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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

ESTABLISHMENT OF NATIONAL CEMENT INDUSTRY

PAPUA NEW GUINEA

(IS/PNG/75/010/11-01/03)

2 May 1975 - 25 June 1975

Feasibility study .

Prepared for the Government of Papua New Guinea
by the United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

Based on the work of Arne Mortensen, mechanical engineer

id.75-6501

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards even though the best possible copy was used for preparing the master fiche

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SUMMARY

1. Because of a resurgence of interest for the establishment of a cement industry in Papua New Guinea, an up-to-date feasibility study has been requested. (pages 5-8)

2. There are three companies who, without any invitation from the government, have made extensive investigations into the establishment of a cement industry in Papua New Guinea. These are : Hyundai Group, South Korea, Blue Circle Southern Cement Group, Australia and Tower Research and Development, Australia (Pages 9-11)

3. The present import of cement into Papua New Guinea is about 70,000 tonnes per year. In harbour towns, the selling price is about K80 (US$120) per tonne cement. In the Highlands, the selling price is about K140 (US$200) per tonne cement. (Pages 12-14)

4. Papua New Guinea has formidable deposits of limestone everywhere in the country. As far as raw materials are concerned, the cement plant could be built anywhere in Papua New Guinea. (Pages 15-23)

5. The technology of a modern cement industry requires a large plant size. The high invested capital in a cement plant can be achieved with different terms of payment. The high fuel cost require the dry-process. The high transport cost require a site where the demand is concentrated and from where markets are easily and economically accessible. (Pages 24-37)

6. Production costs ab fabric would, with the present information, be about K39 (US$55) per tonne cement. With the present transport costs, the selling price

in every town in Papua New Guinea should be about K63 (US$90) per tonne cement. With payment of interest in working capital and preliminary investigation, the consumer price for the first years would be about K70 (US$100) per tonne cement. This is a pessimistic consumer price. With a well organised and cheaper transport of cement, and lower fuel cost, the consumer price should be about K50 (US$70) per tonne cement. (Pages 38-45)

7. Recommendation:

1) The cement plant should be built for 200,000 tonnes cement per year.

2) The process should be dry-process, rotary kiln with preheater.

3) The most suitable site for the cement industry would be the Lae area.

4) Blue Circle, Australia and Hyundai Group, South Korea, should be invited to give proposals for a cement industry in Papua New Guinea, and set out their proposals for financing and marketing. (Pages 47-49)

8. Follow-up activity by UNIDO expert (Page 49).

INTRODUCTION

The manufacture of cement in Papua New Guinea has been under discussion for many years. The government of Papua New Guinea has asked NIDA (National Investment and Development Authority) to carry out an up-to-date feasibility study for the establishment of a cement plant in Papua New Guinea. Therefore, NIDA has requested a UNIDO expert in the cement industry to carry out a feasibility study, even though such a study of the cement industry in Papua New Guinea had already been carried out in 1969 by a UNIDO expert. This feasibility study from 1969 will also be different from the feasibility study of today, partly because of the present high fuel costs and partly because of the new technologies in cement making.

The government has an ambitious development programme for Papua New Guinea, with extensive road construction, hydro-electric power stations, airports, development of timber areas, etc.

One of the most important aspects for the development of the above mentioned subjects to an acceptable price will be to have a local manufacture of cement. Cement is one of the most important materials for development and there is usually interrelation between the standard of living and the cement consumption per capita. Therefore, it is normally found that the cement consumption per capita rises every year as the standard of living rises.

The price for the import of cement into Papua New Guinea is extremely high - about US$120 per tonne cement in harbour towns and about US$200 per tonne in country areas, and it seems that the trend will force prices up even higher.

At the present time, three companies have made and are still making, extensive investigations into the establishment of a cement plant in Papua New Guinea. All these three companies have great tenacity of purpose in their desire to get the project underway and they have provided the government with their proposals.

A well planned and organised cement industry is not easily realised in any country. Its realisation is often made more difficult by underestimation of the importance of preliminary studies, testing and branch. I have made especially long remarks about raw materials because one of the main sins with the establishment of a new cement plant is that these are not made sufficiently, certainly about the quality and quantity of the raw materials.

The best installation will not work satisfactorily if it is built at the wrong location; if the wrong process has been chosen; if, as mentioned above, lack of proper geological prospecting, raw material resources are insufficient in volume and quality; or if the plant size and production costs do not match the commercial situation.

It often happens that in their efforts to promote new industries, developing countries receive advice from persons not qualified to give it. Cement plants have been built with the best of intentions which will never produce cement economically, by any standard, because the advice given was wrong. I will, in this report, give an example of this from Niger, Africa.

Even if it is generally accepted that the limiting factors on a desirable cement plant size are the size and location of acceptable markets and the costs of the physical distribution for adequate services of these markets, it is also a general rule that the manufacture of cement is only economical if it is manufactured in a plant above a certain minimum size.

The Minister for National Development has expressed a wish for the establishment of a cement plant in the areas of Kerema or Kikori, with the farseeing statement of reasons that these areas are not as developed as other areas in Papua New Guinea.

The above mentioned areas are not acceptable, partly because these areas are lowlands and swamps with low population and difficult transport systems.

Some authorities in Papua New Guinea have expressed a desire for a cement plant in the Chimbu area, the centre of the main population in Papua New Guinea. I have visited Chimbu and even if it does have excellent limestone, it is not acceptable because of the high transport costs to and from the area. The Chimbu area is about 400 km from Lae and, furthermore, the area is at a height of about 2,000 metres. The efficiency of the equipment operating in this height will be lower than equipment operating in lower level regions.

If the cement plant is to deliver cement economically, it has to be built close to areas where the demand is concentrated (industrialised and populated areas) and also at a location from which markets are easily and economically accessible.

The three companies who have made, and are still making, investigations, without any invitation from the government, are:-

1. Hyundai Group, South Korea
2. Blue Circle Southern Cement Group, Australia
3. Tower Research and Development, Australia.

All three companies are reputable firms. I have been in close contact with them and have a good impression about their ability to give a proposal for a cement plant.

For the calculation of the cost of producing cement in Papua New Guinea, I have had meetings with :-

1. Department of Labour and Industry
2. Department of Transport
3. Department of Public Works
4. Department of Statