil,
- in the poor recovery of heat in the cooler (secondary air temperature too low. In addition, unheated air is drawn in through the inspection hole located in the kiln operators'floor, an inspection hole which is very often left open).
- unquestionably in the excess amount of air in the fumes (the plant cannot measure the 0_2 content of the fumes, and the automatic Siemens unit never functioned).

We hope other Nigerian and neighboring cement plants (or other companies) will agree to the principle of such traineeships.

It must also be recognized that certain types of training, for example warehouse management, can also be provided at a company

- in uneven raw material quality creating irregularities in kiln operation,

- in the large number of kiln stoppages requiring many reheating operations.

Following the elimination or reduction of some of these causes, we feel this plant will consume 1,100 th/t.

B - ELECTRIC POWER

During the first 9 months of the fiscal year (June 1970 to February 1971) the plant :

consumed	6,160,000 kWh	
	(minimum November 70	379,000 kWh
	maximum December 70	1,006,000 kWh)
produced	42,700 t of clinker	
ground	40,500 t of cement	
shipped	40,500 t of cement	

corresponding to an average 148 kWh/t of cement.

At the present time, the distribution would appear to be as follows :

90 to 100 kWh/t of clinker

30 to 50 kWh/t for grinding and shipping of the cement.

Following proper adjustments, we feel it will consume approximately 110 to 120 kWh/t.

C - GYPSUM

Since estimates of gypsum stocks are not performed regularly, gypsum consumption can virtually only be determined by analysing (1) the products.

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(1) Account must be taken of the fact that a small portion of the SO_3 in the cement is provided by fuel oil sulfur.

II - MAINTENANCE

As concerns tools, it is unfortunate that each qualified maintenance worker does not have his own personal tools for which he is responsible.

Similarly, it is unfortunate the repair (machine, electrical and

With an average 1.8 to 2 percent SO_3 in the cement and gypsum with an SO_3 concentration of 28 to 30 percent, we feel the addition of gypsum is on the order of 6 to 7 percent.

It should be noted it is in the plant's interest to add to its cement the largest amount of gypsum compatible with good quality (since, in Sokoto, the gypsum costs a lot less than the clinker).

D - TORN BAGS

The number of torn bags is noted very carefully every day. It is possible to count on breakage of approximately 1 percent.

By perfecting the installation, it is unquestionably possible to obtain a figure of 0.5 percent for good-quality 6-ply bags.

E - PERSONNEL

In April 1971, the Sokoto plant staff (including Gusau, Kaduna and Maiduguri depots) totaled 247 people (cf. distribution, Chapter V, paragraph A).

Following reorganisation, we believe plant personnel will total 170. The reduction in the number of employees will affect all the departments, but, especially, the general services (offices, courtyard, gardeners, chauffeurs) and manufacturing services (including laboratory technicians on the production line). On the other hand, the number of personnel in the electrical maintenance division should be increased.

V - CEMENT PLANT PRODUCTION CAPACITY

A - ENVIRONMENT AND OUTSIDE CONDITIONS

Although weather conditions are favorable to the manufacture of cement during the dry season, on the other hand during the wet season rainfall and extremely violent storms considerably disrupt the manufacturing process :

- by the dampness in the raw materials used,
- by the shortage of electric power,
- by the flooding of certain pits,

Moreover, many weaknesses in the supply of electric power to the plant cannot be compensated for by the plant's power generators which are not strong enough to operate the kiln-dryer line (the same is true for most cement plants, but, on the contrary, the supply of electric power is more reliable even during very stormy periods).

The Sokoto plant is located far from a major industrial center ; consequently, major breakdowns last longer due to the inability of the plant's maintenance service to call on competent companies or obtain the necessary supplies. Thus, the maintenance service is frequently forced to use makeshift solutions (cf. dryer roller, fuel oil heating).

B - IMPROVEMENTS TO BE MADE

From the production point of view (1), we feel it is urgent :

- to use the correction material hopper by filling it with limestone having the highest possible concentration of $CaCO_3$ to more easily obtain the desired grinder output concentration,
- install an automatic sampler at the output of the raw material grinder to better analyze the average raw material entering the homogenization tanks,
- to properly operate the homogenization proccess (check its proper operation by sample taps located on each tank) after overhauling the entire installation as well as the motors driving the air distribution valves.

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(1) We will examine the other aspects, including management and administration, below.

- to operate the manufacturing process with hour-by-hour calculations of the assumed $CaCO_3$ concentration in the tank being filled and by correcting for possible limestone shortages,

- to return to service inoperative measuring equipment, warning signals and safety systems,

- to improve clinker quenching (by an increase in the volume of air blown over the first cooler chamber, possibly to the detriment of the volume blown over the second chamber),

- to adjust the openings and the charge of the cement grinder as soon as uniform clinker is produced,

- to standardize the plant's laboratory for better quality control,

- to reexamine the problem of replacement parts in light of past experience,

- and to begin a large-scale training operation.

C - PRODUCTION CAPACITY

Those units we feel constitute the bottlenecks are :

- the hots gas fan,
- the homogenization system,
- the quenching cooler cooling fan,
- and the bucket conveyor.

However, we feel the entire plant (including the cement grinder), is well blanced and subsidiary plant equipment all has good enough characteristics for proper operation of the facility.

In Sokoto, due to :

- technological difficulties in operation of the homogenization process and, consequently, of the entire manufacturing process,

- increasing wear of equipment (1) and damage to some machines subjected to makeshift repairs,

- bad weather conditions during the rainy season,

- and industrial isolation (difficulties in obtaining local repairs), we believe that, if all the personnel were European, this plant could only produce 90 per cent of its normal capacity in Europe.

For another few years we feel it is still necessary to add an additional 10 percent reduction to take into account the shortage of qualified staff personnel fully familiar with the plant as well as the inadequate training of the workers.

D - CONCLUSION

In Europe, following a few improvements (especially homogenization) this cement plant would be capable of producing at least 110,000 t of clinker (2) or more than 115,000 t of cement.

In Sokoto, in view of current local conditions, we believe this plant could produce approximately 90,000 t of clinker or 95,000 t of cement.

Should efforts at organising production (in specific as concerns raw material quality) already undertaken by the present general manager continue :

- if plant maintenance can be organised within a short period of time and, as such, preventive maintenance substituted for incident-by-incident repairs,

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(1) There have been few failures in electrical equipment until the present time, but the situation is worsening.

(2) 330 t/daily for 11 months.

- if personnel training can be expanded, which means the hiring of a sufficient number of competent staff.

this plant could approach 100,000 t clinker annually, and we believe the minimum time required to reach this output level will be on the order of 2 to 3 years if the above conditions are met.

CHAPTER V

PERSONNEL AND MANAGEMENT

I - PERSONNEL

A - Present conditions

Changes in the number of worker and employed personnel (leaving out staff and foreigners) have been as follows :

	1968		1969			1970		1971
Month	6	12	1	6	12	1	5	4
Number	258	282	287	251	264	245	251	214

It is presently distributed as indicated in the attached table.

The turnover in staff personnel has been very high. Briefly, there were 5 different technical directors over a 5-year period.

Almost the same has been true for the other staff positions, and it would have been virtually impossible to redraw the company's past personnel structures if we had wanted to due to :

- a lack of sources of information

- somewhat unclear organization, with functions and responsibilities poorly defined with functions overlapping each other.

Certainly, whenever necessary, the company structure must be adapted to present staff personnel, but it is the goal of the general management to organize the plant along conventional lines.

To use this criterion, it will be desirable to introduce to the laboratory new methods of analyzing raw materials, much faster than the methods presently used, including analyses by complexometry and colorimetry (analytic methods using fluoroscopy which are very rapid, have now been perfected but require the use of equipment which is still very expensive).

b) Clinker quality

It must be verified that clinker density is indeed a parameter characteristic of burning (at many plants we observed that clinker density could not be considered to be a characteristic parameter of burning and that we had to use the free CaO criterion. This led to regularly determining the amount of free CaO in the clinker by the kiln operator or a laboratory technician) and, for this purpose, statistically study the correlation between free CaO and clinker density.

c) Gypsum quality

It will also be necessary to examine the uniformity and quality of the gypsum by studying a large number of samples taken at the grinder's input to determine the risks involved in the addition of too much or too little gypsum.

Moreover, the number of trials required to determine the time required for the cement to set can be considerably reduced (this is a lengthy, imprecise determination to which is to be preferred determination of the SO_3 percentage).

If this determination is to be continued, the operator can be satisfied with seeing whether or not setting is rapid.

In the future, the study of the optimum amount of gypsum will make it possible to take the best advantage of clinker characteristics.

NUMBER OF EMPLOYEES AS OF APRIL 1971

	Total	Type of Employees		
		Grade 1	Grade 2	Grade 3
PLANT				
- Quarry	12	3	6	3
- Manufacturing posts	41	7	22	12
- Shipping	13		3	10
- Laboratory	20	8	6	6
- Courtyard ... guards	34	1	7	26
- Chauffeurs	32	1	22	9
- Truck maintenance	18	8	9	1
- Machine maintenance	20	6	10	4
- Electrical maintenance	6	2	3	1
- Office	18		2	16
TOTAL	214	36	90	88
WAREHOUSES				
- GUSAU	15			
- MAIDUGURI	3			
- KADUNA	3			
TOTAL	21			
STAFF				
TOTAL	12			
ALTOGETHER : 247				

The general manager, who receives his instructions from the board of directors, is to have under his orders :

- a production manager responsible for the entire manufacturing process including the quarry and laboratory,

- a maintenance engineer

- an individual in charge of the administrative and financial services,

- a sales manager to be responsible for organizing sales and administering possible deposits.

It would seem the plant suffered badly in the recent past :

- from the disagreements among the foreign personnel. A large number of laboratory documents, with or without any value, is said to have been destroyed by the chief chemist when he was fired.

- from the excessively fast turnover in staff personnel. One of the effects of this turnover is a lack of knowledge of the documents supplied by the various constructors with the equipment.

Sometimes there are mistakes in these documents, and a few revisions have not been made. However, on the whole they are well put together, and the user should be fully familiar with them, although this is hardly the case.

A very large share of the plant's personnel can neither read nor write. Consequently, the professional qualifications of both electrical and machine maintenance personnel leaves a great deal to be desired.

Laboratory personnel are more apt to properly perform their work (unfortunately, as we have seen, their working conditions are very poor).

B - Recommendations

The goal to be attained is plant operation and the manufacture of good quality cement with the smallest possible number of personnel and especially foreign personnel. However, and this is a national duty, it is also necessary to raise the general level of the personnel's knowledge.

Thus, we are proposing the following action :

1/ - INVENTORY OF PERSONNEL AND CLASSIFICATIONS as a function of schooling but also as a function of the understanding of phenomena which determine the plant's operation for :

- the organization of classes

- possibly better adaptation of the men to their jobs by transfers between divisions.

2/ - INCREASE IN GENERAL KNOWLEDGE

The organization of school-type courses after working hours will permit :

- teaching all those desiring it to read and write

- raising the average level of those who already have some education.

Attendance at these classes will be facilitated if there exist :

- financial encouragement (remuneration or attendance bonus, prize for good results),

- or a discouragement, whoever does not know how to read will be dropped from the plant.

It is desirable that these classes be shared with other companies and that they be run by men from the teaching profession.

3/ - TRAINING OF MANUFACTURING PERSONNEL

For this training, it is desirable :

- to create a fourth team (below called D if the three teams which work normally are called A, B and C),

- to have two men on each team having the qualifications of manufacturing foreman.

We propose the following diagram to organise the presence of personnel :

HOURS		6 7 8 9 11 12 13 14 15	16 17 18 19 20 21 22
The kiln operator's job, for example, is to be held by a team member	during normal time	A	B
	during training period	A D A	D B
When team's kiln operator is being trained		A	B

Thus, the work schedule of team D, called the replacement team, is on a daily basis. Each team, A, B, and C is to receive two weeks of training out of every three.

However, it also may be desirable if some of the workers from a team remain on the job for their 8 hours to provide uninterrupted work. Only then will a part of teams A, B and C be receiving training. Either the best or those most likely to advance most quickly are to be chosen.

We believe this training must be carried out using active methods :

Have the workers discover by simple experience :

- the operating principle of the major pieces of equipment that they use,

- the sense and raison d'être of the measuring units allowing them to better operate the equipment.

At the same time, it is necessary to develop analytic thinking. Advantage of this can be taken to :

- have the best workers or foremen draft "guide jobs" using for this purpose the notions and information concerning setting up, use and maintenance operations supplied by the constructor,

- put together the corresponding technical reports.

This means :

1/ - that personnel, at least one engineer and one advisor (1), be hired for this purpose, personnel whose sole responsibility will be training. Otherwise, this personnel will too often be assigned to tasks of immediate interest.

2/ - that this personnel have :

- easy contact with the others

- an excellent pedagogical sense

- a taste for education

3/ - that this personnel reach an agreement beforehand with the members of the staff in order that there be no misunderstandings concerning the teaching.

---

(1) Perhaps also an instructor. It is in the plant's interest that the following basic training :

- in reading and writing
- in plant knowledge

be acquired rapidly in order that the employees not lose their interest. For this training, qualified individuals on mission and assigned to the Sokoto ministries can be used.

4/ - available space and copy equipment for documents, since the trained personnel will like to be able to refer to the documents they will have helped produce or have understood.

5/ - lastly, that the plant's executives express their interest :

- in the training program

- in raising the level of the knowledge of the personnel.

4/ - HIRING

Among others, hiring must be aimed at rapidly raising the qualifications of plant personnel and favoring the training of existing personnel.

Thus, as soon as possible, it is necessary :

- to increase the number of Nigerian engineers on the staff,

- in Nigerian industrial cities to hire already trained electricians and mechanics or hire young men who have recently graduated from schools in Zaria and Sokoto.

- to interest young people attending the Sokoto schools in the plant (1) and hire a few young men having the necessary basic knowledge but who have demonstrated their aptitude for leadership (for example in the army) in order :

- to increase the number of competent plant personnel

- and, to facilitate the training of the others

The best, if they recognize they are not being used sufficiently, will leave the plant to the plant to the nation's greatest benefit.

5/ - TRAINEESHIPS

While waiting for the personnel to be placed in charge of the training program to be recruited, efforts can be made to increase the knowledge of the Nigerian staff members by appropriate traineeships.

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(1) Traineeships during school vacations. These young men are to be followed and guided by the personnel in charge of training who will thus be able to make a selection for future huring.

We hope other Nigerian and neighboring cement plants (or other companies) will agree to the principle of such traineeships.

It must also be recognized that certain types of training, for example warehouse management, can also be provided at a company other than a cement works.

It can be noted that scholarships are sometimes awarded by the French government as part of the aid program to Black African nations. First of all, if necessary, these scholarships include an audio-visual traineeship making it possible to learn French.

6/ - FOREIGNERS

It would be desirable to agree to the necessity for :

1) - longer contracts than the 18-month contracts (including three months of vacation) presently in effect.

2) - adapting the mode of remuneration to the new Nigerian laws concerning the transfers of capital abroad but also permitting :

- the hiring of truly qualified personnel concerned with handing over their knowledge to the Nigerian personnel,
- and making the stay in Sokoto both desirable and lasting.

II - MAINTENANCE

As concerns tools, it is unfortunate that each qualified maintenance worker does not have his own personal tools for which he is responsible.

Similarly, it is unfortunate the repair (machine, electrical and garage) shop is lacking in some equipment (for example a milling machine). However, when this shop is compared with the corresponding shop at the ECN power plant in Sokoto, it is superbly equipped (moreover, the cement works often helps out the power plant).

Above all, however, the maintenance division (machines, electrical and garage) is lacking in qualified personnel, both staff and workers. Thus, as soon as possible, they must be recruited from Nigerian technical schools.

The presence of qualified workers will facilitate the implementation of a preventive program. This maintenance technique, which requires systematic inspections by an excellent maintenance worker, is indispensable if the maintenance division is not to be inundated by unforeseen breakdowns preventing any form of organization.

It should be noted the Ferrostahl Company has supplied the CCNN with lists of operations to be systematically performed and with the desired frequency of repairs. These lists are very useful, but the work described is difficult to perform if no qualified foremen are available.

This applies both to the machine and electrical maintenance division, and for the latter, it is necessary to hire at least two electricians responsible for maintaining electrical or monitoring equipment in good condition but also training their fellow workers in the repair of the measurement devices used in operating the cement plant.

In point of fact, the proper functioning of the plant is highly dependent on the proper functioning of temperature, pressure, speed and other indicators at the installation's various strategic points.

Finally, it will be very difficult to make the personnel "maintenance minded" if the plant does not have a group of competent individuals in the various maintenance divisions.

The maintenance division is highly dependent on the stock of replacement parts available at the plant. Thus, it is necessary to set up effective supervision of items entering and leaving the warehouse as well as of the residual stock.

Being out of stock of certain items is especially undesirable since the plant is located a long way from industrial centers.

Administration of the warehouse in terms of quantity and value is naturally very desirable, but at the outset administration in terms of quantities can be settled for.

Of course, in this instance the book value of warehouse stock will not be better known than is presently the case. It will be necessary to continue to enter as expenditures the spare parts or warehouse supplies as soon as they reach the plant.

Subsequently and as soon as possible, heavy or expensive parts or those easily referenced (for example bricks, balls, fan turbines, kiln rollers and so forth) will be administered in terms of value. Gradually, administrative records will be kept of other parts of less importance.

As concerns orders, it is unfortunate major orders (balls, bricks) are handled via the intermediary of Ferrostahl.

Lastly, the plant must be organised in order that specific replacement parts may gradually be ordered also directly from the supplier (Buttnerwerke, Siemens, Peters and so forth).

Special attention must be given to inspection by the receiving department and to the storage of replacement parts. (1)

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(1) In specific, attention to the dolomite bricks for the burning zone. These bricks are very difficult to store. The containers must be received sealed and kept sealed.

III - BOOKKEEPING

The examination of all annual plant spending clearly indicates that fuel and power spending are very large factors in the cost of the cement and that it is desirable to take action concerning these two elements.

Thus, it is not necessary to set up highly detailed budgetary administration. However, we feel it would be desirable to plan for the future and thus organize plant bookkeeping to know the orders of size of the operating costs of the major shops among which must basically be distributed :

- labor
- power
- fuel
- and spending for replacement parts

Distribution of the amount of electric power used is possible by means of the 8 individual meters installed in each of the main shops. Readings are taken daily, but it would not seem they are used in a systematic manner.

The estimate of stocks (clinker, gypsum and cement) should be made monthly (by 2 or 3 individuals independently) to better determine their influence on costs and better évaluate equipment production.

IV - ORGANIZATION

The staff of Nigerian engineers should be expanded. As part of the responsibilities they are assigned, they must see to :

- the maintenance of discipline
- the updating of documents concerning the plant, for example :
  - manufacturing files
  - the results of tests carried out
  - the condition of replacement parts and so forth
- finally the maintenance of continuity in the organization.

d) Cement quality

A major effort is to be made at ascertaining that the quality of the cement indeed corresponds to BSS standards.

In specific :

- the storage conditions for the test cubes must be improved
- more extensive comparative tests must be performed on the sand replacing the standardized sand.

Moreover, it will be necessary to ascertain that the undesirable effects of the magnesia are not of any worry (tests in a laboratory equipped with an autoclave) or, what would be even better, that the clinker quenching is sufficient.

E - Attending to manufacturing and checking

For a cement plant it is essential to monitor changes in the characteristics of the raw materials, clinker and cement manufactured. Thus, it is necessary to use the same equipment or be familiar with the calibration of one in respect to the other if equipment is changed.

For example, several screens of different mesh sizes have been used at various times to measure the "90µ rejection" without any accurate knowledge of the dates or changes which took place and the characteristics of the corresponding screens. Thus, given these conditions, it is difficult to compare the various obtained results (1).

Production line volume and finished product quality are basically a function of the uniformity of the products being processed.

Efforts are to be made, thus, to standardize the entire process starting with the initial link, a uniform raw material, and samples are to be kept representative of the raw materials, clinker and cement for possible subsequent comparisons. In specific, a check is to be made of clinker hardness, for example, once a week, by determining the Blaine fineness obtained for a certain number of revolutions of the laboratory grinder (it is advised to make one grinding operation with a certain number of revolutions), the rejects corresponding to the N° 900 screen are to be measured and one other grinding operation is to be performed at a higher speed of revolution to determine the Blaine fineness obtained.

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(1) If desired, the screens used to operate the grinders may be screens made in Sokoto, thus less accurate than standardized screens, provided it is regularly checked (intervals to be chosen by the laboratory head) that the correspondence between the standardized screen and screen employed does not vary.

As concerns labor relations, we feel that contact between division heads could be organized in a more systematic manner (it is true that when we visited the plant the number of foreign personnel had been reduced to two individuals).

We feel this number is insufficient (and the plant director shares our point of view), and more systematic briefings should be organised to reduce the response time when the plant's staff has been increased in number.

CHAPTER VI

COST-BENEFIT ANALYSIS

As already stated, this study is to be carried out for a market situation and profitability which are considered to be normal, that is after the correction of the observed defects, while maintaining a margin of security in the form of "contingencies and miscellaneous". This means that the figures used and thus the profitability situation will be attained only after at least two years, that is around 1973-1974.

Since there is no analytical accounting method used at the factory, it has not been possible to evaluate the cost of each distinctive operation, such as: raw materials (from quarry) - clinker - cement- maintenance - administration - capital charges. Thus the expenditures taken into consideration are such as those of overall salaries, fuel, electricity, packing, etc. As already stated, the depot or warehouse expenditures have not been taken into consideration for the present estimation details with the cost ex-factory. On the other hand, the Sales Manager, considered as indispensable for marketing of the product has been included in the calculations .

The expenditures have been divided into two types:
- Variable expenses
- Fixed expenses

I - VARIABLE EXPENSES

These are expenses or costs which are directly connected to the quantity produced. In the present chapter will be considered: the quarry costs; since they are especially comprised of personnel costs, cost of equipment or of the land, they can be incorporated in the fixed costs or expenses.

The variable expenses involve fuel, electric power, packing and miscellaneous items.

A - Fuel

Fuel is delivered to Gusau by the marketer at 21.2 d a gallon and has a density of 0.95. One metric ton thus costs £ 20.5. To this must be added the cost of transport from Gusau to the factory. The fuel is currently transported by means of large tank trucks owned by the Kadara Associated Traction, a fully owned branch of NNDC. From December 7, 1970 to February 18,1971 the tank trucks made 22 trips carrying 63 000 gallons of fuel for a total cost of £ 664/9/1, thus 2.54 d a gallon or Nigeria £ 2.47/ton.

...

By taking into account some loss during storage and handling, it can be estimated one ton costs £ 23.4 which can be considered as taking into account as well an extra amount due to the filling of the kiln with gas oil when in operation (gas oil being worth twice that of fuel) provided that the stops are not very frequent.

Since the net heat value is 17 000 btu, or 9 600 "thermies"/t and with the technical coefficient adopted being 1 100 "thermies"/t, the cost turns out to be :

$$\frac{23,4 \times 1\ 100}{9\ 600} = £\ 2,68/\text{ton}$$

The international price of fuel is currently rising and thus it is quite probable that this figure will become higher in the near future. However, this rise will affect all cement factories in the world and will certainly have an influence on the price of cement.

B - Electric power

At present, the average consumption of electric power is 137 KWh/t. The technical coefficient adopted is 110 (it should be 95 - 100 for such a cement factory in Europe).

In view of the fact that cost rates decrease with the quantity consumed (see Appendix II provinding the rates per bracket), it is necessary to provide several estimates depending on the production volume.

Moreover, the subscription involves a large fixed sum of £ 2 200 per month since the subscribed power is 2 200 KVA - the incidence of which, it is felt, is too high and will of course vary inversely with the production. The comment of the foregoing paragraph will be used to integrate the fixed cost, since it represents about one-third of the total, with the variable costs - that is a sum of £ 26 400 a year.

The variable rates on the basis of the KWh are as follows :

For	5000 KWh	20 000 d
	the next 5000 KWh (up to 10 000)	17 500
	the next 40 000 KWh (from 10 000 to 50 000)	120 000
	the next 100 000 KWh (from 50 000 to 150 000)	250 000
		407 500 d (£ 1 697,9)

Thus $\frac{407\ 500}{150\ 000} = 2,717$ d/KWh

Above 150 000 KWh and up to 1 000 000 = 2 d

The following table is thus obtained :

...

Production /year	KWh/month	Consumption up to 150 000 KWh in d	Extra cost beyond this level, in d	Total d/month	£ for t/year	Fixed charge in £/t	Total £/t	Cost of KWh in d including fixed charge
40 000 t	366 700	407 500	433 400	840 900	1,05	0,66	1,71	3,68
50 000	458 300	407 500	616 600	1 024 100	1,024	0,528	1,552	3,39
60 000	550 000	407 500	800 000	1 207 500	1,006	0,44	1,446	3,16
70 000	643 300	407 500	986 600	1 394 100	0,996	0,377	1,373	2,99
80 000	733 300	407 500	1 166 600	1 574 100	0,983	0,33	1,313	2,87
90 000	825 000	407 500	1 350 000	1 757 500	0,976	0,293	1,269	2,77
100 000	916 700	407 500	1 533 400	1 940 900	0,97	0,264	1,234	2,69

Cost per ton with 2 % discount : (the transport line being operated on 33 KV and although the meter is on 11 KV, CCNN should try to obtain from the ECN a discount of 3 %).

40 000 t :	1,675 £
50 000	1,521
60 000	1,417
70 000	1,345
80 000	1,287
90 000	1,244
100 000	1,209

Comment

Fuel and electricity comprise the power purchased from outside sources ; these items represent in the improved operations 2.70 + 1.4 = 4.1 £ of the selling price of 13.5, thus 30 % and by applying 10 % for contingencies, we obtain 33 % ; in the present operations they represent 42.5 %.

C - Packing

At the present, all the production is sold in 6-ply paper bags manufactured by the Paper Sack Ijora of Lagos. Thus, as outlined in the Chapter on Marketing, 80% of the production delivered to the North Western state (i.e. theregion of Sokoto) could be packed in 4-ply bags. From the standpoint of a new market distribution, the 50 000 to 60 000 tons required for the North Western state (of which 40 000 to 50 000 for Sokoto) could be supplied by CCNN. This means that as of now half of the production could be packed in less costly bags and this is precisely the hypothesis which will be adopted for the present evaluation - by taking the cost of the sack as being the average of the two prices.

The 6-ply bag was worth up until February 1, 1971 £ 38.25 per thousand ex Lagos. An excise duty (10 + 5)% is to be added; this price has risen to £ 40.75. By adding the rail transport cost to Gusau (£ 9/ton), the dividing into consignments and road transport from Gusau to Sokoto (£ 2.5 / ton) a figure of about £ 51.2 per thousand bags is obtained and taking into account a 1% loss due to tearing, the approximate price is thus £ 51.7 per ton of cement (20 bags): £ 1,034.

The quotation for 4-ply bags from the same source was not known in Sokoto. It is assumed that the relation between the types of bags is same as in Europe:

Type of bag	Weight of bag, gr.	- Relative price
3-ply (1)	185	56
4-ply	245	70
6-ply	375	100

On the basis of the same ratios, the 4-ply bag would thus be sold at £ 28.52 per 1000, thus delivered, including freight:

£ 35.4 per 1000 bags
thus with losses £ 0.72 per ton of cement.

According to the analysis of the market situation it can be assumed that at least half of the deliveries could be packed in 4-ply sacks, thus at an average packing price of £ 0, 875 per ton and a slight decrease with the quantity produced since it will be sold mostly on the local market.

...

(1) The 3-ply bag is widely used in Europe for short distances ; it has not been kept for Sokoto.

D - Gypsum

The average consumption of gypsum is 5 % of the weight of clinker. The price currently paid for collected gypsum is £ 10/t delivered to the factory. This appears to be high. In fact, at Malbaza for a collecting distance which is hardly greater and with salaries and transport costs being higher, the cost is £ 4.5. It is thought that the Sokoto price is due mostly to inadequate organization, and the price taken into consideration will be that of Malbaza plus the transporting to Sokoto (200 km) which results in a price of £ 7.5 /t, this price moreover comes within the factors subject to increase for contingencies.

The price of gypsum per ton of cement is as follows :

$$\frac{5 \times 7,5}{100} = 0,375.$$

E - Consumer products

There is first of the gas-oil used by quarry equipment which can be estimated at 35 000 gallons/year for 80 000 t of cement, i.e. at a price of 45 d/gallon for delivered gas-oil, this amounts to a cost expenditure of £ 6 500.

To this must be added on the one hand the ingredients (oils, grease, cleaning cloth) estimated at about £ 2 000 and general accessories (tubes, sheet metal, iron sections, electrodes, hand tools) for about £ 8 500.

The total variable expenditure to be taken into account is $\frac{17\ 000}{80\ 000}$ = £ 0.212. Excluded from this figure are the consumption figures for lorries and personal cars.

F - Excise tax

This tax levied directly at the factory for each delivery on the account of the Federal Budget amounts to 20 sh/t of £ 1/ton. It is subject to the temporary extra tax of 5 %, thus £ 1.05/ ton.

G - Mineral royalty

It is based on a rate of 6 d/ton of raw material, thus more or less a lump sum of £ 0.04/ ton of cement.

...

II - FIXED EXPENDITURES

Personnel costs

This is one of the most difficult aspects of the new organization. In fact, it has been previously indicated that the factory was currently suffering from :

- too many workers, in particular in the laboratory and offices, at the kiln and for driving of vehicules
- a lack of technical executive staff.

The reorganization should be carried out along the following lines and be based on the figures below :

A - Executive staff

The Nigerian staff should be comprised of 10 managers or department heads, namely, general manager, administrative and financial manager - and assistant - personnel manager - sales manager and a commercial assistant - head of quarry department - head of laboratory - an assistant head of production and an assistant head of maintenance.

The technical executive staff should call upon 5 expatriated experienced executives, namely,

- a technical manager, in charge of general organization and cost prices,
- a head of production.

These two men being cement specialists.

- a chief chemist, in charge of quality matters both for the orientation of quarry works and for factory controls.
- a mechanical maintenance chief
- an electrical maintenance chief
- a 6th executive in charge of setting up analytical accounting and the organization allowing for control of the cost price, would not necessarily have to be an expatriate ; his mission would be limited to one year. The cost of this executive has not been taken into account in the final total, for he would have to be convered by the interim costs for putting things in order.

The current salaries paid to expatriates in Sokoto do not appear to be high enough to allow to have personnel with the required competence and authority.

...

In fact, on the one hand salaries are constantly and rapidly increasing in all industrialized countries, and on the other hand, it is necessary to provide for the necessary social security and pension which are generally available in Europe and all the more so since the person involved must contribute to them with his own funds, since the CCNN does not offer these services ; it should at least take on the holiday pay.

To sum up the financial situation could be as follows :

a) Nigerian staff

one at £ 3 500/year	3 500	
three at £ 2 000/year	6 000	
three at £ 1 250/year	3 750	
three at £ 750/year	2 250	
	15 500	
+ benefits and gratuity	2 000	
		17 500

b) Expatriate staff (1)

one at £ 6 000	6 000	
two at £ 5 000	10 000	
two at £ 4 500	9 000	
	25 000	
+ extras (trips, gratuity, medical care, holidays)	7 500	
		32 500
		50 000

Although it may appear to be paradoxical for 5 people under the General Manager to be paid more than this manager, there are however quite legitimate reasons for this in view of the rarety of competent personnel and the large demand for such people in industrial countries.

...

(1) As far as expatriate staff is concerned, the salaries and benefits indicated herein are still lower than those offered by the new cement factory in North Cameroon (FIGUIL) which is currently recruting its executive staff.

The case is not exceptional in Africa and it is possible to pay part of the salary outside Nigeria. The difficulty of finding volunteers teers with experience for working outside their country indicates that although this higher price is at present practically an ineluctable condition. Or else, only candidates not accepted elsewhere, and thus unsatisfactory, will be available.

B - Workers

It has been seen that the labor force should be reduced to 170, not including those in warehouses on the basis of the following breakdown. The current rate has been slightly increased so as to take into account the rise in the cost of living.

	Monthly allowable rate (£)	Number	Monthly amount (£)
Grade III	12	68	820
Grade II	20	68	1 360
Grade I	31	36	1 120
		172	3 300
Increase of 15 % for overtime, transport allowance, medical care			500
			3 800
		Thus for a year	45 500

In total, the personnel item comes within the fixed costs for an amount of £ 95 500 which will also come within the amount submitted for contingencies.

C - Spare parts

This is a very important matter and no accurate estimate can be made on site, because of the initial stock and operating accidents of which some can be considered as being abnormal.

It has been deemed to be more rational to base oneself on European consumption figures and multiplying them by a high factor in relation with the severity of climatic conditions (heat, seasonal humidity), the limited experience of the executive staff, the less regular production operations, as well as to take into account the size effect of the factory in relation to European factories if the spare parts are dealt with in terms of the number of tons of cement produced.

...

This coefficient has been evaluated at between 30 and 60 % ; 40 % has been adopted for calculations.

Another important point is the difference in cost at the European factory and the cost at Sokoto. The analysis of several invoices revealed a markup of between 120 % (in the case of bricks) and 50 or 60 % (in the case of electric motors and mechanical parts).(1) In fact the FOB price includes the cost of special packing for shipping and marks up the price in Europe ; in addition one must take into account that in certain cases the products were sent by plane. For these reasons, the average markup of 100 % on European prices should be applied in Sokoto.

Our reference for normal estimating will be the consumption of all the French cement factories of the Société Lafarge (14 factories for 7 million tons in 1969). This consumption of spare parts was 4.50 F/ton or £ 0.35/ton. By applying the preceding factors, we thus obtain a forecast figure of 0.35 x 1.4 x 2 = £ 0.98. In order to determine the total annual expens, this unit consumption will be applied to the average production of 80 000, corresponding to an annual expenditure of £ 78,500.

In fact, we estimate that for 1 000 t or more the consumption will hardly be greater ; and that similarly it will be reduced only slightly for production volumes of 10 000 to 20 000 tons less. If the consumption of balls for sockets is in fact decreased, weardown due to more interrupted operations and the eg effects of thermal shocks and expansion in the kiln, the cooler and dryer cause premature wear down.

The sum provided for the spare parts will also be taken into account under contingencies. This markup will also cover certain exterior repairs which may be required during the year.

D - Overheads

This tiem covers :

- work insurance covering personnel
- stock insurance (petroleum products, bags, warehouse, supplies)
- equipment insurance (building, cars)

...

(1) As an example, the following is an approximate estimate for a 92 t consignment of bricks from Germany :

CIF price	£	4 350
Shipping		1 300
Duty		2 150 (rate 33 % + 5 %)
Transport		1 700
	£	9 500

Thus, $\frac{9\ 500 - 4\ 350}{4\ 350}$ = 119 % markup on price in Europe.

The best equipment and finest personnel, however, do not protect a laboratory from unsuspected deviations. To avoid them, or at the very least detect and correct them, it is necessary to perform frequent calibrations. For this purpose, it is necessary :

- to compare the results obtained in Sokoto with the raw materials, clinker or cement with the results obtained on the same materials by other laboratories, cement plants, official Nigerian laboratories or other nations.

- test in Sokoto those cements considered to be standards

- test the cement test press using crushers

- lastly, using standard cements, test the sand used for the mechanical strength tests (large lots of this sand are to be prepared in order that the cost of checking its quality may be acceptable).

  In specific, it will be necessary to ascertain that this sand contains no impurities capable of speeding up or slowly down the cement setting process.

As concerns production volume, ignition loss is to be determined most frequently (1) in the laboratory, and it will be compared with that resulting from stock calculations to compare, on a month-to-month basis, changes in the clinker - raw material ratio with changes in measured ignition loss.

Lastly, it is highly desirable that the laboratory be rebuilt as the plant managers have been planning, and that it be equipped with airconditioning.

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(1) In the laboratory we only found two values for raw material ignition loss.

- administrative expenses (paper, PTT, approvals, business trips)
- accomodation expenses for executive staff (maintenance, water, electricity, gardening, keeper)
- gasoline consumption of vehicles assigned to personnel about 15 000 gallons/year
- legal services and Board of Directors costs. (audit..)

Without going into the details of this item, it is estimated that the forecast provided by the CCNN, namely (administrative personnel and medical costs accounted for elsewhere will be excluded) £ 45 500, is too high and a serious effort should be made to bring it down to £ 25 000 including contingencies. It may be possible to make certain savings (insurance, participation of personnel involved in accomodation costs, gasoline consumption).

E - Working capital fund

Although working capital funds are, to a certain extent variable with the production output, they should be considered as fixed costs within the limits of the production anticipated.

These funds should cover direct production costs during about three months. With these direct costs being about £ 11/ton, a fund of £ 250 000 is required for an annual production of 90 000 tons.

The corresponding capital will be assumed to be borrowed from regional banks at an interest rate of 8 %. Thus the annual cost of £ 20 000 will be adopted and taken into account under contingencies.

III - COSTS AND DEPRECIATION

By applying the data just given to cement plant output of between 40,000 and 100,000 t. we obtain the following table for per ton costs.

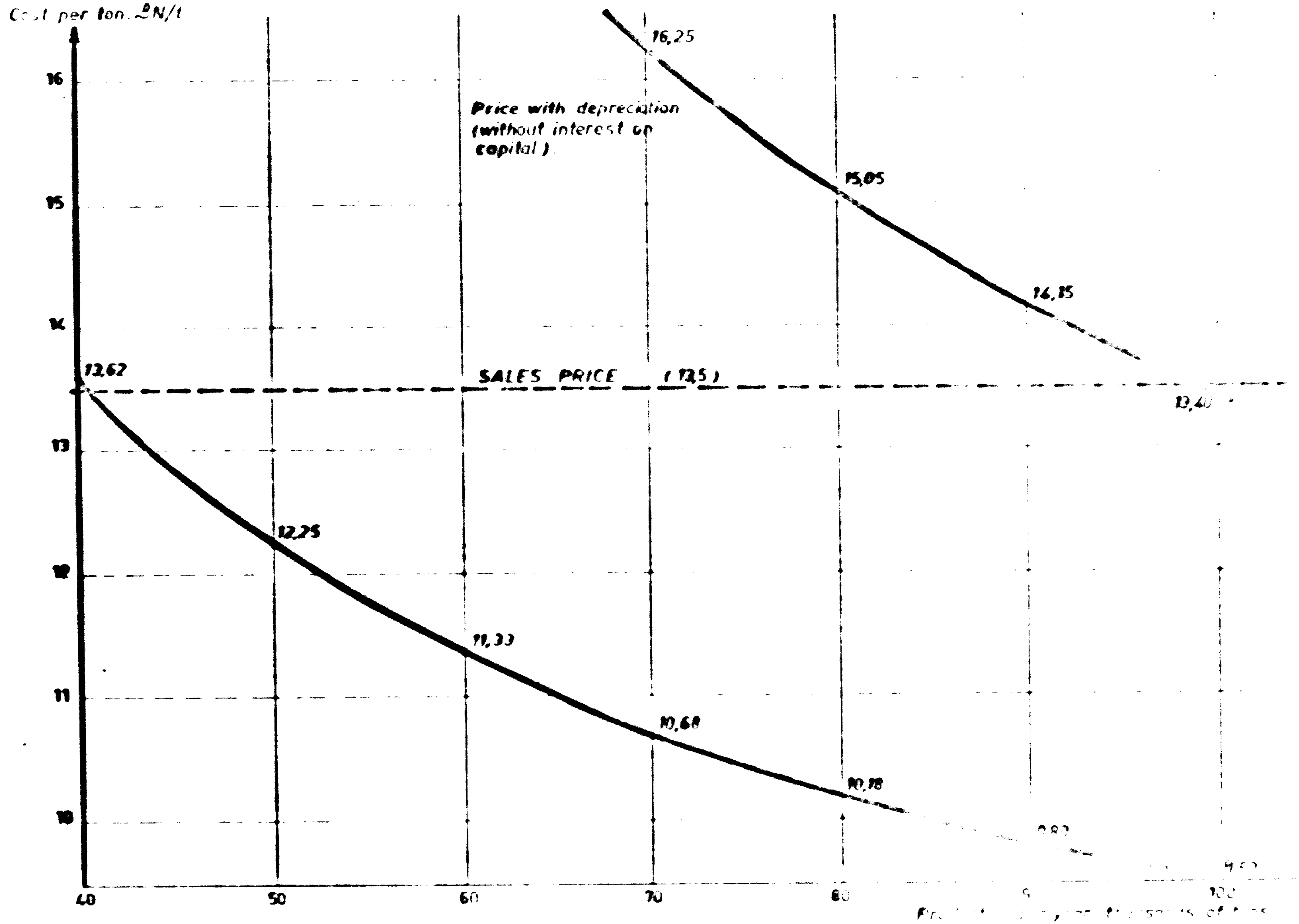
It should be remembered this output combines all increases in productivity detailed in the previous chapters. Since some can be very difficult or very long to achieve so long as no experienced personnel and organized stock of replacement parts are on hand, we have provided for contingencies calculated, as is the rule, on 10 percent of the total.

In point of fact, the factors not requiring any efforts at productivity should have been left out, these being the excise duty, royalties and the bags. We have kept them, and this means adopting contingencies of approximately 12 percent.

Output in tons per year / Cost of factors in $	40.000	50.000	60.000	70.000	80.000	90.000	100.000
Fuel oil				2,68			
Bags				0.875			
Gypsum				0.375			
Consumables				0.212			
Excise Duty				1.05			
Royalty				0.04			
	5,232	5,232	5,232	5,232	5,232	5,232	5,232
Electricity	1,676	1,417	1,417	1,345	1,287	1,244	1,209
Personnel	2,387	1,591	1,591	1,364	1,193	1,061	0,955
Spare parts	1,962	1,308	1,308	1,121	0,981	0,872	0,785
General expenditures and bank agios	1,125	0,750	0,750	0,643	0,562	0,500	0,450
Total	12,382	11 133	10,298	9,705	9,255	8,909	8,631
Contingencies 10% rounded off	1,238	1,117	1,032	0,975	0,925	0,891	0,869
Direct cost	13,62	12,25	11,33	10,68	10,18	9,80	9,50

These results are expressed in the attached graph:

DIRECT COST IN RELATION WITH PRODUCTION



This leaves capital costs to be taken into account, in other words depreciation and interest on the loans. In doing this, we do not take the past into account, in other words the excess amount paid for the construction (resulting, for example, from excessive shipping costs for the equipment, losses involved in changing currency, the over-estimate of the quarry), of certain auxiliary facilities such as the depots, since we are basing our calculations on the ex-factory price.

In addition, we are not taking into account successive operating deficits covered by a part of the loans. Also, we will calculate depreciation on the total as given in Chapter I and which, in our opinion, represents an approximate figure which is fairly correct although at least 10 percent higher than the true value.

We will not depreciate the purchase of the land, the latter being considered to maintain its value.

Investments and depreciation are divided into 3 major categories whose approximate totals are as follows :

- Buildings, various structures and quarries ₤ 650,000 Depreciation over 20 years, or yearly	32.500 ₤N
- Production equipment : 3.200.000 ₤ N Depreciation over 10 years, or yearly	320.000 ₤N
- Dumpers, vehicles, office equipment and household equipment ₤N 150,000 or over 4 years 4.000.000 ₤N (1)	37.500 ₤N
	390.000 ₤N

Thus, it appears immediately that even for 90,000 t. of output (depreciation is then ₤N 4.33/t), they cannot be completely covered (9.[illegible] of direct cost + 4.33 = 14.33, a figure exceeding the sale price). Thus, there is no question of being able to cover the interest on the borrowed funds (supplier credits or others).

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(1) This figure of ₤N 4,000,000 corresponds to ₤ 35/t yearly of capacity for a dry process plant, which, as we have said, would have a capacity of 115,000 t in Europe. As it happens, such a plant located there would cost approximately 16 ₤/t., thus giving an increase factor of 2.2 which is acceptable, accepted figures varying between 1.3 and 1.5 for a plant near the coast and up to 2.5 to 3 for a plant located a long distance from the port and access railroad (but all with little duty taxes).

In point of fact, however, this treatment of the problem, orthodox in terms of depreciation, does not seem precise enough to us in terms of financing costs, since the reserves for depreciation are used in repaying the loans, and annual interest will thus gradually diminish.

Consequently, we will examine possible viability using another method which, moreover, is indispensable with a view towards financial restructuring of the company.

IV - FINANCIAL VIABILITY AND RESTRUCTURING

It is important that each year the company produce :

- the sum corresponding to periodic purchases of equipment which depreciates rapidly and for minor work or productivity purchases. This sum is estimated at a minimum ¥N 40,000 and preferably 60.000. We will take 50.000.
- the constant annuity on the interest and depreciation of that part of the capital to be consolidated as borrowed
- possibly (statutory or other) interests on the capital which can be evaluated at 5 percent or, here, ¥N 80.000. We will forgo this entry, since, as such, the stockholder states benefit directly through cheaper supplies

Precedently, the calculations of direct costs led us to the following margins produced by the company :

Annual Output	50.000	60.000	70.000	80.000	90.000
Per ton margin (difference at ¥ 13.5)	1,25	2,17	2,82	3,32	3,7
Total produced in ¥	62.500	140.200	197,400	265.600	333.000
Total available apart from annual needs (¥ 50,000)	12.500	90.200	147,400	215.600	283.000

Given different possibilities concerning the borrowing time and interest rate, the available margin corresponds to the constant annuity of a loan whose figure is given in the following table for the 90,000 t. output considered to be normal.

Rate	Coef.	10-year loan	Coef.	12-year loan	Coef.	15-year loan
6 %	15,59	2.080.000	11,93	2.380.000	10,30	2.750.000
7 %	14,24	1.980.000	12,59	2.250.000	10,93	2.590.000
8 %	14,90	1.900.000	13,27	2.125.000	11,68	2.410.000

The major elements in a financial solution to company restructuring appear as follows :

1/ - a reduction by 50 or, even better, 75 percent in the capital stock, since this capital can never be paid back in its original amount. Thus, the new total would be 400,000 ₤.

2/ - An increase in this capital for a new inflow of fresh money to pay for company reorganization. As an example, a twofold expansion would make available ₤ 400,000.

3/ - Elimination of the company's present indebtedness which has passed its due date

4/ - Consolidation of present indebtedness in an amount to remain less than or equal to ₤ 2,000,000 for a 7 or 8 percent rate over 12 years.

The ₤ 2,500,000 figure given in the preceding table as the maximum amount which can be made profitable and depreciated corresponds closely to the present undepreciated value of the plant.

In point of fact, the latter has operated for 5 years of a total lifetime of 15 years (4,000,000 x 10/15 = 2,700,000 ₤) which means entering the depreciation annuities paid until now in the profits and losses column.

Other solutions can be examined (for example current account advances, convertible following the reorganization into stock or bonds) which had the advantage of creating greater flexibility for the transition.

It will be up to experts and accountants to determine with the NNDC directors the most appropriate method of defining a viable structure adapted to the company's potential.

Moreover, a change in the production plant, for example an increase in production capacity, would considerably modify financial results including the ability to pay back capital already invested or capital to be mobilized to carry out the change.

From a realistic point of view, first of all it is important to reorganize the present financial structure. However, the chances of obtaining good profitability can militate in favor of a structure reserving, to a certain degree, the rights of the first lenders who have agreed to the cancelling of their debts.

CHAPTER VII

THE MARKET OF THE SOKOTO CEMENT

It should be recalled first of all that in the terms of reference of the contract only cursory verification of this factor was required in order to determine whether or not this was an obstacle to satisfactory operation of the company.

A comprehensive study was in fact requested for the specific surveys in each of the consumer sections both public and private in all the Northern States among competitive suppliers in the south and transport organizations. The whole study taking into account the middle term of both the reconstruction phase after the war period and the expected major petroleum product developments which will make it possible to intensify the public investment effort.

These factors cannot be considered from Sokoto, and especially within a short delay. However, the lack of information on the future marketing problems turned out to be important for the study of the future prospects of the cement factory (marketable quantity at a profitable price). Thus, in view of the above mentioned shortcomings, it has been felt necessary to examine this problem more carefully than expected. This was done more or less under the poor conditions in Sokoto and without statistics on imports and production for each state which, due to the recent troubled period in the country, was not very significant. As an indication, given in the table below is the total consumption in Nigeria since 1966.

Year	Imported clinker (t)	Imported cement-(t)	Nigerian production	Total in t cement with 5 % gypsum on clinker
1966	93 000	160 000	1 002 000	1 260 000
1967	38 000	137 000	750 000	927 000
1968	42 000	80 000	557 000	681 000
1969	49 000	108 000	564 000	723 500
1970 (6 months)	37 000	214 000	292 000	545 000 (rythm of 1 100 000 t/year)

It can be seen that the events from 1967 to 1969 resulted in difficulties. The 1970 consumption as compared with that of 1966 shows that a potential demand was certainly not satisfied.

There are three possible ways of approaching the marketing problems from Sokoto :

I - Designation of the geographical areas constituting a true market for the cement factory in the near future, which would be competitive with the factories of the south and the consequence of this.

II - A rapid survey among consumer services of the state of Sokoto, with the intention of combining the first approach.

III - Indicative evaluation of the order of magnitudes of consumption in the Northern States through an economic correlation.

It should be pointed out again that this document is incomplete and possibly contains some uncertainties, thus it would be advisable to carry out such a study in greater detail.

. . .

I - GEOGRAPHICAL MARKETING AREA

It has been previously stated that the Sokoto cement factory was built by the group of six Northern States in order to ensure a part of their supply of cement. But this is justified only if no other source of supply is available at lower prices. This is to be examined by comparing the prices of the cement from Sokoto in the six states with the delivery conditions from other sources.

Comptetition from imported cement will be excluded in the present analysis. In fact, the CIF price of this cement is normally from £ 7 to 7.5 (some imports arrive at dumping prices, lower than £ 6 to 6.5 and cannot be a reliable and regular source, but only several opportune occasions). To this price must be added a very high customs duty (43 %) and various other taxes. The total reachs so 12,5 to 13 £ at the port which compared to £ 13.5 ex Sokoto does not leave enough difference for transport for this imported cement having a chance of being competitive in the north.

Thus, there remains essentially the Nigerian cement from the south. This cement is currently produced by :

- the Ewekoro factory with a capacity of 250 000 t in two kilns which provides cement under the trade name "Elephant" at £ 10.5/t in 6-ply bags. In 1971-1972, this cement factory will increase its production to 840 000 t by the installation of a third kiln. This factory is provided with a siding track and is located some 30 miles south of Abeokouta. It is operated by APC.

- Nkalago factory, with a production capacity of 200 000 t, but is currently closed down, however it should be reopend in 1973. This factory uses coal from Enugu which is closeby (32 miles). The engineering services are provided by the Danish firm Schmidt.

- the Vkpila factory project (to be located between Auchi and Nbiala), although planned to be small, will be discontinued due to difficulties encountered with raw materials for correction, for the limestone is too pure.

- milling clinker from Lagos (Lagos Cement Works) : this factory has a small capacity and processes imported clinker and gypsum.

- the Calabar factory appears to have been completely destroyed by the war.

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III - MANUFACTURING CONTROL

A - Present situation

To easily feed the crusher during the damp season, large stocks of raw materials are assembled during the dry season near the crusher. We are afraid the plant will encounter crushing problems when using these materials which will have soaked up water.

In the storage bay the crushed material is separated into 2 heaps, one with a low $CaCO_3$ and the other with a higher $CaCO_3$ content (1).

The travelling crane feeds the grinder hopper from these two heaps. It is unfortunate that the orders given the travelling crane operator do not take sufficiently into account the $CaCO_3$ content of the full tanks (as could be estimated from the measured concentrations of instantaneous samples taken at the grinder output).

The grinder output raw material is sent to the tanks, and the laboratory tries to feed the kiln with a raw meal containing 74 to 74.5 percent $CaCO_3$, but the means it uses to obtain this result are very limited since it is virtually impossible for it to determine what is actually in the tank (due to a lack of homogenization) and correct it.

At the present time, since there is no correction material (1) available and the concern with cement sales comes before quality, the laboratory is virtually trying to produce the raw materials having the highest possible concentration and use the highest concentration tanks (2) to feed the kiln. When it successfully manufactures an overproportioned tank, it mixes it with an underproportioned tank or simultaneously feeds the kiln with the two tanks (here arises the problem of mixture quality and uniformity, difficult to obtain from inaccurately adjusted silos).

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(1) Cf. Chapter III - II/A/C/4. During our stay the heap with the higher $CaCO_3$ content contained 76.3 percent of $CaCO_3$. This material may not be considered as correction limestone and could virtually be sent to the kiln as is. Cf. Chapter III - II/B.

(2) In general, these are under proportioned.

The first two factories, assumed to be completed or in operation, are in a good position to compete with cement form Sokoto :

- in the case of Ewekoro, because its current extension will make it possible to lower its selling prices probably down to £ 9 and will even be a dangerous competitor for Kaduna. However, the requirements of the south are such that competition should be limited.

- in the case of the Nkalagu factory, since it sells at a lower price than Sokoto and it is in a better position for serving Kafauchan, Jos, Bandi, Gombé and the north-east generally speaking.

At present, the ex-Ewekoro price applied (the only factory capable of handling deliveries) is £ 10.5/t packed. Therefore, it has an advantage of £ 3 which may balance a longer transport to the north.

A concise examination of how these data appear on the competitive situation of prices in the major cities in the north is provided herein. These cities are possible outlets for the cement from Sokoto either via road alone or road and rail whereas there is rail alone from Ewekoro. For this factory, only this mean of transport have been examined, but it must be kept in mind that like in all developing countries, the most distant areas from the coast are greater exporters than importers in terms of tonnage and that the unbalanced traffic situation can allow for return shipping at low rates. This is not the case for rail, the rates for which are strictly applied, but there may be deliveries by trucks looking for filling up an empty return trip. It has been assumed that this could only involve small volumes of cement.

The concise comparison results will be presented in a table. For rail transport we have usde the official tariff schedule n° 7 which supercedes n° 6 of 1962 (N° 7 is valid as of November 1970) local cement is classified under index B, by sometimes rounding off the distances from Ewokero. This rate is given in Appendix. Road transport is performed on an average rate of 3.2 d/ton-mile which depends of course on the condition of the road and the capacity of the truck as well as the return trip cargo. In certain cases a bracket has been indicated which in fact appears in the invoices of shippers.

Road transport from Sokoto to Gusau as far as the railroad has been estimated at £ 1.6 (134 miles with transport rates barying between 1.5 and 1.75) and the division into consignments in Gusau has also been taken into account.

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In order to estimate the cost of the latter, the cost of operating the warehouse of Gusau which appears to be high has been taken into account. In fact, the total 1970 salaries of the 3 warehouses were about £ 5 500, that is including Kaduna and Maidugari, but have only a local role and are not very costly in comparison with Gusau ; Gusau has in addition renting and amortization costs. The role of Gusau is mainly to redistribute cement (since the transport of fuel ex-warehouse is now direct) with a minor function of receiving railroad consignments. The transport of cement involved some 4 350 t in 1970, and the cost of handling and dividing consignments exceeded £ 1/ton, however this latter figure will be used in our calculations.

With the above data the following table is obtained :

From Sokoto to	Zaria	Kaduna	Kano	Jos	Maidugari
By direct road in miles	245	300	340	400	715
Cost in £	3.3	4	4 to 5	6.5	9 to 10
by road via Gusau handlings (£ 1) and rail Total cost	4.2	4.8	5.7	6.6	8.8
From Abeokouta to					
by rail (via Kaduna, Kafouchan) in miles	553	505	640	675	1 050
Cost in £	5.1	4.8	5.7	5.9	7.9
thus for Ewekoro (+ 30 miles)	5.3	5	6	6.1	8

The railroad stations in the neighborhood of Jos (Kafouchan, Banchi, Gombé) show the advantage of the railroad, since the route via road seems to be longer.

For greater accuracy, the two last cost figures via rail will have to be increased by an additional disadvantage in the range of £ 1/ton so as to take into account the handling upon arrival for delivery to clients ; this division into consignments is not required in the case of direct delivery via truck.

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Thus, it can be noted that :

- Sokoto has an advantage in delivering by road over Zaria, Kaduna, Kano and probably Jos. In the case of Maidugari the costs are about the same, especially if it is kept in mind that the warehouse handles deliveries.

- the transport advantage of Sokoto via direct road over Ewekoro by rail compensates the difference in price ex-factory (which is £ 3) only to Zaria and runs the risk of being jeopardized by the lower price which could normally result from the extension of Ewekoro. However, the balance is attained for Kaduna, and it is almost attained for Kano. It can be thought that if a good direct road existed for heavy trucks between Gusau and Kano the advantage would be certain owing to the possibilities of quick, door-to-door deliveries.

It would seem on the contrary that once the present poor condition has disappeared, Sokoto will no longer be in a position to supply the north-east market within economical terms, except if it lowers its selling price, thus its cost price or if it takes advantage of a premium for quick delivery which it can provide through its warehouse.

The best solution would certainly be to provide a cement factory for the north-east and this has in fact been contemplated with reference to the limestone deposit of Aschka.

The above facts will be checked by examining the present situation for deliveries from the factory of Sokoto.

It has been said that the latter, set up by the 6 states, should provide these states with quantities according to the regulations each month on the basis of the share of these states in the capital. At the present time, the shares are as follows :

North Western State	26 %
North Eastern State	19 %
Kano State	19 %
Benue Plateau State	14 %
North Central State	14 %
Kwara State	8 %

In actual fact, sales respect these percentages very little and this is in particular due to the fact that the outstanding amounts for a State cannot be carried over to another month and are thus divided among the other States.

...

The breakdown of deliveries has benn made for the period June 1969 to March 1971, by taking into account the redeliveries from the Gusau warehouse.

Thus the following table is obtained, in which the second figure, wherever it exists, corresponds to this redistribution from the Gusau warehouse (due to certain differences stemming from the various documents consulted : certain figures have been rounded off). (See table of Tonnage delivered)

The total including private supplies amounts to 50 000 t, whereas the records of the factory previously examined showed 54 914 t for the year 1970. The difference arises from the fact that the private supplies of the first 5 months were not indicated, or that there were certain differences between the sales and the delivery services of Sokoto, Kaduna and Gusau. Whatever the reason may be, the percentages indicated below have been calculated in relation to the sum of only the geographically identified tonnages, that is 46 450 t (50 000 - 3 550 privately delivered).

The same analysis for the first three months of the year 1971 give the following results : (See table of Tonnage delivered)

Upon examination of the table of Tonnage delivered, it can be immediatly noted that :

1 - Kwara obtains cement from other sources that just the Sokoto cement factory

2 - Benue Plateau and North Eastern states do not take their quota, which reveals the importance of the cost of combined road + rail delivery, especially for certain markets directly served by rail from the cement factories in the south.

3 - North Central state (Kaduna, Zaria) use up more or less their quotas.

4 - Sokoto and Dano states not only take their quotas but also take advantage of the cement left by the others.

The natural sales area for the cement factory thus appears to be essentially comprised of the states of Sokoto, Kano and the North Central state (Kaduna, Kafanchan, Kwai) with several outlets in addition in the North Eastern state (Maidugari, Gombe, Banchi) and occasionally Benue (Jos, Bukuri, Kefi, Gudi, Makurdi, Atempko). But it is certain that the latter sales reflect in part the shortage of cement which existed and continues to exist in Nigeria.

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TONNAGE DELIVERED

	N.W.	N.E.	N.C.	Kano	B.P.	Kwara	Privates	Total
In 1969 June to December	8.950 (8350+600)	6.410 (3000 + 3410)	14.950 (13323 + 1627)	11.850.	2.600 (1935 + 645)	720 (0 + 720)		45 480
Soit en %	19,7	14,2	32,8	26	5,7	1,6		100
In 1970								
January	1.350	(714 + 250) 964	1.936	1.785	(245 + 105) 350	0 + 20		
February	976	(1247+217) 1.462	(915+20) 935	1.107	(167 + 114) 281	0 + 5		
March		0 + 129	0 + 20		0 + 35			
April	1.511	(1487+304) 1.791	0 + 893	0 + 803	(267+55) 322	0 + 66		
May	460	(348 + 386) 734	(528+40) 568	0 + 513	(223+25) 248	0 + 20		
June	1.150	(338 + 257) 595	(690+65) 755	0 + 636	(267+229) 496		1.822	
July	783	(27 + 37) 69	0 + 91	0 + 20	(34 + 35) 69			
August	2.329	0 + 27	0 + 165	0 + 58	0 + 25		55	
September	2.247	(52 + 47) 799	(937+80) 1.017	0 + 657	(244+160) 404		283	
October	1.840	(297+581) 878	(626+20) 646	00 + 1.036	(380+385) 765		1.243	
November	1.712	0 + 405	(498+25) 523	0 + 1.100	(258+160) 418		62	
December	2.050	(398+127) 525	0 + 375	0 + 1.302	0 + 159		81	
Total	16.348	9.478 (dont 2.803 ex Gusau	7.924 (dont 275 ex Gusau)	9.017	3.572 (dont 1.270 ex Gusau)	111	3.550	
% des Etats	35,2	20,3	17,1	19,6	7,7			
In 1971								
January	2.384	(436+471) 907	0 + 589	0 + 1956	(257+197) 454	0	38	6.328
February	1.781	(248+37) 285	0 + 537	0 + 1177	(250+108) 358		17	4.155
March	3.048	(292+0) 292	0 + 785	0 + 830	(346+118) 464	10	9[illegible]	5.519
Total	7.213	1.484	1.911	3.963	1.276	10	145	16.002
	46%	9 %	12 %	25 %	8 %			
Nota :	Sales growing	Sales decreasing	S. decreasing	S. stable	Little and stable sales	Sales negligible		

The decrease between 1969 and 1971 in the purchases of cement by the North Eastern and North Central states would tend to confirm this fact, whereas Kano maintains its purchase level and Sokoto is increasing its own, with Benue remaining marginal and Kwara disappearing from the market of Sokoto. Another indication as to the instability of the present situation is the existence of a black market for cement, prices such £ 18 seem to be applied in Lagos and £ 22 to 24 for small quantities in Kaduna, Kano, Maidugari. This will of course disappear with the cement factories which are to be put into operation again in the south.

The following conclusions can be drawn drom the above facts :

1 - The capital buildup of the CCNN could be modified so as to take into account the relative interest of each state in the operation of the cement factory. Such changes are currently made in petroleum refineries beloging to several companies whose participation follows the evolution of the portion of the delivery that each company assumes from the refinery.

An example of such a breakdown in view of the present transitional period could be as follows :

NW : 40 to 45 - NE : 10 - NC : 15 to 17 - Kano : 20 to 25
BP : 8 to 10 - Kwara : nil

Unless, it could appears to be preferable to adopt immediately a breakdown only between NW - NC and Kano states.

2 - As far as the future market situation from 1975 on is concerned, it can be adopted that Sokoto would supply :

- the whole market of Sokoto
- most of the market of Kano
- a decreasing part of the market of the North Central state
- a small part of the market of the North Eastern state.
-

3 - As far as the role of the warehouses is concerned, it can be noted that their operating costs are relatively high, in particular for the equipment which has to be amortized over small quantities. It would appear that under these conditions a better solution would be provided by an agreement with a representative already installed and equipped who could write off his expenditures and his equipment on a group of products or demi-products.

The Gusau warehouse alone, since fuel no longer needs to be delivered by truck from the factory, should be re-analyzed in these terms.

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Truck deliveries should also be better organized by road carriers in order to be able to fill empty return trips.

4 - However, if one lets the economic conditions follow their natural path, the offensive action of the developed and modernized cement factories of the south may turn out to be dangerous for the Sokoto factory and even if the market of the south is not completely saturated ; in fact, all that is needed is that the profit gained from certain points in the north becomes greater than certain profits made in the south.

It is recalled that this phenomenon is quite generally encountered in all developing countries. The most favored areas are those around ports and such factors as production costs, size of local market and thus the size factor facilities are to their advantage. To this is added the possibility of obtaining marginal return trip cargo on the basis of the normal rates.

It would thus appear that on the scale of the Federation, and within a voluntary policy for development of areas which are less favored, it would be legitimate to apply certain measures for assistance by acting on the cost factors or the taxing procedure. Some of the measures which could be taken are as follows :

- lowering the price of fuel delivered to factory, by acting not on the ex-refinery price (which would benefit all the factories) but on the transport cost (applying a very degressive rate for haulage over long distances).

- lowering the price of industrial KWh, especially the fixed premium for the large industries in the north (even if certain residential or commercial rates have to be increased, for the present difference between the rates at certain levels is, in our opinion, too little.

- exempting the basic products processed in the north from half or even all of the excise tax. This appears all the more legitimate since the customs duties collected by the Federation heavily affect the price of spare parts and new equipment.

...

II - CONSUMPTION IN THE STATE CF SOKOTO

The consumption sectors are essentially comprised of :

- construction of administrative facilities, buildings, housing which is carried out by the Ministry of Public Works acting on the behalf of the other ministries and which represents at least 80 % of the demand for cement (currently : main hospital, 2 other hospitals, Secretariat General Cffices, Sokoto College, water services, etc. for about £ 15 million for the 3 years to come).

- construction of roads, both for the state of Sokoto (3, 5 million) and the Federal Government (£ 13 million).

- the requirements of the Ministry of Natural Resources involving 300 t/year for small works and 900 t/year for irrigation dams (400 t/year for small structures and 500 t/year for the Bobo Scheme over 3 000 acres, to be continued by the Bakalory Scheme amounting to £ 10 million).

- private construction and maintenance, representing only 5 to 10 % of the public demandbut which are in the course of development.

- private or semi-public contractors ; the demand in this case is very low for the present but certain large projects have been planned (tannery and hotel at Sokoto, oil factory at Gusau, high voltage line from Zaria to Gusau and from Kainji to Sokoto and Dosso, etc.). This sector would then correspond to 15 or 20 % of the public needs.

For the first two items, which are the most consequential, the needs are estimated at about 45 000 to 50 000 t/year at the present pace. Since the Sokoto cement factory could not supply this tonnage owing to its low production and its obligations to the other states, it has been necessary to slow down or defer the works and even import cement from other sources. This is how cement was purchased from Lagos during the last year : 6 000 t of cement at 12/6 a bag, that is 22/6 delivered to Sokoto, thus leading to an overrun of more than 50 000 £ as compared to the price which could have been obtained locally. Another proof of inadequate supplies is the appearance of a black market, although limited in quantity, it is very high in price.

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If the needs outlined above for the sectors are summed up, the total present needs amount to about 55 000 t and should grow considerably in the next years so as to attain 62 000 to 65 000 t in 1975, thus a higher figure than that provided in the theoretical calculations in part III of the present chapter.

If we divide this quantity by the estimated present population of 6 900 000 inhabitants, a figure of 8 kg of cement per capita is obtained, which is much higher than the present situation ; the deficit corresponds to forced restrictions, especially in the private sector.

Finally, it should be noted that 80 % approximately of the needs of the state come from the province of Sokoto itself, the remainder coming from the province of Niger and that this factor can allow for savings on packing, or even its elimination in the case of major site operations where a silo can be provided, which would be fed in bulk from the factory. This should of course be examined in a more detailed study in view of the special equipment which would involve, however, it can be noted that this method is currently being used in Dakar.

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III - THEORETICAL DEMAND FOR CEMENT IN THE NORTHERN STATES

Assuming that the general objectives of the Plan are attained, the consumption in 5 years will be estimated. The theoretical solution is quite simple : since the product is a consumer good, the elasticity factor for demand in relation to income is calculated (ratio between the percentage of consumer growth and the percentage of income growth) and it is then assumed that this coefficient is valid for the future, which accurate enough if this period involves few years. Since cement is an intermediate product, the problem is slightly more complex for the choice of the consumer is not made directly for this product and thus the demand for final consumer goods must be assessed and the consumption of cement is to be calculated by using technical factors from an inter-sector exchange table. It should be pointed out that in view of the present state of the national accounts of Nigeria it is not possible to use this method.

As an alternative to this analysis, a study can be made of the compared evolution of the gross domestic product and the cement consumption. The correlation thus obtained can be extrapolated for future years. This correlation between the per capita product at constant prices and the consumption of cement in kilograms per capita is generally very good for developing countries with a major and diversified public and private economy. It is not as good for countries with a low per capita income (and thus a low consumption of cement) for the per capita consumption is influenced to a great extent by programs for the construction of major basic facilities. This is the case of Nigeria, and in particular that of the states of the north for which the National Plan makes no distinction within the Federation. For example, in the state of Sokoto, the Public Building and Civil Engineering Sector accounts for 80 % of the consumption of the cement.

The last possible approach has been adopted herein, that of international comparisons which consists in determining the gross domestic product of these states and placing them on a curve which provides information on a group of countries on which statistics are available in terms of two elements : per capita income - per capita consumption of cement.

...

However, it is necessary to see that this solution, which leads to all kinds of difficulties in terms of clinker uniformity and quality, is but a makeshift substitute already not very compatible with production requirements and desired cement quality if the plant's future is to be guaranteed in the face of foreseeable competition from plants in the South.

The clinker leaving the kiln is very ununiform (cf. table in Chapter II-A/C) and it is thus very difficult to correctly add the gypsum. In addition, it is still necessary for the SO_3 content of the gypsum used to be uniform or that its limits of fluctuation be known.

Lastly, given the conditions of inaccuracy in which the plant is operating, it is virtually impossible to obtain the organized, economic manufacture of uniformly high-grade clinker.

B - Recommendations

The major preoccupation in the operation of a cement plant should be the obtaining of homogeneous, uniform raw material properly proportioned when entering the kiln. The $CaCO_3$ content must be sufficient to obtain the maximum possible amount (compatible with good burning) of C_3S responsible for good mechanical strength and easier to grind than C_2S.

It would appear this operating approach was accepted at the time the plant was built and is now still being followed. However, these consequences have not been extrapolated far enough.

A major share of the plant's problems will be eliminated if attention is given to the raw material from the very start of the manufacturing cycle, in other words at the quarry.

It is necessary to be able to mix the raw material at the time of the crushing process and correct it at the time of the grinding process, or, as a last resort, at the time homogenization is performed. For Sokoto this means :

- having carefully studied the quarry, having full knowledge of the various zones exploited and having arranged the working faces in such a fashion that the shovels can extract the material at several different points.

Such a curve should be used with certain reservations as to its exactitude. In fact the notion of income per capita in dollars allows only an overall classification, for example one cannot compare, without committing errors, a country with a high local consumption and a country with a more sophisticate market. Moreover, the transposition of revenues into dollars brings into play an arbitrary exchange rate and poorly reflects the structure and the real value of the production.

The very definition of income is often not the same within the international accounting ; the differences with the G. N. P. are fortunately much lower in less industrialized countries.

In the absence of a better method, this analysis has been made and the curve appended has been prepared (previously for works conducted by the SEDES - 1960) and thus provides certain results. Logarithmic scales have been used for the magnitudes, so as to compare the relative variations ; such a graph immediately provides the elasticity coefficient for consumption on relation to income by reading off the tangent at the adjusting curve (1).
In order to diminish the difficulty of an abnormally high cement consumption through the implementation of major works, whenever possible, the averages for the 3 successive years were taken. Whenever data for a country was available for a larger number of years, we have also shown a arrow ... the slope of which is equal to the elasticity resulting from the temporal correlation. The general direction of these versed sines (the slope of which is generally greater than the corresponding tangent at the adjustment curve) shows that the evolution of cement consumption should be greater than what is obtained from the graph. In other words, the present elasticity of demand in the country in relation to per capita income is equal to £ 100 (log 100 = 2) will be greater than the slope of the tangent at the point 2 along the x-axis.

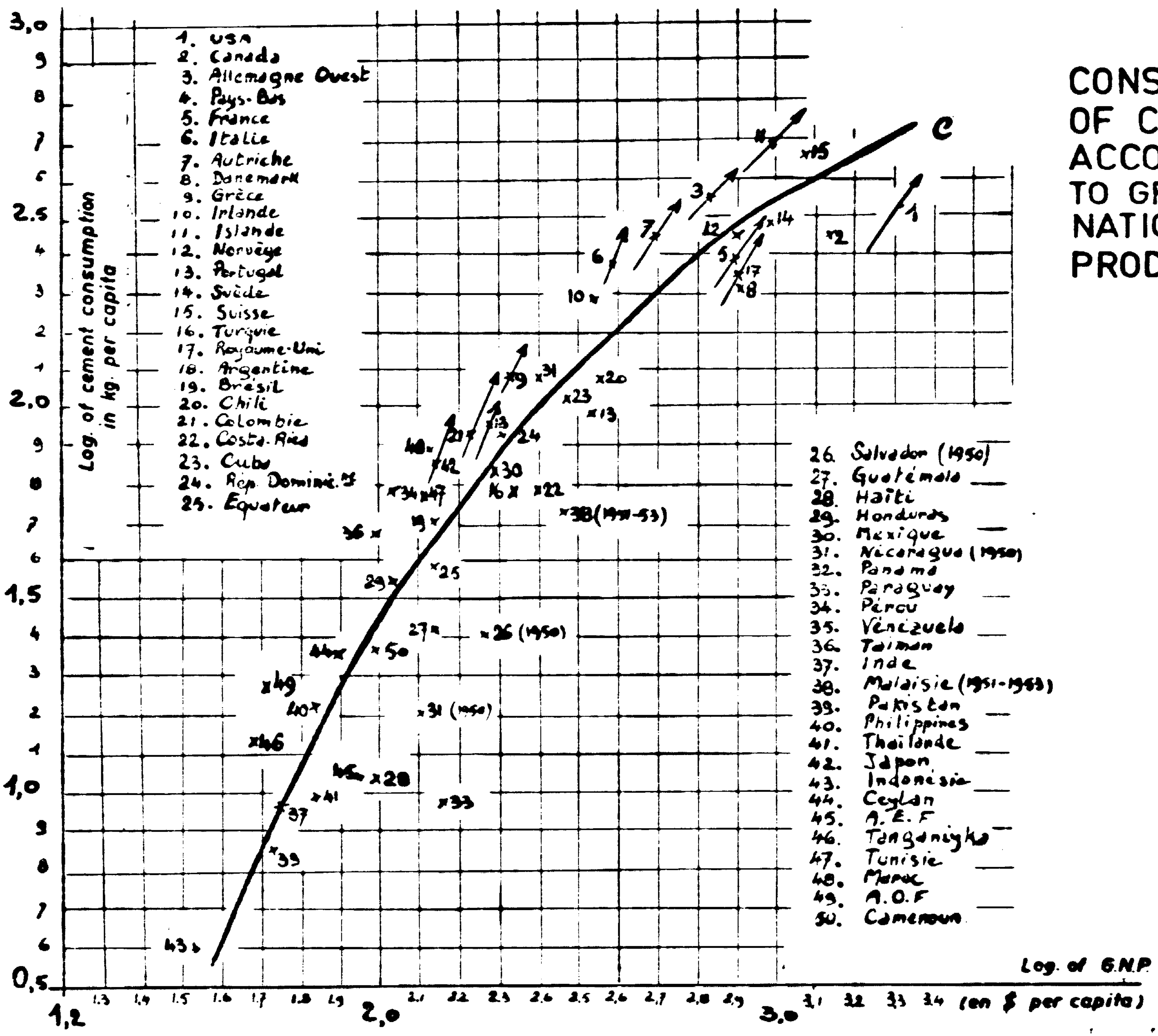
...

(1) It is known that the slope of the tangent is expressed as

$$\frac{dy}{dx} = \frac{d(\log c)}{d(\log R)} = \frac{\frac{dc}{c}}{\frac{dy}{y}}$$

which is the definition for the consumption elasticity factor.

CONSUMPTION OF CEMENT ACCORDING TO GROSS NATIONAL PRODUCT



S.E.D.E.S.

A second graph with ordinary coordinate axes provides the data for the second year of cement consumption and the income of the developing country (1966) (1).

A straitght line is shown for visual adjustment and confirms the preceding curve.

At this point, there remains to determine the gross domestic product, on the one hand, for the states of the north and the growth rate which will result from the 1970-1974 Federal Plan along with the investment budgets of the States, which is the main directive element of their development and, on the other hand, the corresponding evolution of the population.

The only data available is the evaluation of the gross domestic product on the Federal scale and the growth rate adopted for the second National Plan (1970-1974) at constant 1962 prices.

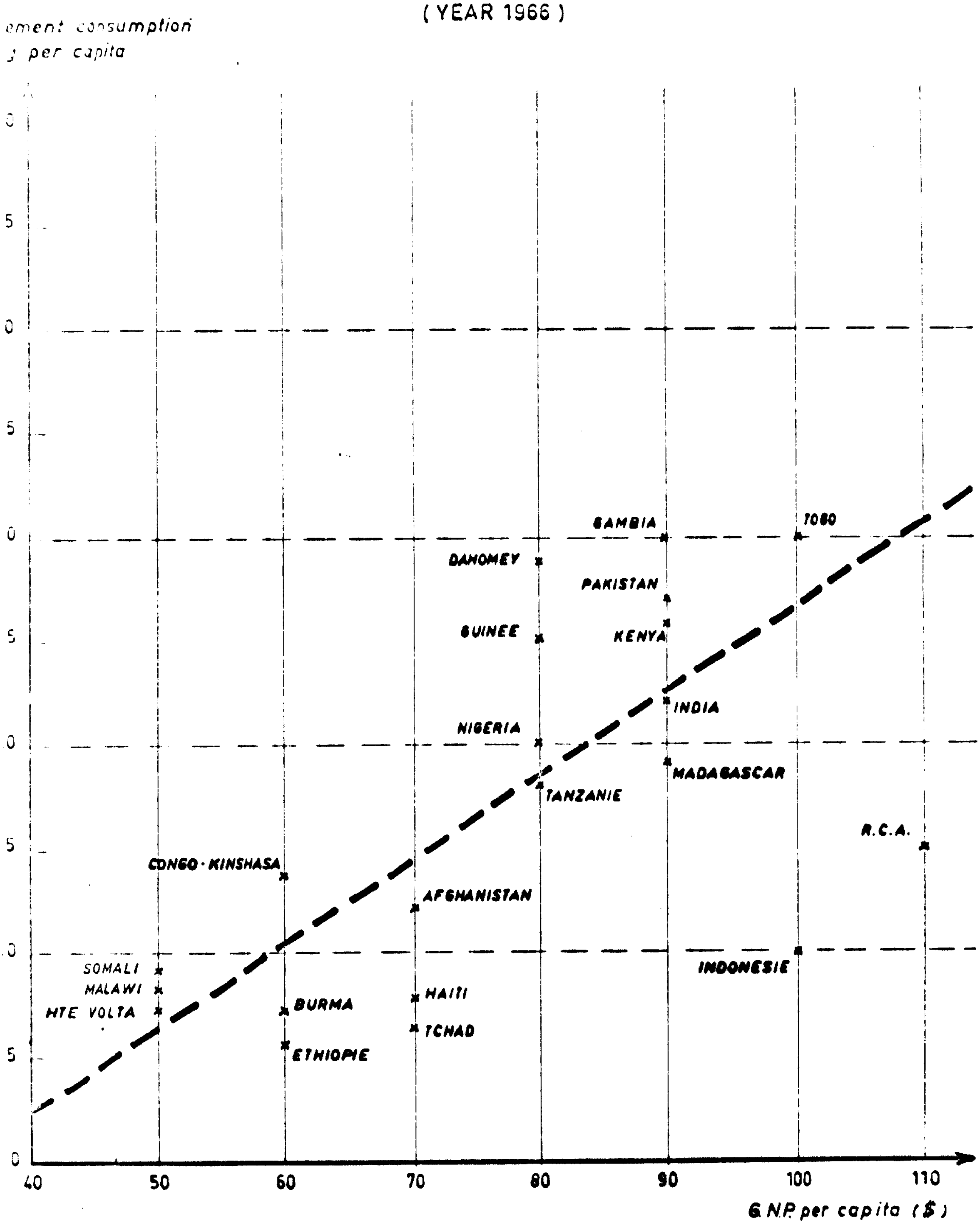
In the Plan prepared in 1970 for the period 1970-1974, the following data has been obtained for the whole of Nigeria :

...

(1) Source : consumption of cement : Cembureau
2, rue St-Charles - Paris.
income and population : World Bank Atlas - 1968 .

CONSUMPTION OF CEMENT
ACCORDING TO GROSS NATIONAL PRODUCT

(YEAR 1966)



SOURCE: World Bank Atlas (third edition 1968) for Population and GNP
Cembureau, 2 rue St Charles, Paris, for Cement ... umption

Past période

(limited to 1966-67 since the 1966-1969 war lowered the GNP)

	Unit	1962-63	1965-66	1966-67	Annual growth rate
		(recorded)	(estimated)	(estimated)	
Population	million	55,67	58,2	59,7	2,5 %
Gross domestic product at factor prices	million £				
current prices		1 315	1 540	1 605	5,2 %
(constant prices 1962)		1 315	1 540	1 583	4,75 %
Building and construction sector		57,5	80,6	82,7	9,5 %
G.D.P. £/capita	£	23,6	26,4	26,8	3,2 %
US $/capita (£ x 2,8)	$	66	74	75	3,2 %

For the coming period (1970-74) covered by the Plan, the values adopted will be in current £, although for the estimate of quantities (as in the case of cement), it would have been better to base oneself on the constant monetary value. The following three reasons explain why it is felt that the consumption would be underestimated :

1 - The price of cement should remain relatively more constant ; this is a basic product whose price should be maintained as constant as possible Factories in the south will moreover tend to stabilize it. And if assistance is to be provided for the production of the north, it would be preferable for it to be a direct or indirect aid periodically revisable than an increase in the price.

2 - The GDP appears to be evaluated slightly too low (the United Nations provide a figure of £ 80 for 1966) perhaps as a result of the difficulty of evaluating the local consumption.

3 - The portion of the construction sector which is the largest consumer of cement grows more rapidly than the GNP in the Plan forecasts.

...

Projected period (in the Plan)

	Unit	1968-69	1970-71	1973-74	Annual growth rate
Estimated population	million	62.7	66	71.2	2,5 %
GDP at factor prices (current prices)	million £	1 570	1 743	2 281	7,7 %
Building and construction sector	million £	77	88,1	116,7	8,65 %
GDP £/capita	£	25	26,5	32	5,1 %
GDP $/capita (£ x 2,8)	$	70	74	90	5,1 %

The figure of $ 90 per capita, shown in our would consumption curve, gives a value of 22.5 kg per capita, which would correspond to a total of 1 600 000 t in 1974-75 for the whole of Nigeria.

A regional breakdown is to be provided for this figure of £ 90 so as to determine the consumption of the northern states (that is mainly North Western, Kano and North Central). The Nigeria national account provide no breakdown for the states and the estimate provided herein are debatable and are only provided as an indication of the possible methodology.

The population and the GNP must be estimated for each state.

Population

A 2,5 % is applied to the only available sensus and which is quite old, the one of 1963. More particularly, the new migratory phenomena whether or not due to war, are not taken into consideration.

In 1963, all the norther states represented 53,3 % of the population of Nigeria.

...

Domestic Product

The only source of information is the estimate of tax revenues of each state of the whole of Nigeria, as given in the Plan on pages 301 and 302 and it is assumed that the relation between these revenues is a reflection of the relation of the GDP for each state. This is certainly not exactly so however it does provide, in the absence of other data, an order of magnitude. The relationships between the tax revenues are as follows and these coefficients are applied to the overal revenues of Nigeria previously obtained. Considered in relation to the population, we thus obtain the per capita GDP.

State	% Revenues	GDP £ 10^6		Population 10^6		GDP £/capita		GDP $/capita (arrondi)	
		70-71	73-74	70-71	73-74	70-71	73-74	70-71	73-74
Nigeria	100	1 743	2 281	66	71,2	26,5	32	74	90
Northern States	36 %	629	821	35,40	38,1	17,8	21,6	50	60
	% in N. S.								
North Western	16,2	102	133	6,81	7,34	15	18,2	42	51
Kano	21,8	138	179	6,86	7,39	20,2	24,2	57	68
North Central	16,8	105	138	4,87	5,24	21,8	26,6	61	75
	54,8	345	450	18,54	19,97	18,7	27,6	51,2	63
North Eastern	20	126	164	9,26	9,97	13,7	16,5	40	49
Benne Plateau	14,8	93	121	4,75	5,12	19,6	23,7	57	68,5
Kwara	10,4	65	86	2,85	3,07	22,8	28,3	66	82
	45,2	284	371	16,86	18,16	16,8	20,5	47	57,5

In terms of the current budget revenues as a whole, the southern states represent :

- Lago and Western : more than 30 %
- and with Mid-Western : more than 40 %

There is no need in recalling the little actual value of the foregoing estimates on the per capita GDP for the northern states. In any case, by referring to the general consumption curve, the following table can be drawn up :

...

States	1970 per capita		1974 per capita		Total consumption rounded off in tons	
	Revenues in $	Consump-tion kg/h	Revenues in $	Cons. kg/h	1970	1974
North Western	42	4,6	51	7,5	31 500	55 000
Kano	57	9,5	68	13,5	65 000	100 000
North Central	61	11,2	75	16,5	55 000	86 500
North Eastern	40,7	4,3	49	6,8	40 000	68 000
North states combined	50	7,1	60	11	250 000	420 000
Whole of Nigeria	74	16,5	90	23	1 100 000	1650 000

The two figures coincide with those given in the table of consumption at the beginning of the chapter.

As already explained, the states of B. P. and Kwara have been omitted, since they will provide no natural clients for Sokoto in the future. The data are primarily for the north-western states and Kano and one part (perhaps a third) for the north-central state as well as several occasional sales in other states, representing perhaps some twenty thousands tons. Thus for 1975 we obtain a potential market in the range of 200 000 tons, by assuming that the cement factories in the south are in a position at that time to produce about 1 200 000 tons and that they can freely compete with the north. These figures are only approximations.

Nevertheless, they are encouraging enough to reasonably raise the question as to whether the Sokoto cement factory should be doubled in size and capacity. This, of course, would have to be analyzed in detail, however, this is not the purpose of the present study. Moreover, for reasons outlined previously, it is deemed herein that it would be a mistake to make such a decision at the present time, in view of the unsatisfactory operations of the cement factory of 1967, for quality will be a major factor for success on the competitive market of the future.

CHAPTER VIII

THE FUTURE

In the previous chapters we saw that present operating conditions prevent taking full advantage of the existing production plant and that, effectively, a peaking out exists both of quantity and quality not corresponding with the technical potential and which might risk compromising the company's future.

From a detailed examination we deduced a certain number of technical and administrative corrections which should improve both qualitative and financial results.

Commercial reorganization has also become necessary in order that sales be concentrated in profitable markets, in other words, those near the plant, without becoming involved -- and naturally we are fully aware the company has been acting in this way out of necessity and not lightheartedly -- in a price war which would be lost before it started in distant markets.

Two conclusions, however, have also emerged :

- corrective maneuvers, which we have called the reorganization, will take a relatively long time. In our opinion, they could be spread out over at least 2 years due to the training they require for all of the personnel, a point which seems to have been overly neglected until now.

- even once this reorganization has been carried out and the indebtedness eliminated, there will nevertheless still not be enough funds to provide for the minimum depreciation needed for "self regeneration" of the production plant, in other words the self financing of its survival. Even by limiting sales to the closest markets, which are the most profitable, operations will nevertheless be very delicate.

Consequently, the conclusions are not optimistic and could only lead to an attempt to determine if it would be possible either to increase income or reduce certain spending using new technical means.

A - DIVERSIFICATION

An increase in income would obviously mean (independent of a hike corresponding to an increase in factor costs) an increase in sale prices which is very certainly not in the general interest and would further burden the investment budgets of the states.

In addition, this would probably also not be in the interest of the company which would thus be more vulnerable to shipments from cement plants in the South.

With the exception of this policy, there would be diversification of CCNN activities, in other words involving the sale of cement already valorized in the form of a semifinished or by-product.

Such products include :

- hollow blocks and lintels, at first glance not very profitable due to transportation losses (as much in combined materials as in delivery costs)

- precast concrete products including tanks, claustra, fences and enclosures, large and small pipes. These unquestionably constitute the most conventional and the most reliable application, and it would be necessary to perform a market study of contractors and users without exaggerating the extent of the improvement such activities would provide,

- asbestos cement products, flat and corrugated plate, pipes and tubes. The presence of a sufficient plant in Kaduna makes the examination of such an application untimely.

B - SAVINGS

Direct spending can only be reduced substantially, apart from productivity efforts reviewed, by concentrating on fuel oil and electricity costs.

For the first, while verifying that ex-refinery conditions are equivalent to those extended to cement plants in the South, this would mean concentrating on transportation costs, and this is a general problem which can and must be raised by the CCNN but which cannot be solved by it alone.

This could also consist of replacing fuel oil with another, cheaper fuel, in other words of local manufacture. The only possibilities we can see would be farm waste and, primarily, seed husks (peanuts, cotton). A special study, published in the Appendix, shows that even at the cost of considerable organization and collection efforts this rather difficult substitution would not provide the needed help.

- using the grinding correction material hopper filled with limestone of the highest possible concentration

- being able to mix 2 tanks if required.

Given the present condition of the quarry, it is possible to produce raw material for correction purposes having a $CaCO_3$ content exceeding 80 percent, but this will require the sorting of high-concentration limestone blocks (which will considerably increase quarry operating expenses).

Without taking a step of this order, it will be difficult to regularly produce high-quality raw material, and the plant will be virtually obliged to feed into the kiln raw material with an insufficiently low CaO content.

Thus, we assume that quarry operation will be organized to produce correction limestone (1). The manufacturing process can be carried out according to the following outline :

In the storage bay are made :

1 - a heap of ungraded, underproportioned raw material, as homogeneous as possible, by feeding the crusher simultaneously with two shovels working different layers.

2 - a heap with the highest possible concentration on the order of 80 percent $CaCO_3$, or more if possible, to be used as correction material.

The raw material grinder is simultaneously fed with :

1 - ungraded quarry material while the crusher is operating normally and ungraded material coming from the bay during the night.

2 - high-concentration limestone using the existing correction hopper. The $CaCO_3$ percentages determined every hour must make it possible to vary the addition of correction limestone.

Following a certain number of hours of grinding in a silo, using the measured concentrations and grinder volume the laboratory is to calculate the tonnage contained in the silo and its concentration. The laboratory judges that the ungraded material will not change and

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(1) or that the plant has been organized to receive such limestone from outside (the exploitation of another quarry, the purchase of limestone and so forth).

The general manager, who receives his instructions from the board of directors, is to have under his orders :

- a production manager responsible for the entire manufacturing process including the quarry and laboratory, This leaves electric power for which it would appear that negotiations bringing out the factors of long duration, daily regularity and nighttime consumption without a peak period effect should provide the advantages of a preferential rate in comparison with all other industries not offering the same power factor.

It is even possible that, during peak operating periods, the cement mill would be disconnected thus allowing the ECN to get through the peak load periods which are always so difficult for a public power plant without any problems and at the cost of adequate organization of work at the CCNN and better hourly productivity at the mill. By adjusting both the fixed rate and proportional rates, it would not be impossible to annually save more than ₤ 20,000.

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However, naturally without excluding the factors just quickly mentioned, it is certain the best solution is to be found in the conventional method studied for any company whose direct fixed expenses comprise a large share of the costs. As it is, in the case of Sokoto it can be seen these expenses (apart from capital expenses) (Chapter III, Costs) totalled 32 percent for 80,000 t. annually and 27,5 percent for 90.000 t.

An increase of X percent in output which would only bring into play the direct proportional expenses would theoretically permit a reduction in costs of about 32/X% ; in other words, in the case of a twofold expansion at 180.000 t. a considerable sum on the order of 110.000 ₤ annually would be available.

Thus, it is necessary to more closely examine the various aspects of this point. As such, the CCNN has already been thinking about them.

C - THE INCREASE IN THE CAPACITY OF PRESENT EQUIPMENT

We have already indicated that we feel that all plant equipment is well balanced. Any major increase in output would require the installation of 1 dryer, 1 raw material grinder, 1 kiln and 1 cement grinder with all their accessories. The other installations will either be sufficient (crushing and shipping operations working with 2 posts) or will have only to have their capacities increased (for example homogenisation).

A variation can be studied taking into account our previous remarks about kiln dimensions and the plant's high heat consumption. In point of fact, we believe the Sokoto kiln equipped with a tower with a Humboldt type exchanger (1) with 4 cyclone collector stages (there is only one

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(1) Now all cement mill equipment builders construct towers of this type.

at the present time) could produce at least 500 t. daily of clinker with heat consumption of less than 900 therms per ton.

Given this possibility it is certain that :

1/ - the dryer would not be fed with hot enough gas, but the existing auxilliary furnace should permit, by supplying additional hot air, adjusting the temperature of kiln fumes to that needed to dry the raw materials,

2/ - the raw material grinder, equipped with the existing separator should approach the necessary production (perhaps by grinding a bit more coarsely).

3/ - homogenization with 5 tanks should be sufficient if progress is made with the process.

4/ - the capacity of the cement grinder will have to be doubled.

This solution is highly attractive from 2 points of view :

- investments, since the unit cost of the additional capacity (measured in tons per year) is less than that corresponding to the installation of a second kiln,

- fuel savings, in view of their share in the cost.

On the other hand, this has the drawback :

- of being more difficult to implement than the conventional arrangement, which has nevertheless proven its worth in Sokoto,

- of limiting output to approximately 150,000 t. annually, although tomorrow's markets appear to be even larger.

D - A TWOFOLD INCREASE IN CAPACITY USING A SECOND KILN

In view of what has just been said, it would be interesting to conceive of the second output with advanced heat exchanger devices in order to save as much as possible on fuel oil. We will limit ourselves to examining the case of a second production line closely modeled on the first.

Several aspects of the problem require examination.

The market

To avoid being subject to the initial restrictions, we would only plan an increase in capacity for profitable markets, in other words in accordance with the conclusions of Chapter VII, these constituting the 3 states nearest the cement plant and adopting 1975 as the first year of possible production. In the previous chapter, we saw that, under these conditions, a market of 150,000 t. was foreseeable. Since the plant is to have a production margin at the time it is set up, the construction of a second kiln with an effective capacity of 100,000 t. is to be planned. However, this market must first be examined more concretely than we were able to do, in other words by on-the-spot. surveys.

<u>The quarry</u>

As was outlined in Chapter III, the problem of the availability of high-quality raw materials has not been solved, even for the present plant. Thus, it is important that the indicated prospecting be started immediately, keeping in mind a twofold increase in output for the exploitation. As has been said, there is every reason to believe suitable solutions can be found but with such a margin of imprecision that the cost cannot be evaluated. We assume it will continue to be of the same order.

<u>Electricity</u>

As is stated in the corresponding appendix, the present supply remains precarious and there is absolutely no question of building a second kiln given the same conditions.

Power available from the Kainji Dam and the planned high-voltage network will provide a suitable solution, but the construction timetable must be carefully studied and adhered to. At least partial help can be provided by the present diesel power plant, should the line fail.

As has been said, we can hope for a 5 percent rate reduction which we assume will be obtained.

<u>Fuel Oil</u>

A larger contract should make it possible to obtain better prices. Due to their instability, we will not take this possibility into account.

<u>Investments</u>

In Chapter I we indicated that the cost of a twofold increase in output would require an additional investment of ₤ 3,000,000 in the form of equipment. This applies to an equivalent plant having an average capacity of 90.000 t. When considering a 100,000 t. facility, we will use the ₤ 3,300,000 figure for the investment.

A prestudy will have to be carried out to define the characteristics and list of specifications of the new plant. It will probably differ from the present facility in the homogenization. Advantage will be taken of this to better study the controls and simplify adjustment procedures.

Operating account

Proportional expenses, leaving out electric power, naturally remain unchanged in respect to our improved balance sheet for the present plant.

As concerns personnel, no additional foreigners will be required, and the staff will remain unchanged.

Another 50 Nigerian workers should be hired and trained, with the following approximate distribution :

Production (drivers, quarry and manufacture)	18
Maintenance (workshops and electrical)	18
Clerks and secretaries	8
Packing	6
	50

Corresponding annual expenses can be estimated at ₤N 15,200.

Operation of the 2 kilns it to be organised in such a manner that no additional supervisory personnel will be required.

Direct operating costs can then be estimated as follows for outputs of between an effective 70,000 and 100,000 t.

	70,000 t.	80,000 t.	90,000 t.	100,000 t.
Proportional spending (see above)	5,232	5,232	5,232	5,232
Electricity (-5%)	1,278	1,223	1,182	1,149
Personnel	0,217	0,190	0,169	0,152
Spare Parts	1,543	1,000	0,888	0,800
General Expenses and bank agios	0,425	0,375	0,333	0,300
Total	8,695	8,030	7,804	7,633
Contingencies (10% rounded off)	0,865	0,800	0,776	0,767
Total	9,56	8,83	8,58	8,40

Depreciation and profitability

By keeping the sale price at ₤N 13.5/t the margin produced by the output from the supplementary kiln added to the first one thus takes on the following values :

	70,000	80,000	90,000	100,000
Difference at ₤ 13.5	3.94	4.68	4.92	5.10
or, in absolute value, ₤ Total	275,800	374,400	442,800	510,000

As it happens, technical depreciation can total :

	Total	Depreciation
- for buildings, quarry installation, depreciation over 20 years	400,000	20,000
- for equipment to be depreciated over 10 years	7,760,000	276,000
- for rapidly depreciated equipment 4 years	140,000	35,000

Thus, it can be seen that, starting with approximately 80,000 t. annually, operation of the new kiln can begin to pay back the invested capital, and a calculation made as above, using the constant annuity method, makes it possible to throw light on the question.

Presuming the entire investment comes from a CCNN loan at 8 percent amortized over 15 years (with payment deferred by 2 or 3 years which will be necessary but which we will not take into account here), the annuity totals : 3,300,000 x 11.68 = ₡N 385,000.

By adding to this the ₡N 35,000 annually needed for the ordinary purchase of replacement equipment for the plant (in specific quarry transportation equipment for instance) it should produce an annual figure of ₡N 420,000. It can be seen this amount is reached between 85,000 and 90,000 t.

It is possible to see the fundamental importance of the long period of loan amortization within limits compatible with the technical lifetime of the equipment, since, if we wanted to amortize over 10 years at the same rate (annuity 14.90 percent), it would be necessary to annually make available more than ₡N 500,000, in other words as soon as the plant was placed in operation begin working at full output or otherwise only borrow money at 3 percent interest.

A comparison of this balance sheet with the one established for corrected operation of the kiln presently in service would permit combining the two sets of results and possibly correcting the data for the financial restructuring.

In connection with what will be said at the end of this chapter, we did not feel it useful to perform this integration, which, moreover, involves no problems, the principle of the calculation having been sufficiently outlined in preceding pages.

The twofold increase in the size of the plant thus would seem to provide a logical, effective and perhaps the only solution to the company's financial problems.

However, experts can only formally advise the CCNN against undertaking this at the present time. In point of fact, they believe they have shown that, as it is operated at the present time, irregularities in raw materials, ineffective controls, the stagnation of insufficient productivity and the dispersion of profitable and unprofitable markets make its future uncertain in the face of the competition it will be most likely facing from plants in the South in the near future.

The reorganization of production and marketing operations and the improvement in the financial situation should thus come before any other consideration. The efforts of the present management, which appear to be fully aware of these problems without perhaps having all the technical solutions in hand, cannot be allowed to become spread over other tasks which, moreover, put into practise would only complicate and interfere with present production. There is no need to increase it if this means running the risk of an increase in the total deficit (even if this resulted from a reduced per ton deficit).

Moreover, the fact must not be hidden that the financial results advanced for the twofold increase remain very fragile. The investments have not been truly studied, and the problem of the future quarry and its exploitation, which are moreover related to correction problems, has been defined but not concretely solved.

The question of increasing sales has been examined as concerns more the method than an on-the-spot survey. As it is, all these questions are fundamental. As such, the experts, extremely reserved about any decision pertaining to an immediate expansion, can on the contrary only encourage the CCNN and NNDC in immediately undertaking the study, since this would be a true, logical solution to the company's difficulties.

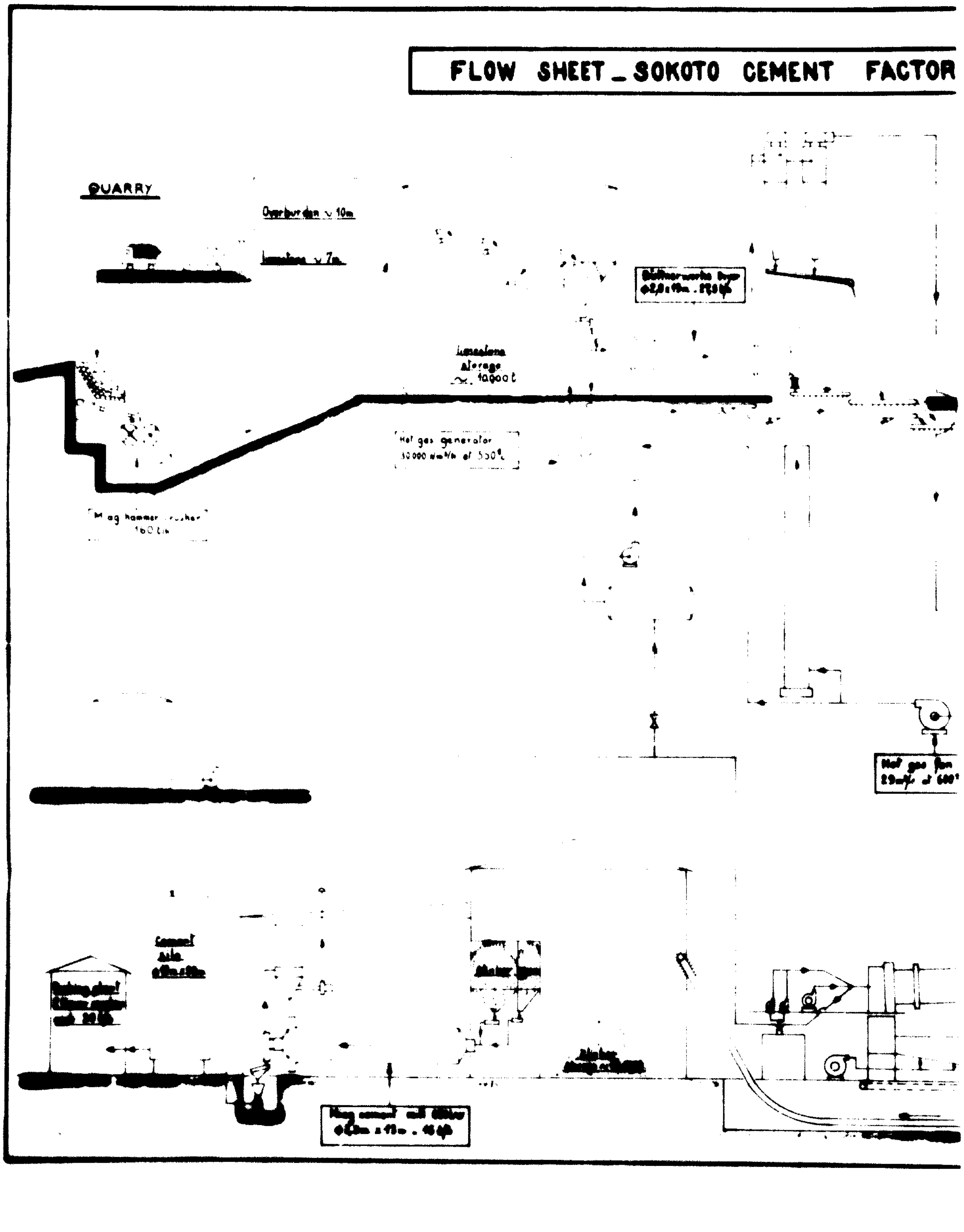
The experts, however, cannot overemphasize the fact that this study, carried out as thoroughly and completely as possible, constitutes the preliminary step to any decision if the investing organizations do not want to run the risk of becoming involved in a new financial adventure.

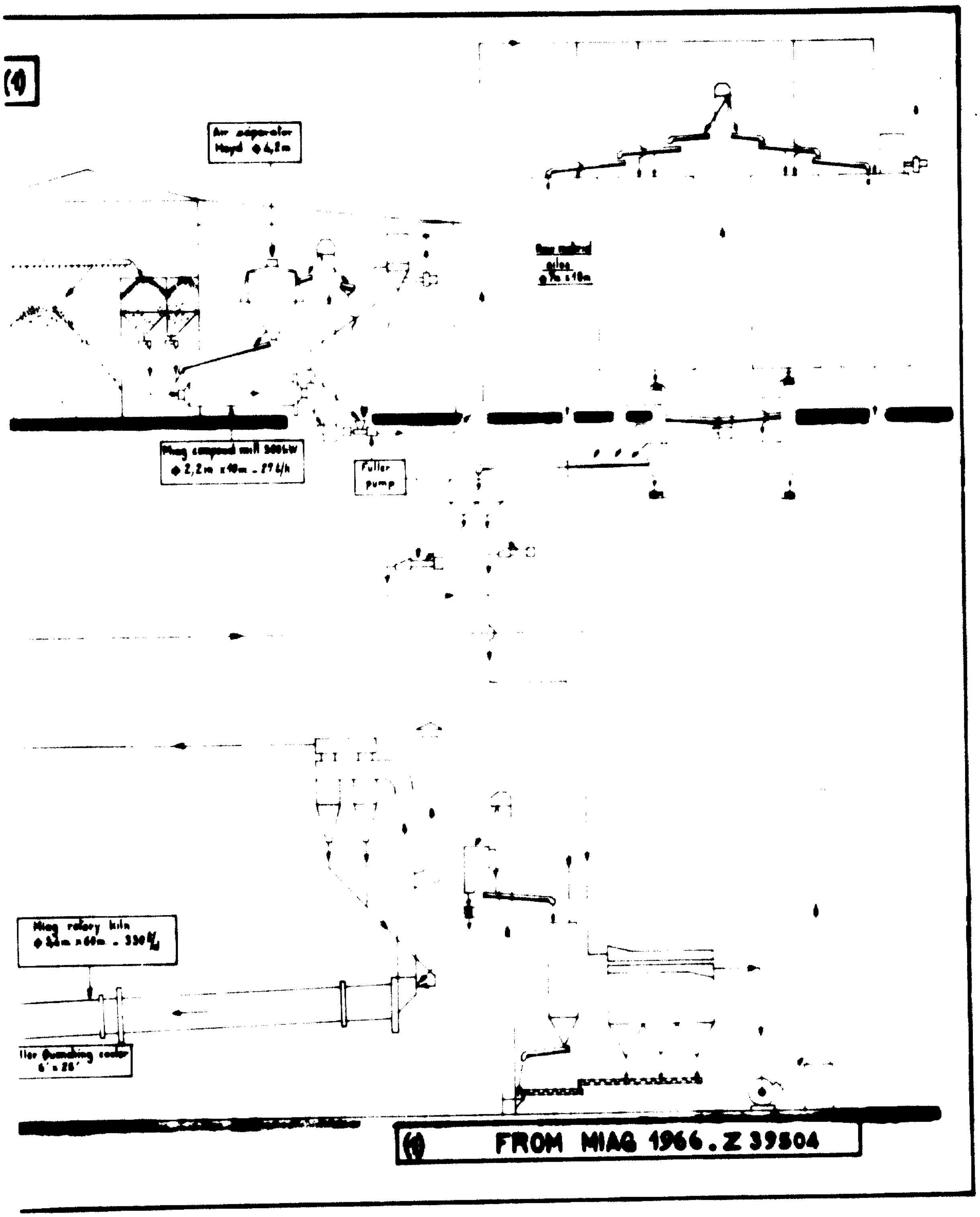
APPENDIXES

APPENDIX TO CHAPTER I

Flow sheet

Electric power supply


FLOW SHEET _ SOKOTO CEMENT FACTOR
QUARRY



(4) FROM MIAG 1966. Z 39504

determines the amount of high-concentration limestone to be added to obtain the desired concentration. Such calculations are to be performed every hour starting when the silo contains 5 to 6 m of raw material (or 60 percent of the height determined to be valid in obtaining proper homogenization).

Thus, in Sokoto tanks having within two points of the desired concentration, can be obtained, and in most instances this will give a concentration lower than the desired concentration due to the rather low limestone content of the various layers being worked (1).

Following homogenization, the necessary correction must be performed using the homogenization elevator and taking the necessary quantity of overproportioned raw material stored for this purpose in a silo. New homogenization (and, as required, a new check) will make it possible to send the properly proportioned raw material to the kiln or intermediate storage silo kept in a state of homogenization.

A better solution would consist of setting up at the raw material grinder output a sampler (acceptable equipment is available) permitting the determination of the average quality of the ground raw product during each one-hour period and thus the more reliable determination of the correction to be made to bring the silo to the desired concentration.

Lastly, ideally, a scale should be available at the grinder feed, a scale which would permit the determination of which tonnage corresponds to the average hourly sample.

However, the feed scales, although easy to use, are difficult to maintain if they are to produce accurate, faithful readings (2).

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(1) If there is 3 percent $MgCO_3$ in the raw material and if 75 percent $CaCO_3$ is to be obtained, this will give tanks having between 73 and 76 percent $CaCO_3$.

(2) In Europe and the USA, modern plants are now equipped with :

- a prehomogenization installation permitting minimum corrections at the grinder input ;

- or else continuous sampling combined with continuous analysis by fluoroscopy and a computer. This computer continually adjusts the correction quantity required to fill the tanks at the desired concentration.

B - Recommendations

The goal to be attained is plant operation and the manufacture of good quality cement with the smallest possible number of personnel and especially foreign personnel. However, and this is a national duty, it is also necessary to raise the general level of the personnel's

APPENDIX

Electric Power Supply

A/ - E.C.N. Power Station

The cement factory is connected to the Sokoto network which is supplied by a power station located 12 miles away, along the Gusau road (cf diagram) (1). The site of the power station was selected as far away due to the fact that the resistance of the soil was sufficient only on this location ; elsewhere, piers would have been required. However, the absence of water on the selected site has necessitated cooling in a closed circuit. This station was built in 1965 at the same time as the cement factory and it cost £ 630.000.

The power station is presently comprised of 3 MAN sets with a capacity of 1.500 KW and supercharged with 9 cylinders with a 300 r.p.m. speed and coupled to SIEMENS alternators with a capacity of 1900 KVA. A place has been prepared for a fourth generator set which at the final moment was sent to Kano.

The three generator sets are overworked, respectively totalling 21.200 hours and 1600 hours for N° 1 and N° 2 in March 1971. Only N° 3 has recently been overhauled and since this time totals 2800 hours. The average consumption of these sets is 0.60 lb/fuel per KWh produced. The fuel is delivered on the basis of the same conditions and by the same means as for the cement factory. The total operating labor force is comprised of 36 men.

It should be noted that there is a large shortage of spare parts and a lack of workshop equipment (no machine tools), thus the major repairs must be performed by outside services, and in particular at the cement factory.

The generator sets supply a common trunk and two antennae by means of two 5000 KVA transformers ; one antenna leads to Sokoto and the other 33 KV antenna leads to the cement factory.

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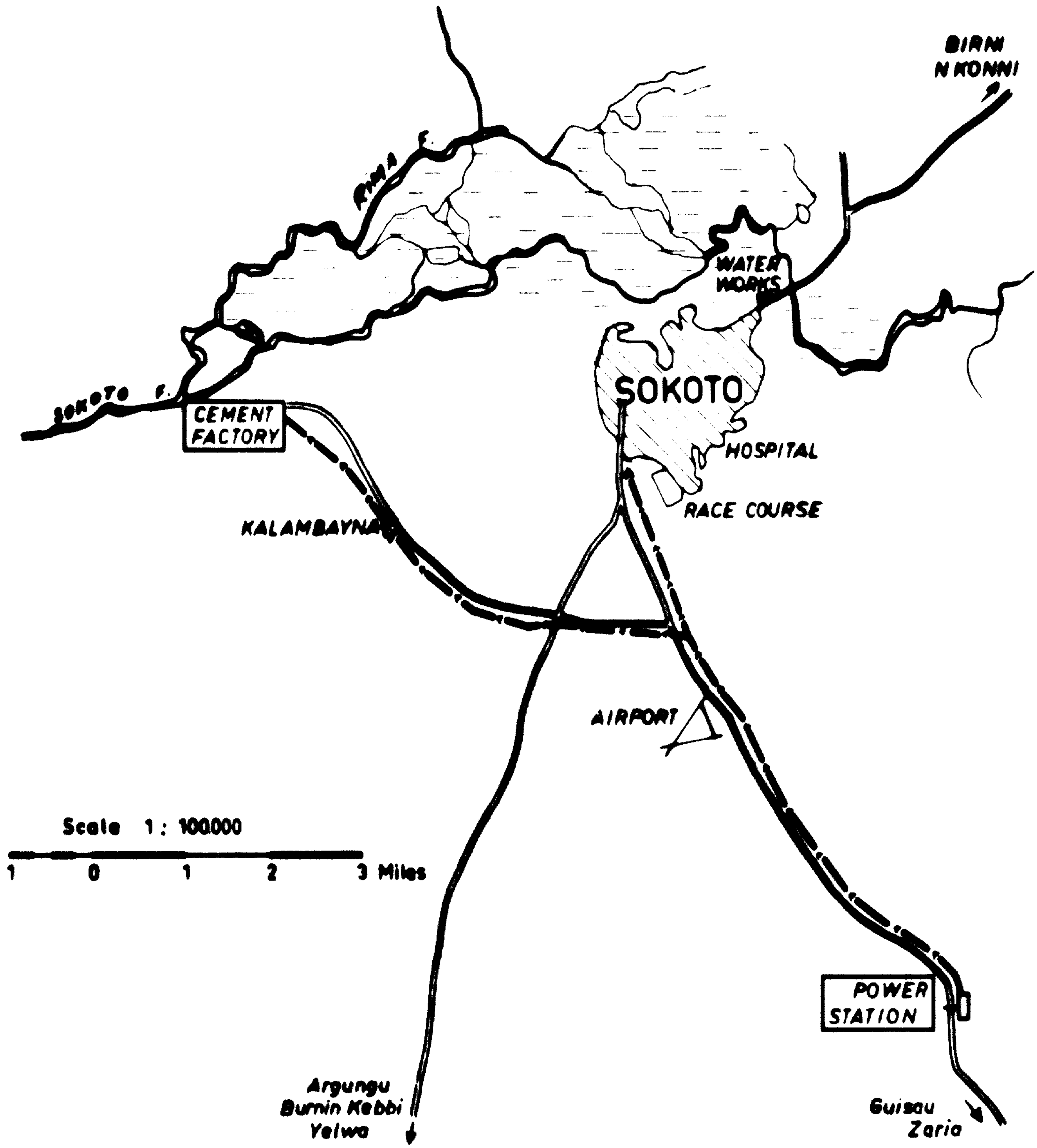
(1) This distance required the installation of a permanent short wave line between the factory and the power station

ELECTRICITY SUPPLY



The latter has a 5000 KVA 33/11 KV terminal transformer at the exit of which the compacting takes place. The 11 KV line feeds a 3500 KVA 11 KV / 6.6 KV transformer. The factory is in fact supplied with 6600 V which is the voltage of the motors of the raw mill crusher (500 KW) and the cement crusher (650 KW). Two 1250 KVA 6600/230-400 V transformers supply the other ancillary equipment.

B/ - Safe Power Supply Conditions

The fact that there are only 3 generator sets at the power station means that the guaranteed power is 1500 kW (the overhauling of a set requires 3 or 4 weeks and in this interval, one of the sets which remains in service could have a failure and the normal maximum power is 3000 kW. The peak power capacity recorded in March 1971 is 2850 and was provided by two motors of which one was considerably worn down.

The power absorbed by the cement factory is 1800 KW with a normal power factor of 0.8 and a relative constancy. There is, of course, the possibility of turning off the cement mill (750 KW with accessories) whenever necessary.

The city of Sokoto currently absorbs 600 KW, but the power consumption does not correspond to that of a city of 100.000 inhabitants and demand is clearly quenched. It is increasing, however, by 200 KW a year and new extensions are progressively provided (Secretariat General of the Government, new hospital, college, continuation of general electrification, public lighting, tannery project requiring 350 KVA).

The present situation may thus be considered critical and measures have been taken by the E.CN. to solve this problem. Due to the arrival of current from the dam of Kainji to the Kano station several months ago, the MAN set of this station has become available and is currently being transfered to Sokoto where a place has already been provided for it.

This operation should be completed in the summer of 1971 but the state of fatigue of the generator sets 1 and 2 requires overhaul without any further delay and the operations should be planned with this factor in mind. After this overhaul, the guaranteed power will be 3000 KW and the normal power 4500 KW, thereby allowing for the extension programs planned for this network.

Within two years these extensions should be completed and with the normal development of the consumption of the town, the situation will become tight. For example, it will not be possible to plan the doubling of the cement factory.

However, a project has been included in the Plan for drawing a 132 KV line from Zaria to Gusau which is part of a high voltage network (330 and 132 KV) (Grid) supplied by Kainji.

This latter hydroelectric station designed for 12 Kaplan turbine generator sets with 80 MW, has already received four in 1969 which at present do not operate at full capacity. Thus, it would be advisable to encourage, as of now, the project for a line from Gusau to Sokoto.

The power stations of Gusau and Kano could then be closed down, those of Kaduna and Sokoto being maintained for standby power which is necessary for reliable electric power for towns. It may be inadequate for the industry in a region where tornadoes are formidable (12 towers knocked down in 1970 resulting in 4 days without power) and where the stopping of operations in a factory are very costly (for the Sokoto cement factory ₤ 1580/day for fixed costs alone).

The 132 KV Kainji-Sokoto line forming a loop should also be encouraged ; this line goes directly from Kainji to the north via Yelva and Birnin-Kebbi with a high voltage station at Argungu (from where the Sokoto branch would leave) in the direction of Dosso and Niamey. The provision of the line from Kainji to Sokoto is included in the Plan and should be installed for 1974.

C/ - Tariff rates

The following extract is taken from the E.CN. Tariff Rate Schedule C which bears on the industrial tariff rates and which applies to the cement factory.

As complementary information we are providing the monthly rates for the other low voltage applications :

	Schedule A (230V single phase) per KWh		Schedule B (400 V three phase) per KWh
	Lagos, Port Harcourt	Other Regions	
first 20 KWh (minimum charge)	£ 1	£ 1	£ 1
next 130 KWh	from 4.5 to 3 d/KWh	5.5 - 4	5.5 d
more than 200	3 d/KWh	3	5 d
next 2000 KWh	-	-	4 d
all over 2500	-	-	3 d

For B a power demand charge is added per KVA :

30 Shillings between 5 and 10 KVA
25 Shillings over 10 KVA

It should be noted that there is little difference in the rates beyond 20 KWh for the various schedules, while A and B are on low voltage and thus require more costly installations.

This system, which corresponds to the presence of small scattered power stations, is exceeded by the installation of high voltage networks and lines over long distances.

This does not come within the standpoint of the policy on power distribution (too expensive for first 20 KWh, too cheap over this) and the industrial application (too high demand charge).

SCHEDULE C

Three-Phase Service Tariff With Maximum Demand Metering

AVAILABILITY OF SERVICE

Applicable to medium and large commercial/industrial consumers who will normally be connected to the Corporation's three-phase medium or high voltage supply.

HOURS OF SERVICE: 24 Hours.

CURRENT, PHASE AND VOLTAGE

Alternating Current, 50 cycles/second, three-phase. The voltage may be 400 V; 3,300 V; 6,600 V; 11,000 V; 33,000 V; 66,000 V or 132,000 V.

TARIFF PER MONTH: Applicable in all Undertakings throughout the country.

PART (a): POWER DEMAND CHARGE	£	s	d
First 75 kVA of Demand or less	75	0	0 (min. charge)
All additional kVA of Demand at	1	0	0 per kVA or part thereof

PART (b): ENERGY CHARGE

First	5,000	kwh at	4d per kwh
Next	5,000	kwh at	3.5d per kwh
Next	40,000	kwh at	3d per kwh
Next	100,000	kwh at	2.5d per kwh
Next	850,000	kwh at	2d per kwh
All over	1,000,000	kwh at	1.7d per kwh

DISCOUNT

There is discount on electricity bills of consumers supplied at high voltages as shown in the following table:

Supply Voltage	Discount
3300 V; 6600 V; 11000 V	2%
33000 V; 66000 V	3%
132000 V	5%

DETERMINATION OF MAXIMUM DEMAND

The Corporation shall install maximum demand meter in the consumer's premises. The consumer shall pay a Maximum Demand Metering Contribution for each metering set depending on the size of the meter required.

Maximum Demand Meter will be read monthly at the scheduled meter reading date. The normal billing demand is the highest single reading of the demand meter established during the billing period.

MINIMUM CHARGE

The minimum charge shall be £75 per month.

APPENDIX TO CHAPTER II

Detailed run of the factory

Complete list of samples analysed by LAFARGE laboratory

Analysis of a Sokoto cement sample

Microscopic study of clinkers

ANNEX II

DETAILED RUN OF THE FACTORY

A = A number of days with continuous run
B = " " 23 and 24 hours run (less then 1 hour stoppage)
C = " " 16 and 23 hours run (between 1 and 8 hours stoppage)
D = " " 8 and 16 hours run (more then 8 hours stoppage)
E = " " of complet stop.
F = number of working -hours of the kiln for the month
G = tonnage of clinker produced inthe month (calculated for the estimated raw material utilized

	A	B	C	D	E	F	G
Year 1967							
June	0	0	4	9	17	262	3 826
July	6	[illegible]	1	2	22	190	1 367
August	1	2	1	1	12	431	3 100
September	1	0	1	2	26	68,5	679
October	9	0	0	5	17	274,5	3 643
November	7	0	3	0	20	197	4 098
December	2	0	0	2	27	63,5	892
Year 1968							
January	6	2	4	1	18	281	3 827
February	11	2	3	5	8	420	4 871
March	17	1	3	1	9	493	7 146
April	16	0	1	1	12	406,5	5 093
May	0	0	0	0	31	0	0
June	15	0	3	1	11	425	4 849
July	5	0	1	0	25	125	1 604
August	0	0	0	0	31	0	0
September	0	0	0	0	30	0	0
October	0	0	0	0	31	0	0
November	0	0	10	3	17	293	5 299
December	17	1	1	1	12	438	8 198
Year 1969							
January	13	0	2	1	15	353,2	6 005
February	0	0	0	0	28	0	0
March	7	0	1	4	19	231	3 755
April	26	1	0	2	1	660	10 443
May	4	0	2	0	25	135,3	2 400
June	12	0	10	1	17	297	4 664
July	22	0	12	1	6	581,3	8 570
August	24	0	4	1	2	662,6	9 641
September	16	1	3	0	10	465	6 631
October	15	2	12	1	11	453,7	6 749
November	24	1	1	0	4	618	8 537
December	13	0	1	4	13	374,3	4 921

	A	B	C	D	E	F	G
Year 1970							
January	20	2	6	3	0	677,7	9 658
February	9	2	6	1	16	270,3	4 118
March	10	0	1	2	18	276,6	4 456
April	12	0	2	6	9	397,8	6 386
May	16	1	7	2	5	481,7	9 350
June	5	0	1	4	20	170	2 148
July	15	1	2	2	11	442,5	6 199
August	5	0	1	5	20	200,7	3 813
September	11	2	6	5	6	506,7	6 764
October	7	2	2	3	17	274,5	3 321
November	5	1	2	2	20	204,3	2 308
December	10	1	3	3	5	575	7 733
Year 1971							
January	9	2	5	7	8	435,4	4 929
February	14	0	1	7	6	416,2	5 578
March	6	1	5	9	10	386,4	4 546
April (23)	6	1	2	3	11		

PROSPECTION

NIGERIA

	No.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	TiO_2	CO_2	H_2O + M.V.	K_2O	Na_2O
DANGE clay	1	58,15	19,40	7,50	1,25	2,00	1,20			1,30	
Dissolving limestone	2	1,45	0,85	0,60	52,00	0,50	0,02			0,04	
Clay	3	56,60	16,55	6,70	2,90	4,00	0,94			0,71	
	4	53,00	15,40	9,00	2,60	4,80	0,76			0,55	
Shale	5	11,70	3,70	1,40	44,65	1,10	0,16			0,12	
Chalky limestone	6	0,70	0,20	0,30	54,70	0,20	0,00			0,00	
	7	4,85	1,50	1,10	50,80	0,35	0,06			0,00	
Limestone Boulders	8	0,15	0,05	0,20	55,35	0,10	0,00		4285	0,00	
Clay shale	9	56,95	14,80	8,45	1,65	4,95	1,03			0,35	
Pile of raw materials hall of the plant	14	15,70	4,30	3,30	39,80	1,50	0,19			0,17	
	15	16,45	4,50	2,80	39,90	1,60	0,19			0,19	
	16	16,55	4,55	3,00	39,8[illegible]	1,60	0,20			0,18	
	17	15,15	4,15	[illegible]	40,[illegible]	1,[illegible]	0,16			0,15	
	18	15,70	4,35	3,05	[illegible]	1,[illegible]	0,19			0,16	
	19	16,20	4,60	[illegible]	40,[illegible]	1,60	0,19			0,17	
	20	16,50	4,50	3,05	39,6[illegible]	[illegible]55	0,19			0,17	
	21	15,50	4,20	2,85	40,2[illegible]	1,60	0,18		34,60	0,17	
	22	16,05	4,45	2,90	40,10	1,60	0,19			0,17	
	23	15,85	4,40	3,00	40,35	1,55	0,18			0,17	
	24	16,30	4,35	2,90	39,80	1,60	0,18			0,17	
Pile of raw materials high per cent of CO_3Ca	25	14,65	4,20	2,10	41,90	1,25	0,18			0,13	
	26	14,35	4,00	2,15	42,05	1,25	0,18			0,18	
	27	13,50	3,85	2,00	43,10	1,15	0,18			0,14	
	28	14,10	4,10	2,10	42,10	1,10	0,18			0,13	

In all instances, further attempts can be made to improve the raw material entering the kiln by simultaneously drawing from 2 (or even three if a fifth has been built) silos containing meal ready to enter the kiln.

In conclusion, it can never be overemphasized that good cement is already prepared starting at the quarry. In Sokoto, preparation of the raw meal means :

- complete knowledge of the deposit,

- and, no matter what solution is adopted (1), the possibility of exploitation at several spots of well-known average composition in order to begin the mixing at the crusher's output.

(1) Unless a prehomogenization unit is installed.

3/ - TRAINING OF MANUFACTURING PERSONNEL

For this training, it is desirable :

- to create a fourth team (below called D if the three teams which work normally are called A, B and C),

PROSPECTION

NIGERIA

		SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	TiO_2	CO_2	H_2O + M.V.	K_2O	Na_2O	
	29	14,90	4,40	2,20	41,60	1,30	0,18			0,14		
	30	14,05	4.10	2.15	42,45	1,20	0,18			0.12		
	31	12,65	3,55	1.90	43,80	1,15	0,15			0,11		
	32	12,40	3,60	1,60	43,80	1.30	0,15			0,11		
	33	11.55	3,10	1,65	44,90	1,05	0,14			0.10		
	34	14.10	4.15	2.00	42,35	1,15	0,17			0,13		
Clinker	35	21,30	6,85	3,65	60,00	2,65	0,37		0,85	0,84		
Gypsum	36	20,20	4,00	3,50	22,95	0,80		0,50		0,35	27,85	
	37	19,70	3,80	5,15	22,35	0,70		0,60		0,36	27,75	
Pile of raw materials high per cent of CO_3Ca	38	12,15	3.40	1,70	44.40	1.30	0,15			0,12		
	39	15,15	4,30	2,10	41,25	1.45	0.19			0,16		
	40	12,70	3,90	1,95	42,40	1,30	0,17			0,13		
	41	14,25	3,95	2,00	[illegible]	[illegible]	[illegible]			0,15		
	42	14,25	4.10	2,10	[illegible]	[illegible]	0,17			0.12		
	43	12.60	3,80	1,80	43,80	[illegible]	0,16			0,12		
	44	12,25	3,50	1,95	43,85	[illegible]	0,15			0.12		
	45	14,80	4.20	2,15	41,15	[illegible]	0,19			0.15		
	46	13.85	4,00	2.05	42,40	1,35	0,17			0,14		
	47	13,45	3,90	2,05	42,45	1,40	0.16			0,13		
	48	12,90	3,85	1,80	43,25	1,20	0,15			0,13		
Big samples	49	13,30	3,85	1.85	42,35	1,25	0,16		36,15	0.13		
	50	11,20	3,25	1,60	44,95	1,20	0.13			0,11		
	51	14,45	4.05	2,00	41,60	1,75	0.15			0,13		
Dange clay	52	57,85	19,95	6,40	1,40	2,45	1,15			1,35		

PROSPECTION

NIGERIA

		SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	TiO_2	CO_2	H_2O + M.V.	K_2O	Na_2O
Brown clay of Dange	53	55,00	18,65	7,10	4,50	4,95	0,10			0,90	
Lower calcareous formation (simple from a fit) — Lower part	54	28,90	9,70	3,45	27,40	2,65	0,39			0,55	
	55	29,30	9,05	4,55	28,25	2,20	0,40		29,60	0,53	
top	56	16,15	4,20	1,90	39,55	2,10	0,47			0,20	
The whole rock face	57	10,25	3,40	1,55	42,95	1,70	0,13			0,12	
	58	13,00	3,45	1,70	42,70	1,50	0,14			0,12	
	59	8,85	2,10	1,00	47,40	1,10	0,06			0,03	
	60	15,05	4,35	2,00	40,65	1,35	0,17			0,13	
	61	11,35	2,95	1,65	44,60	1,35	0,10			0,07	
	63	22,70	6,65	3,40	33,10	2,30	0,29		30,30	0,22	
Laterite	64	16,40	11,45	58,30	1,[illegible]	[illegible],35			11,75		
	65	18,4[illegible]	9,15	1,15	[illegible]	[illegible]			9,60		
Clay shale	66	53,40	16,65	7,80	1,80	[illegible]	[illegible]			0,63	
Brown sand	67	90,40	4,40	3,35	0,[illegible]	[illegible]	0,40			0,05	
Latérite	68	53,4[illegible]	4,[illegible]	[illegible]	[illegible]	[illegible]			5,40		
	69	53,[illegible]	1,[illegible]	[illegible],55	[illegible],5[illegible]	[illegible]			3,50		
Gypsum	70	17,90	3,3[illegible]	2,8[illegible]	[illegible]3,7[illegible]	[illegible]		1,05		0,36	29,85
Sand for mortar		98,60	0,80	0,50	0,00	0,04	0,00			0,60	
Sokoto cement		21,55	6,05	3,40	64,45	2,40	0,32		1,00	0,63	

PROSPECTION

SOKOTO CEMENT

	Time	No.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	TiO_2	SO_3	H_2O + M.V.	K_2O	Na_2O		
	17h30	74	13,25	3,70	2,05	43,20	1,30	0,16		35,75	0,17			
	17h40	75	13,55	4,00	2,10	42,90	1,30	0,15		—	0,19			
	17h50	76	13,60	3,90	2,05	43,15	1,35	0,15			0,18			
	17h55	77	14,60	4,10	2,25	42,20	1,50	0,17			0,20			
	18h	78	14,45	4,15	2,25	42,25	1,45	0,16			0,21			
Raw mix from 5h30 to 6h50 P.M. on the 17 of April	18h05	79	14,35	3,85	2,25	41,95	1,45	0,16			0,20			
	18h10	80	14,35	4,15	2,25	41,90	1,52	0,16			0,20			
	18h15	81	14,75	4,10	2,35	42,40	1,50	0,16			0,21			
	18h20	82	14,55	4,15	2,20	42,00	1,50	0,17			0,24			
	18h25	83	14,20	4,05	2,20	42,65	1,40	0,16			0,21			
	18h30	84	13,85	4,05	2,15	43,05	1,40	0,15			0,21			
	18h35	85	13,85	4,10	2,10	42,95	1,20	0,15			0,15			
	18h40	86	13,95	4,05	2,10	42,90	1,30	[illegible]16		35,10	0,15			
	18h45	87	14,05	4,10	2,10	42,55	[illegible]	[illegible]16			0,15			
	18h50	88	13,75	3,90	2,15	42,85	[illegible]	0,16			0,14			
		101	11,85	3,40	1,75	45,00	1,05	0,13			0,13			
		102	11,20	3,40	1,85	44,70	1,05	0,14			0,15			
		103	11,40	3,40	1,85	44,70	1,10	0,13			0,14			
Raw mix		104	11,20	3,40	1,80	44,75	1,00	0,13			0,15			
		105	11,90	3,35	1,80	44,75	1,15	0,14		35,52	0,12			
		106	11,75	3,40	1,80	44,60	1,20	0,14			0,12			
		107	11,70	3,30	1,85	45,00	1,10	0,14			0,12			
		108	11,75	3,85	1,30	45,10	1,10	0,15			0,15			
		109	11,90	3,40	1,80	44,70	1,15	0,15			0,13			

PROSPECTION

SOKOTO CEMENT

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	TiO_2	CO_2	H_2O + M.V.	K_2O	Na_2O		
110	11.95	3.45	1.75	45,10	1.15	0.15			0,13			
111++	11.85	3.45	1.80	44.70	1.15	0.14			0.12			
111	12,90	3,70	1.95	44.25	1.15	0.15		36,10	0.11			
113	12.90	3.85	2.00	43.55	1.20	0.15			0.13			
159	13.50	3.85	2,25	43.10	1,25	0.16			0.14			
160	13.50	4,10	2.15	42,90	1.25	0.16			0.12			
161	11.85	3,50	1.80	44.95	1.15	0.14			0.13			
162	11.90	3,35	1,75	44.65	1,20	0.13			0,12			
163	14.40	4.10	2.50	42,00	1.20	0.18			0.13			
164	11.80	3.25	1.75	44.55	1.15	0.12			0.13			
165	11,90	3,35	1,75	44.75	-1.20	0.13			0.13			
166	11,60	3,45	1.80	44.95	1.10	0,14			0,12			
3h A	14,50	4,20	2,50	41,45	1,30	0.17			0,14			
18h B	12,45	3,65	1.85	44,40	[illegible]	[illegible]		36,10	0,12			
19h C	12,70	3,70	2,05	43,70	[illegible]	0,14			0,13			
2h D	13,40	3,65	2,10	41.90	1,20	0,14		35,60	0,12			
1h E	13,90	4,05	2,20	42,65	1,30	0,15			0,14			
4h F	12,70	3,75	2,00	44,15	1.15	0,14			0,12			
22h G	12.25	3.60	1.95	44,30	1.10	0,13			0,12			
21h H	13.10	3.85	2,00	43,65	1,20	0,14			0,13			
20h I	13.25	3.85	2,20	43.50	1,30	0.15			0,15			
17h J	12,00	3,75	1,80	44,55	1,10	0,13			0,11			
23h K	12.50	3,75	1,90	44,20	1,10	0.14			0,12			

Raw mix from
5h P.M. to 4h
A.M.
April 1971

CENTRE D'ÉTUDES ET DE RECHERCHES DE L'INDUSTRIE DES LIANTS HYDRAULIQUES

CENTRE TECHNIQUE INDUSTRIEL · LOI DU 22 JUILLET 1948

LABORATOIRE
23, RUE DE CRONSTADT
PARIS-XV^{e} - TÉL. : 532 58 40

PARIS, le [illegible] Juillet 1971.

V/Réf. : Y. [illegible] [illegible] [illegible] [illegible] GÉOLOGIE du 1.[illegible].71

N/Réf. : L-MV(41).[illegible]/5589 Essai N° [illegible].096 - [illegible]

CIMENTS LAFARGE
Usine de Boussens
B. P. N° 5
31 - BOUSSENS

Échantillon de ciment de [illegible]

Masse volumique : [illegible],21 g/cm^3
Surface spécifique [illegible] : 3770 cm^2/g
Eau de gâchage : [illegible],9 %
Début de prise (pâte pure) : [illegible] h [illegible] mn — **Pas de raidissement**
Fin de prise (pâte pure) : 5 h [illegible]0 mn — **Expansion ASTM** : 0,07 %

Résistances mécaniques

AFNOR	bars							Médianes
1 jour	TF	1		1,5		1,6		1,5
	C	8	8	8	8	8	10	8
[illegible] jours	TF	28,5		28,5		33,0		28,5
	C	85	90	95	100	100	105	98
7 jours	TF	58,2		60,0		70,5		65,0
	C	175	180	185	185	190	190	185

L.S. ([illegible])

				Moyenne [illegible]	Moyenne exprimée en bars
1 jour	1[illegible]5	[illegible]	[illegible]	[illegible]50	11
3 jours	[illegible]	1750	1700	1730	123
7 jours	[illegible]	[illegible]	[illegible]	2900	204

B.S. (avec sable ayant une granulométrie aussi voisine que possible de celle du sable de [illegible])

1 jour	480	460	540	500	35
3 jours	2700	2640	2990	2650	200
7 jours	4700	4640	4840	4800	336

Le Chef de la Section Mécanique-Physique :

P. LEVY.

MICROSCOPIC STUDY of CLINKERS

FROM SOKOTO

The examination under the microscope has been made of polished sections of rejects from the cement mill and of clinkers picked in SOKOTO hall.

1 - LIST of SAMPLES

S. 73 - Dark clinker, manufactured April 1971

SC. 10 - Clinker considered as poor, manufactured before July 1970. Each sample shows a particular aspect : grey, beige or black coloured with variable apparent porosity.

SC. 37 - Projects from cement mill, ground April 1971 Rounded particles 3 - 5 mm diameter.

.../...

2 - COMPARATIVE MICROSCOPIC STUDY

	S 73		SC 10 - 11 - 12 - 13 - 14	
Alite	Prevailing phase Polygonal crystals Clinker having stayed for too long in the burning zone (overburnt)	$\sim 50\%$	Scanty phase (very small for SC 13 $\leqslant$ 10%) more or less well formed crystals	$\sim 30\%$
Belite	Normal phase Crystals slashed into lamellas with sometimes 1 series of strias Belites show themselves as well enough dis- tributed areas $\leqslant$ 600 µm	$\sim 25\%$	Abundant phase Slashed aspect Belites show themselves around the edges and as areas up to 1000 µm	40-50 %
Celite	Entangled aspect $C_4AF > C_3A$	$\sim 15\%$	C_3A crystals $C_4AF > C_3A$	$\sim 15\%$
Free Lime	Some areas $\leqslant$ 200 µm Irregularly distributed	0-1 %	Areas $\leqslant$ 250 µm in SC 12 - 13 - 14 no detected in other samples	1-2 %
Magnesia	Plentiful isolated and joined crystals 5-20 µm diameter	2-3 %	Plentiful isolated crystals 5 - 20 µm diameter	2-3 %
Porosity	Medium to great		Great Lesser for sample SC 14	

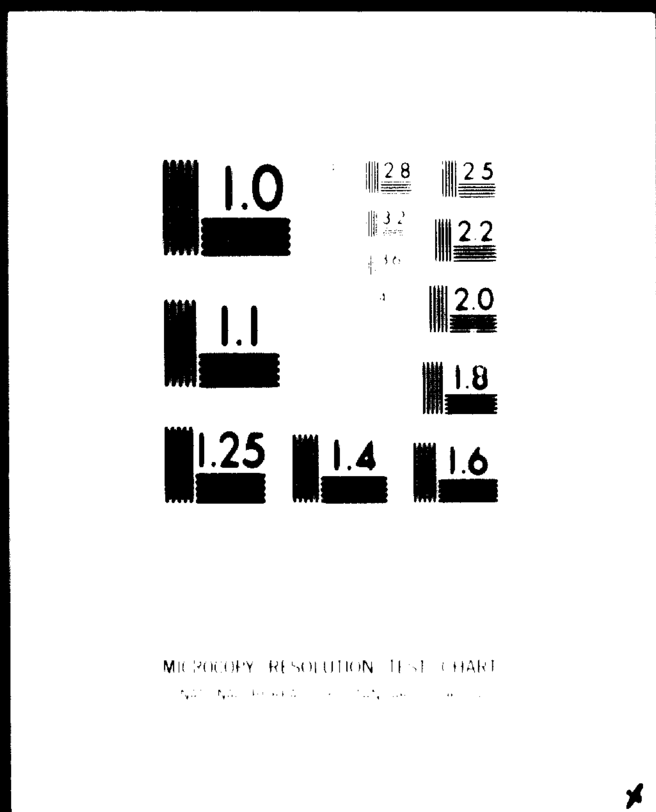
B - 563

→

81.08.28

3 OF 3

01865



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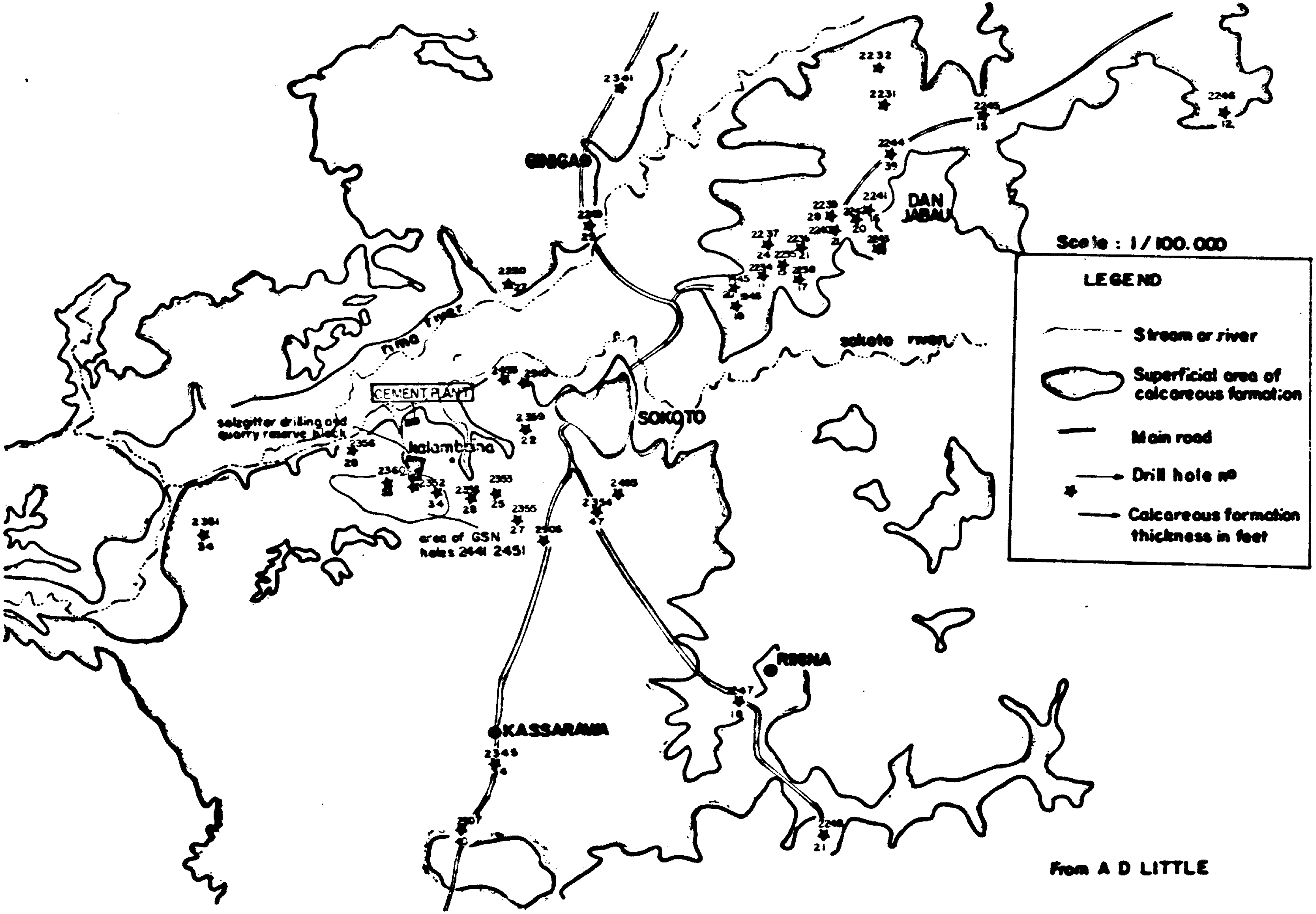
D

NOTE ON REGIONAL GEOLOGICAL SURVEY

The attached table and map, drawn from the report by A. D. Little, briefly indicates the results of the geological surveys carried out in the Sokoto region by the GSN.

It would appear that, for the 30 borings, including 21 located outside the Kalambaina area, we only know the thickness of the formation crossed; that seems not enough to us. It would have been desirable to also know the percentage of core recovery and the chemical analysis of each formation. These informations would be very precious for a prospection of limestone outside of the actual claims of the plant.

CALCAREOUS FORMATION DRILLING & GEOLOGY



From A D LITTLE

TABLE C-1

GEOLOGICAL SURVEY OF NIGERIA RANDOM DRILLING NEAR SOKOTO

Hole No.	Completion Date	Total Length (ft)	Collar Elevation	Kalambaina Area	Calcareous Formation Elevations: Top, Zone 2	Top, Zone 4	Bottom, Zone 4	Total Thickness	Lab. Report No.	Zones 2 and 3: Thickness	Core Rec. (ft)	Core Rec. (%)	$CaCO_3$ (%)	Zone 4: Thickness	Core Rec. (ft)	Core Rec. (%)	$CaCO_3$ (%)
1945	14/12/59	106	933	No	--	--	887	20	1042	10	--	--	--	10	--	--	--
1946	7/ 1/60	45	933	No	--	--	887	19	1046	9	--	--	--	10	--	--	--
2234	17/ 3/60	50	949	No	--	--	906	11	1062	3	--	--	--	8	--	--	--
2235	22/ 3/60	59	963	No	--	--	909	15	1062	5	--	--	--	10	--	--	--
2236	26/ 3/60	61	969	No	--	--	910	21	1062	11	--	--	--	10	--	--	--
2237	5/ 4/60	74	961	No	--	--	891	24	1069	14	--	--	--	10	--	--	--
2238	7/ 4/60	42	946	No	--	--	909	17	1069	9	--	--	--	8	--	--	--
2239	12/ 4/60	60	972	No	--	--	916	28	1069	19	--	--	--	9	--	--	--
2240	14/ 4/60	53	957	No	--	--	908	21	1069	15	--	--	--	6	--	--	--
2241	20/ 4/60	44	965	No	--	--	926	16	1069	**	--	--	--	**	--	--	--
2242	23/ 4/60	53	967	No	--	--	920	20	1069	11	--	--	--	9	--	--	--
2243	26/ 4/60	45	967	No	--	--	925	14	1069	5	--	--	--	9	--	--	--
2244	3/ 6/60	78	997	No	--	--	925	39	1081	29	--	--	--	10	--	--	--
2245	10/ 6/60	47	999	No	--	--	958	15	1081	7	--	--	--	8	--	--	--
2246	21/ 6/60	62	1086	No	--	--	1045	12	--	6	--	--	--	6	--	--	--
2247	13/ 7/60	36	1005	No	--	--	[illegible]	18	1097	10	--	--	--	8	--	--	--
2248	17/ 7/60	39	1064	No	--	--	1031	21	1097	13	--	--	--	8	--	--	--
2249	28/ 6/60	76	896	No	--	--	849	25	1087	**	--	--	--	**	--	--	--
2250	29/ 6/60	68	855	No	--	--	822	27	1087	17	--	--	--	10	--	--	--
2345	26/ 7/60	66	937	No	--	--	875	34	1097	24	--	--	--	10	--	--	--
2351	1/ 8/60	69	830	No	--	--	765	34	1097	26	--	--	--	8	--	--	--
2352	5/ 8/60	84	913	Yes	856	843	823	34	1103	23	16	70	89.7	11	11	100	69.0
2353	9/ 8/60	45	903	Yes	887	872	862	25	1106	15	11	73	78.5	10	10	100	60.5
2354	12/ 8/60	[illegible]	975	Yes	933	896	886	47	1106	37	24	65	86.8	10	10	100	64.2
2355	16/ 8/60	51	916	Yes	894	876	867	27	1106	18	14	78	77.5	9	8	89	63.2
2356	19/ 8/60	60	846	Yes	818	804	790	28	1106	14	12	86	51.0	14	14	100	65.3
2357	26/ 8/60	104	903	Yes	861	815	803	58	1103	46	33	72	84.9	12	12	100	61.3
2358	29/ 8/60	66	915	Yes	887	871	859	28	1106	16	12	75	80.4	12	11	92	62.5
2359	1/ 9/60	60	902	Yes	867	856	845	22	1106	11	10+	95	60.4	11	11	100	68.7
2360	3/ 9/60	76	890	Yes	871	828	818	53	1103	43	33	77	87.7	10	10	100	65.8
							Kalambaina Area Only										
Total	34 Days	546	--	--	--	--	--	322	--	223	165	--	--	99	97	--	--
Average	4 Days	68	--	--	--	--	--	36	--	25	18	74	--	11	10+	98	--

**Undifferentiated

Source: GSN Report No. 1182.

APPENDIX TO CHAPTER IV

Fuel sample analyse

Annex

FUEL SAMPLE ANALYSIS

A sample of the fuel used in the factory in April 1971 was taken at Sabeto and studied by OCCR in Paris. The results are :

It is a fuel of rather good quality with low ash content. This fuel includes probably some asphalt.

It is possible, according to the low calorific value and the low sulfur content, that this product would be a blend of domestic fuel oil (n° 1) and heavy fuel (n° 2), and this fact could create risks of segregate by density for utilisation.

It would be possible to verify this eventuality by testing the distillation curve of the product. The distillation point of the domestic fuel is in fact at 80 - 90° C, that of the heavy fuel at a higher temperature.

16 JUIN 1971

Paris, le 14 Juin 1971

OCCR

ORGANISATION . CONCEPTION
CONTRÔLE . RÉALISATION

[illegible]
[illegible]
[illegible]

[illegible], PARIS-14e

Téléphone : [illegible]
Télégrammes : [illegible]

SERVICE APPLICATIONS - LABORATOIRES

CIMENTS LAFARGE
Usine de Viviers
B.P. N°8

07 - VIVIERS S/ RHONE

PROCÈS-VERBAL N° 3.770

Analyse demandée le 3/6/71 (Réf. Y DERREAL/DD 2012)

Echantillon reçu le 8/6/71

DÉSIGNATION : Echantillon de fuel "SOKOTO" GEOLOGIE

- Masse Volumique à 15°5 C. # 60 F.	0,9626
- Viscosité à 37°8 C. # 100 F.	(80,0 cSt (10,53 E.
- Viscosité à 50° C. # 122 F.	(40,86 cSt (5,44 E.
- Viscosité à 70° C. # 158 F.	(18,09 cSt (2,65 E.
- Viscosité à 90° C. # 194 F.	(9,[illegible]6 cSt (1,[illegible]7 E.
- Teneur en soufre	[illegible],02 %
- Teneur en cendres [illegible] C.	0,022 %
- Teneur en eau	0,[illegible]5 %
- Teneur en sédiments	0,029 %
- Teneur en hydrogène	11,22 %
- Teneur en carbone	87,40 %
- Teneur en azote	0,15 %
- Teneur en oxygène (par Dif.)	0,11 %
- Pouvoir calorifique supérieur	10.420 mth/kg
- Pouvoir calorifique inférieur	9.814 mth/kg
- Point d'éclair "Luchaire"	156° C.
- Point d'écoulement	- 20° C.

Le Chef du Service Applications :

APPENDIX TO CHAPTER VII

Cement railway tarification

Annex to the Chapter VII

CEMENT RAILWAY TARIFICATION

(from tarification n° 7 - November 1970)

For nigerian cement : special rate n° 2 - tarification B

For imported cement : tarification D

Miles	B (sh/t)	D (sh/t)	Miles	B (sh/t)	D (sh/t)
10	12	18	500	94	120
20-30	13	19	525	100	126
30-40	14	21	550	102	128
50	16	24	575	105	131
60	17	27	600	108	134
80	22	32	625	113	139
100	28	38	650	115	141
125	35	45	700	120	146
150	42	52	725	126	152
175	48	58	750	128	154
200	52	62	800	132	158
225	56	70	825	135	161
250	59	76	850	137	163
275	62	80	875	140	166
300	66	84	900	142	168
325	70	93	950	147	173
350	74	98	1000	152	178
375	78	103	1050	157	183
400	80	106	1100	162	188
425	85	111	1150	172	198
450	90	116			
475	92	118			

APPENDIX TO CHAPTER VIII

Use of groundnuts shells

APPENDIX

Use of groundnuts shells

The chapter on profitability showed how important was the share of fuel in the making of the cement price since that share reaches at present almost 24 % and will not decrease beneath $\frac{2.7}{13.5} = 20\ \%$

The only resource of Sokoto State in fuel except wood seems to be the shells of some seeds (groundnuts, cotton) the calorific value of which reaches 4 000 kilo calories per Kg. on the completely dry product

The importance of the local grounduts crop (1) which is fully exported under the shelled form and the example of the Malbaza cement factory in Niger naturally lead to raise the question of substituting, partially and even completely, the groundnut shells to the cement plant fuel

In the countries producing groundnuts or cotton you will often find that the shell around the seed is used as fuel for burning : hereafter are a few examples.

1) - Into the five groundnut oil plants in Senegal which buy groundnuts in their shells, the shells are burnt under relatively low pressure boilers of the classical type. The steam is used inside turbo-groups which may reach thousands of KW and supply the integrality of the driving power, the refining included. A variant solution (the case of Kaele cotton oil works in Noth Cameroon) uses this steam inside less powerful piston steam engines.

2) - The initial project of a cement factory in Bargny near Dakar, prepared in 1939, provided for the gasification of ground nut shells into gas generators. The gas produced was delivered at poor gas motors. The equipment was bought then, but not erected because of the war. The cement factory was built in 1948 on a double scale and this type of power was given up for diesels of the classical type.

. . .

(1) The crops would have reached, under shells form, the following tonnages in the Sokoto State :

62 - 63	108 000 t	66 - 67	142 000 t
33 - 34	100 000 t	67 - 68	90 000 t
34 - 65	94 000 t	38 - 69	81 000 t
65 - 66	119 000 t	69 - 70	75 000 t

The figure of 70-71, yet not well known, seems to stand around 45 000 t, commercialized in Nigeria (bad weather conditions ; a few sales to Niger).

3 - **CONCLUSIONS from the MICROSCOPIE EXAMINATION**

S. 73

Normal clinker. Overburnt. Alitic phase : medium.

SC 10 - 11 - 12 - 13 - 14

Very heterogeneous clinker, undersaturated very abundant belitic phase, especially in sample SC 13.

Samples SC 12 - 13 - 14 correspond to weathered clinkers. The quantity of CO_2 in those 3 samples could cause false set due to carbonates.

The periclase, distributed as isolated crystals, indicates the dolomitic nature of the limestone.

Porosity is greater than for clinker S 73.

S. 35 - Casts from cement mill

Alite	:	very scanty phase more or less well formed crystals	< 10 %
Belite	:	very abundant phase ; the C_2S areas correspond to a grain size 5 mm	50-60 %
Celite	:	C_3A crystals, $C_4AF > C_3A$	15-20 %
Free lime		not observed	
Magnesia	:	isolated crystals	2-3 %
Porosity	:	low enough	

For all those clinkers, the C_2S with 1 series of strias, corresponds to a rather low burning temperature, under 1450°C.

The reaction is easy because of the abundance of the liquid phase.

.../...

3) The Malbaza cement factory which produces 110 t/day uses pulverized groundnuts shells. They are directly blown in the fuel nozzle of the kiln. The proportion of shells corresponds to 30 to 60 % of the calories to be supplied. The normal running seems to be 30 to 40 %. This last process is by far the least expensive as regards the investment requirements. It seems to be the most appropriate in the Sokoto case. Nevertheless, before examining its profitability, it is necessary to state precisely the scale of tonnage and price of available shells, for this is one of the most critical points and probably the stumbling block of the problem.

1 - Available tonnage and price of the shells

In the present study, we shall systematically choose optimistic assumptions in order to reach a maximum possible profitability. As previously stated, the average crop in shelled groundnuts, may be evaluated to 90 000 tons, if we suppose that the dicrease of the last few years is accidental or that it results from a leakage towards Niger due to a temporary shifting of the quotations and of the exchange rates. This tonnage corresponds more or less to 45 000 tons of shells ; the output of the shelling process, i. e. 66 %, is not excellent in the system used which is the shelling on the workings by little hand machines (1) operated by women. But, these shells are scattered in all countrymen's farms and few are gathered on markets. Thus the total shells the main part of which is rejected and lost unused, are not in fact available and due to their low density they are hardly transportable.

It is thus impossible to know beforehand which could be practically made available. It is a question of payment of the additional transport which should be asked then to the producer, including the cost of the necessary corresponding packing.

. . .

(1) The price of each small hand shelling machine, is 12 £ N The two thirds of this price are subsidized by the Marketing Board. The working of these machines is rudimentary and it causes a lost of seeds. The output in Senegal is 70 % in central stations. Such an experiment was attempted in Katsina with Boby machines but was not carried on.

After several talks about this question in Sokoto and in Kaduna, we agreed on the price of 2 £ per ton paid to the producer. This price corresponds :

- for two thirds, to the purchase of the product to the Marketing Board which is regularly the only one enabled to deal for this product. This amount, i. e. 1 7 £ almost corresponds to the half of what was required, but not yet obtained, by SONARA, a shelling company of Malbaza, at the exit of the station adjacent to the cement factory. But it must be noted that the fuel oil n° 1 used in Malbaza is worth nearly twice the price of the fuel oil in Sokoto.

- for one third to the transport, to the amortization of the packing, to the weighing expenses and to the loading of lorries in the collecting centers.

For such a price, taking into account the reasons hereinbefore explained, it will be impossible to collect most of the shells. Lacking of more precise information we supposed it would be possible to recover almost half of these i. e. 2[illegible]00 tons. Let us notice that these additional 2 £ on a weight corresponding to half the shelled peanuts weight (paid 31 to 32 £ /ton) only adds 3 % to the payment of the country man.

2 - <u>Transport to the factory</u>

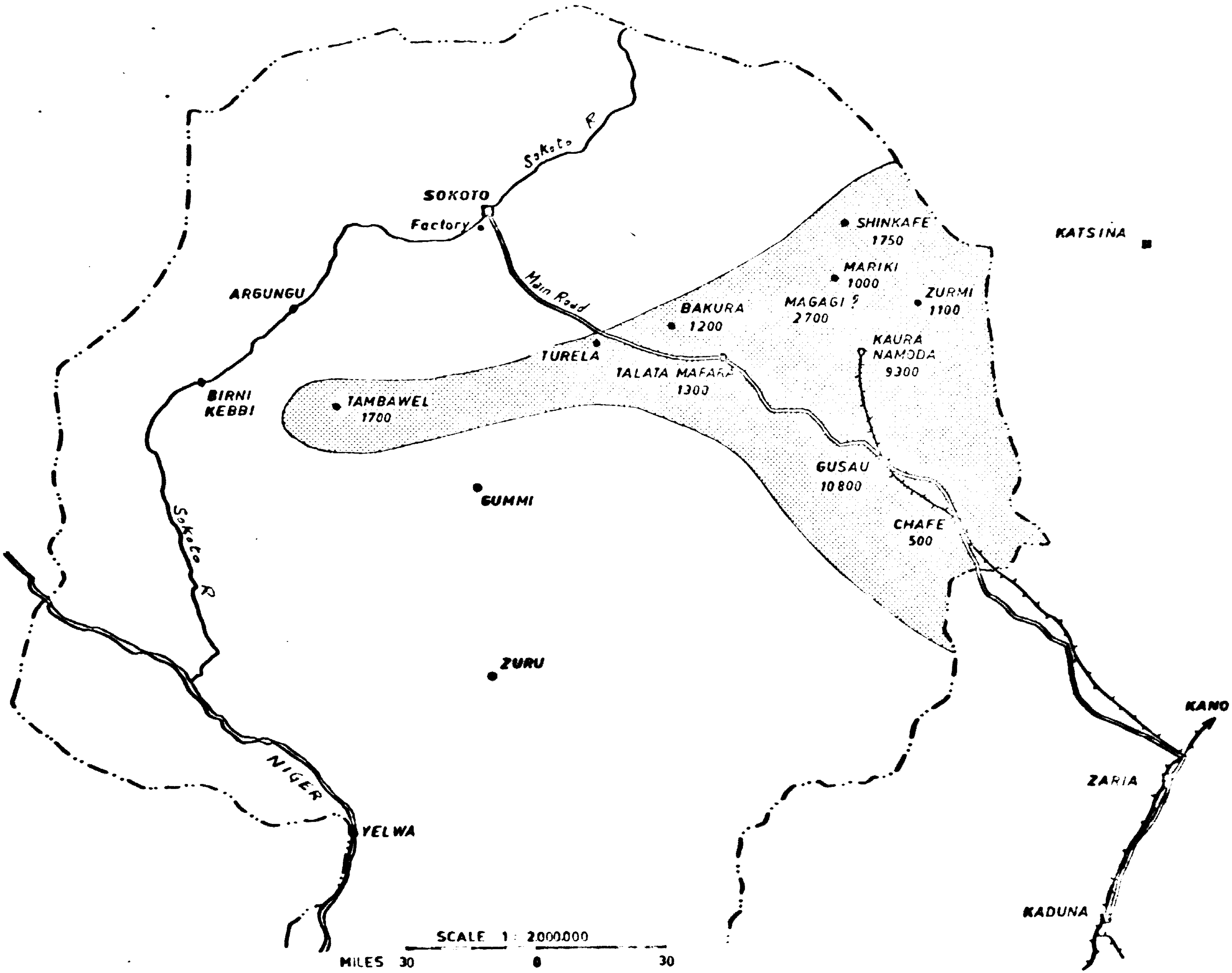
We noted on a map annexed hereto the principal collecting points for the shelled groundnuts of the 1970 1971 crop, as we got them officiously at the Sokoto Natural Resources Ministry. We admitted :

- that the shells should be available there within the same quantities ratios

- that, during the normal years of production (twice that of 70-71 campaign), the tonnages will increase proportionally in each market.

One may notice that in actual fact there are no markets within a radius less than 60 miles from Sokoto and that the average transport distance, calculated through big centers spaced out from Guisau to Shinkafe, particularly Guisau Kala, Namanda and Magagi, exceeds 100 miles. Let us remind that Guisau is 134 miles from the cement factory by road. Taking into account Talata Mafara and Tarbawel (located S. W.) it is difficult to bring down the average transport distance below 100 miles

. . .


SOKOTO
Factory
Sokoto R
Main Road
ARGUNGU
BIRNI KEBBI
TAMBAWEL 1700
TURELA
TALATA MAFARA 1300
BAKURA 1200
MAGAGI ? 2700
MARIKI 1000
SHINKAFE 1750
ZURMI 1100
KAURA NAMODA 9300
GUSAU 10800
CHAFE 500
KATSINA
KANO
ZARIA
KADUNA
GUMMI
ZURU
NIGER
YELWA
Sokoto R
SCALE 1 : 2000000
MILES 30 0 30

It remains to evaluate the price per ton-mile for such a product. Considering :

- the low density which, similar to that of the cotton-seed, reduces the normal loading of the lorry by half,

that in their greater part transports will be without any return freight,

- the condition of the tracks to be used,

- the equipment of the lorries for bulk transport, i. e. sideboards and tarpaulin cover, without any pressing. The weighing will be made by markets weighing machines

We agreed on a price of 7 d/ton mile, i. e. 2 9 £ for 100 miles. In addition are the unloading expenses on the arrival and a few losses due to blowing off, so that the total is : 3 £ /ton of gross shell, i. e. 60 000 £ N for 20 000 tons.

One must note that the gross shell contains on the one hand moisture (a content of 7 to 9 % seems normal), on the other hand earthy particles which may involve a cleaning on the arrival. A 12 % decrease seems to be justified in order to obtain the theoretic tonnage of completely dry shells. In practice complete dryness shall not be obtained and the calorific value will be proportionally decreased. It will be equal to 4 000 x 0,88 = 3 500 calories for 12 % impurities. The 20 000 tons of gross shells will thus be taken as equivalent to 17 300 tons of 100 % dry shells.

3 - Technical process and working cost

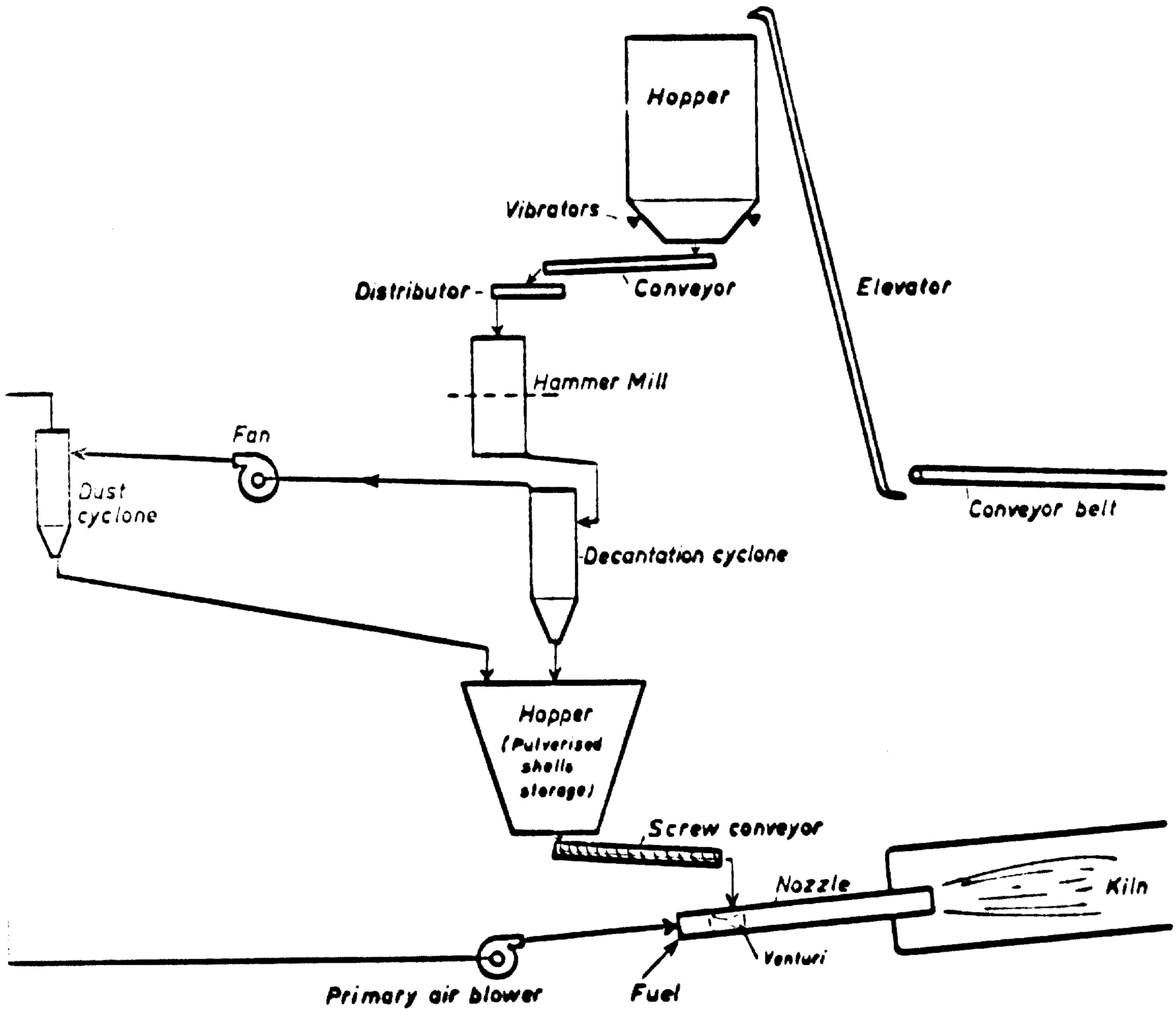
The summary flow sheet annexed hereto shows the general running of the device used in Malbaza studied in 1964 by FIVES-LILLE Company and erected in 1967-68.

The shells kept in bags are put on a belt conveyor and lifted up by a 12 m bucket elevator into an hopper. Reclaiming is made, with the help of hopper vibrators, by a multi extractor. The grinder is fed by an apron distributor. This 120 HP Condard grinder, weighing almost 3 tons and running at a speed of 3 000 r. p. m. is equipped of 36 hammers. Drying was formerly made by circulation of exhaust kiln gases, but, due to fire risks such process is no longer used.

...

PRINCIPLE SCHEME FOR SHELLS UTILISATION

Malbaza_Sokoto



Pulverized shells go through a decantation cyclone and are collected in a storage hopper with a volume of several ten cubic meters. From there they are extracted by a multi-screw distributor the output of which is adjustable from 300 to 1 800 Kg/hour. Then they fall in a special venturi placed for such purpose into the kiln fuel nozzle. Air circulation is created by a fan (25 KW 8 000 c.m./hour under a pressure of 400 mm W. G.) exhausting the air from the decantation cyclone and blowing it through a dedusting cyclone toward the primary air fan of the kiln. Therefore the primary air blowing must sustain a certain modification. The dust are carried to the storage hopper.

The running seems satisfying on the technical point of view. The normal operation is obtained with a mixture of 30 % pulverized shells and 70 % of fuel oil (calculated in thermies). This percentage of shells can be easily exceeded, but in fact the limit comes from the lack of shells from the SCNARA next shelling center.

One may note two imperfections which moreover do not affect the operating principle :

- Reclaiming from the SCNARA stock is made by manual bagging and hand conveying when, due to the short distance, a blowing device could be used.

- Shell bags are stored near the drying and grinding equipment, which involved assured fire risks.

One may notice that the high silica content of peanut shells leads to a very important wearing of the hammers which are made of ordinary steel (12 hammers per day). When reckoning the raw mixes to be burnt, such silica must be taken into account. On the other hand, the alkalies content (12 to 14 % K_2O) of the shells does not entail running perturbations in the kiln, at least as regards the adopted percentage of shells.

The total electric power consumption is high, about 70 to 80 KWh/ton of pulverized shells. In the case of Sokoto (17 600 tons) the consumption would amount to 1 320 000 KWh, which, at the marginal cost of the KWh, corresponds about to 14 800 £N.

. . .

The important wearing of the grinder hammers involves a high cost which, in addition to other consumptions of materials and spare parts, brings into the evaluation some dubiousness. In consideration of Malbaza experience (change of the hammers every 3 days) and of the very abrasive nature of the groundnut shell, we were lead to estimate it between 0,5 and 1 £N per ton of pulverized shell. For the 17 600 tons needed in Sokoto, this would give an annual expense of 14 000£N.

The production staff is fairly reduced. One may account for a running in two shifts with two workers, one of them only being well skilled, for a period of 11 months per year, i. e. a total of 44 months-worker. The corresponding expense (with overtime) may be evaluated to 1 200 £N.

Low agios on stock must only be taken into account because they are balanced with the fuel ones, though the storage period be longer (as a matter of fact the groundnut crop only lasts 3 or 4 months and the storage must last almost 8 months).

4 - Characteristics and cost of the plant

We planned a storage outside the plant in order to decrease fire risks, but this storage will be under a very simple form (cemented areas surrounded by walls in order to receive piles covered with tarpaulin).

The plant is expected to treat 20 000 tons during 11 months, i. e. 1 800 tons per month, and to pulverize 17 600 tons of dry shells, i. e. 59 tons per day when working 300 days as works the kiln. However pulverization work will be made only in 2 shifts, which corresponds to a grinding capacity of $\frac{59}{16}$ = 3,7 tons per hour or more if the dryness is not complete.

With such a rhythm, the shells bring per day 59 000 x 4 = 236 000 thermies when the production of clinker requires 330 t x 1 100 th = 363 000 thermies, i. e. a proportion of 65 % brought by the shells and 35 % by the fuel-oil. This percentage is much higher than the one of Malbaza (30 % of shells) but does not seem impossible to reach. However an adjustment shall be made which, in the optimistic assumption we adopted, we shall suppose already implemented.

Malbaza plant includes only one grinder capable to produce 1 to 1, 2 tons per hour of pulverized shells, but it is possible to plan a grinder more powerful with an output

...

of 1,5 to 2 tons per hour. Two machines of this type would theoretically suffice, but it would be judicious to plan three of them. However we shall limit the plant to two grinders thus running 20 hours per day, but a complete third grinder will exist in the spare parts. We thus shall have 2 grinders of 160 to 170 HP with 48 hammers, reaching on the whole 250 KW.

The cost of the equipment F.C.B. of the Malbaza plant was about 20 000 £ N in 1967. It is necessary to add 40 000 N for civil engineering works and local supplies (sheet-steel work, framework). Considering the very expensive transports, the erection and ajustments which took quite a long time, the total cost reaches about 70 000 £ N for the plant in operating conditions.

In the case of Sokoto where two grinders, each having a 50 % higher output, would be set in parallel and where the equipment particularly for the shells storage would be more complete, the expenses to be contemplated, taking into account the increase of costs, would be twice as big at least. However due to the acquired experience and to the fact that the transport expenses and the costs of local prestations are much lower, we shall admit an increase of only 85 %, i. e. 130 000 £. This involves too that, within our intentionally optimistic views, no custom duty be exceptionally paid on the entrance in Nigeria. A cross-checking of this amount of 130 000 £ can be approximately made by the estimation of FIVES-LILLE Company worked out in 1968 for a slightly more powerful plant.

To this amount of 130 000 £ corresponds a constant annual charge for a capital borrowed at 7 % and amortized in 8 years (the product being particularly abrasive), i. e. :

130 000 x 16,75 % = 21 775 £ N.

...

5 - Profitability and conclusion

If we recapitulate the whole expenses necessary to use the shells, we come to the following balance-sheet :

Shells		Fuel-oil
Purchase	40 000 N	The saving of fuel-oil corresponds to the tonnage to which have been substituted the 17 600 tons of 100 % dry shells at 4 000 Kcal. (or 20 000 tons at 3 500 Kcal.)
Transport and storage	60 000	
Production expenses		
- Power	14 000	
- Spare parts	14 800	
- Manpower	1 200	
Agios on stock (as a reminder)		If the calorific value of the fuel-oil is taken at 9 500 Kcal., the saving of tonnage is $\frac{17\ 600 \times 4}{9.5} = 7\ 450$ tons
Annuity of amortisation and interest	21 775	
	151 775	The price per delivered ton being 23.4 N, the saving of fuel will be
Contingencies (except on shells)	11 225	
Total	163 000 N	173 000 N

Due to the inaccuracy of some elements which were quite arbitrarily evaluated though always with a view favourable to the use of shells, it is difficult to take into consideration such a saving of 10 000 N and <u>the operation seems to be profitless</u> on first approximation. The main profit-earners would be the country-men and the carriers.

This result is comparable to that of Malbaza where the operation is considered as just interesting, in spite of the much more high cost of fuel (carried on lorries from the shore) and of the practically null cost of shells transport, but the quantity of available shells is very low and is far from saturating the plant.

. . .

In Sokoto the profitability of the operation is essentially cancelled by the distance and the cost of transport. Even a decrease of 50 % on the anticipated cost-price, which is hard to imagine, would not permit a sufficiently attractive profitability. Most certainly the operation could show itself more interesting in the future with the sensible rise expected on the price of fuel-oil, but it should be advisable then to reexamine entirely the problem with the Marketing Board, in order particularly to sound the farmers reactions and to state precisely the purchase and approach expenses.

In the present state of the running of the factory we think that it must devote itself wholly to its re-ordering as described in this report, without dissipating its efforts on this aspect of its present economy which may be interesting at the State level, but is for it very secondary.

Chemical analysis

Designation	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	CO_2	H_2O + Vol. M	K_2O Total	Na_2O Total	TiO_2	Total
SC 10	23,60	6,35	3,60	62,50	2,60	0,30	0,05	0,10	0,33	0,04	0,00	99,67
SC 13	22,40	6,00	3,30	58,50	1,25	0,60	2,00	4,80	0,22	0,04	0,20	99,31
SC 35	23,80	6,60	3,75	60,60	2,60	0,45	0,10	0,65	0,32	0,09	0,40	99,36
SC 73	22,20	5,90	3,20	64,90	2,55	0,10	0,05	0,20	0,22	0,05	0,00	99,37

Désignation	Free Lime	Δ k	Δ nc	K_2O soluble	Na_2O soluble
SC 10	0,15	16,5	16	0,10	0,02
SC 13	2,10	24	18	0,07	0,02
SC 35	0,50	20,5	21	0,10	0,03
SC 73	0,75	9,5	8,5	0,05	0,03

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Potential composition

	C_3S	C_2S	C_3A	C_4AF	Free Lime	Undetermined	Liquid at 1450°C
SC 10	26	48,3	10,8	11	0,15	3,75	30,1 %
SC 13	3	62,5	10,3	10	2,10	12,10	26,9 %
S 35	12,2	59,5	11,2	11,5	0,50	5,10	31,2 %
S 73	48	27,8	10,3	9,8	0,75	3,35	27,7 %

x 200 1 cm = 50 µm

Etching : Sodium citrate + gaz H.F.

Grey : C_3S crystals

Dark : C_2S crystals

A 5791

O/S 99 616 - SOKOTO - Clinker S 73 "Good clinker"

x 750 1 cm = 13,3 µm

Etching : alcoholic HNO_3

Slashed crystals of C_2S sometimes with 1 series of strias

A 5792

x 200 1 cm = 50 µm

Etching : sodium citrate
+ gaz HF

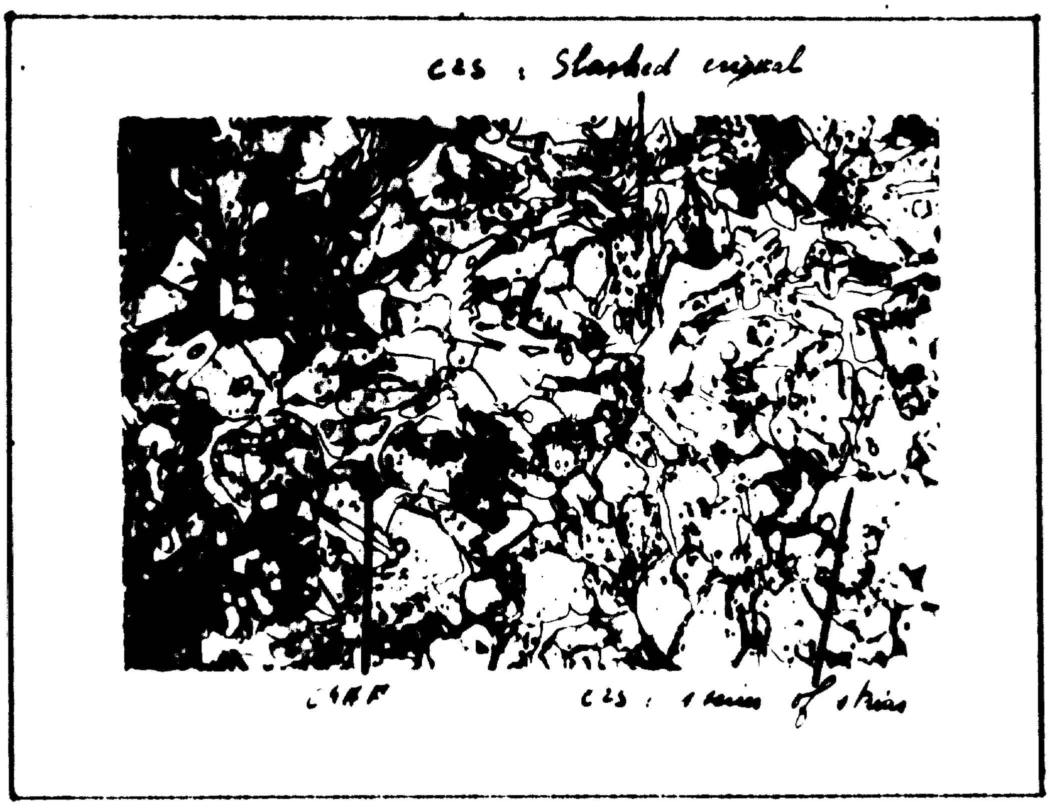
Grey : C_3S crystals

Dark : C_2S crystals

Clinker rich in C_2S

A 5794

O/S 99 616 - SOKOTO - CLINKER SC 10



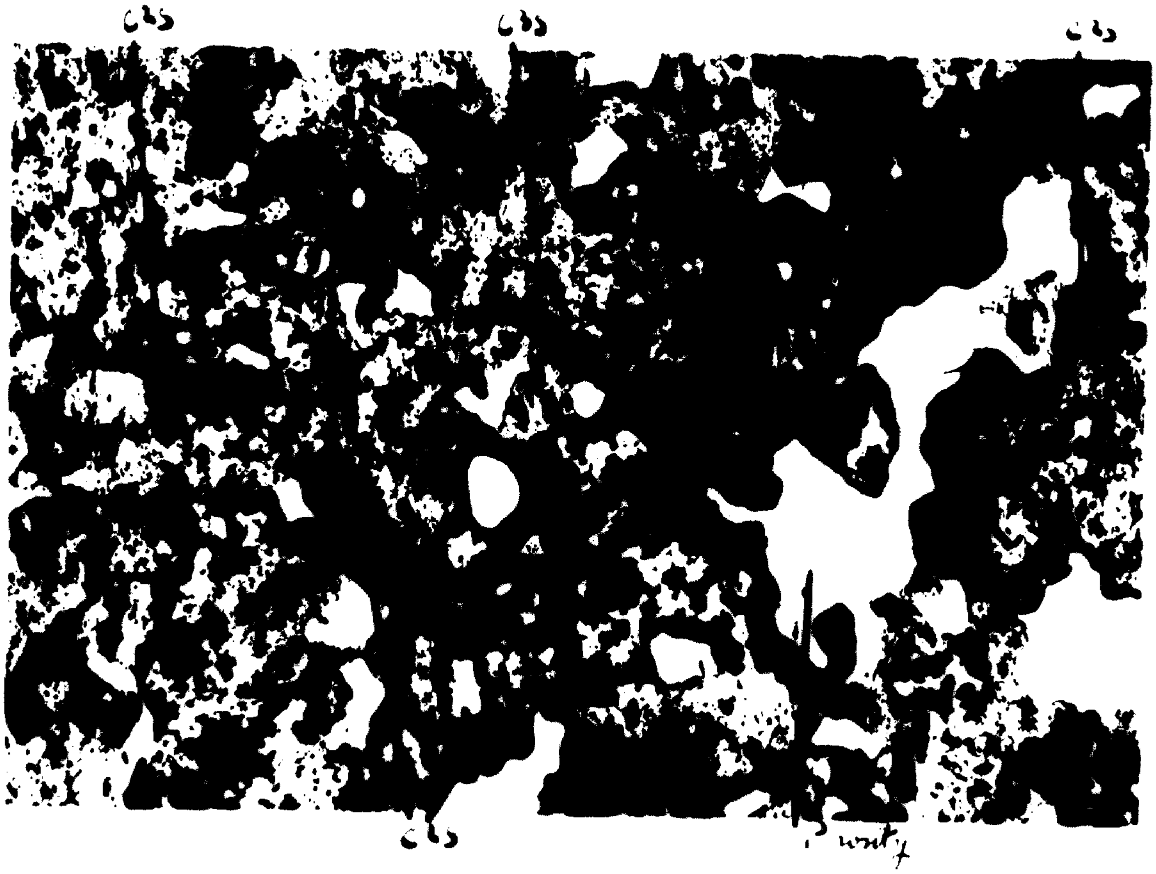
x 750 1 cm = 13,3 µm.

Etching : alcoholic HNO_3

Slashed crystals of C_2S with 1 series of strias

O/S 99 616 - SOKOTO - CLINKER SC 10

Silicates distribution



A 5796

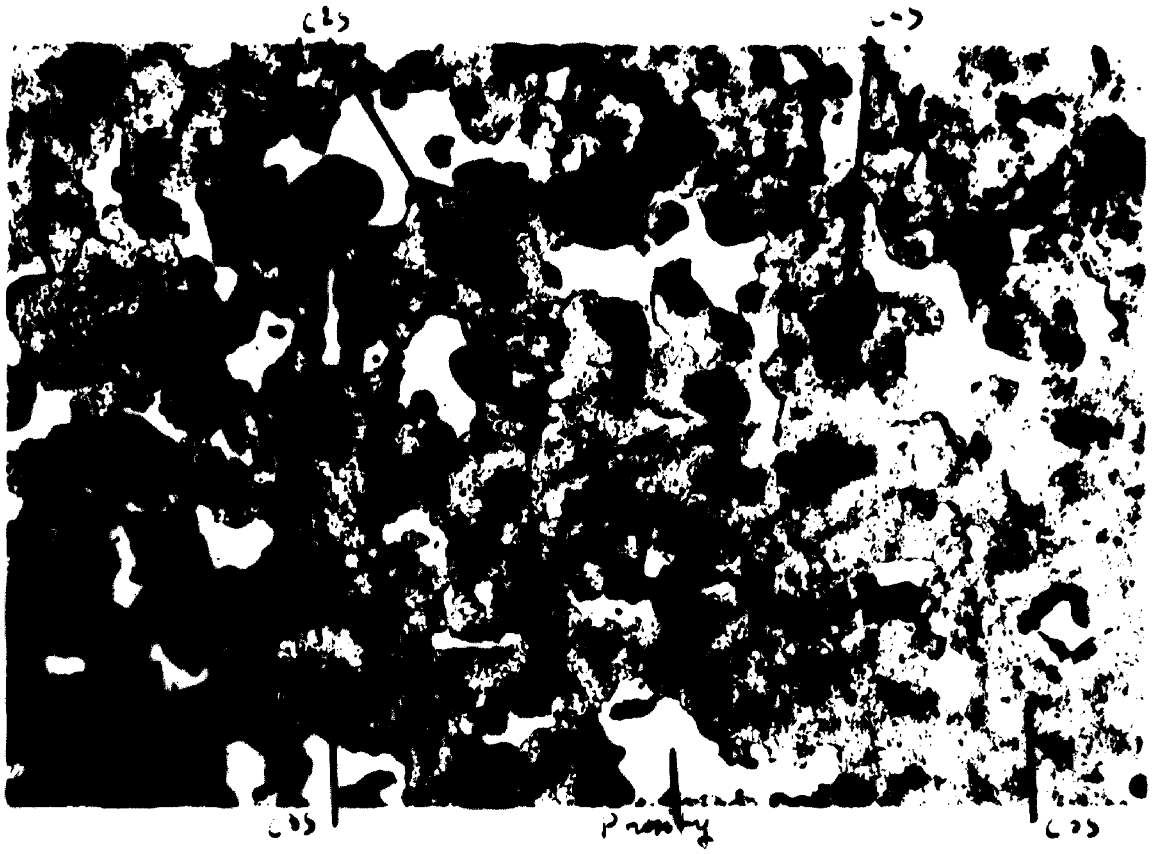
x 35. 1 cm = 285 µm

Etching : sodium citrates + gaz HF

Dark : belite areas - those areas are numerous and up to 1000 µm

O/S 99 616 - SOKOTO - CLINKER S 73 "Good Clinker"

Silicates distribution



A 5793

x 35 1 cm = 285 µm

Etching : sodium citrate + gaz HF

Dark : belite areas

APPENDIX TO CHAPTER III

Note on regional geological survey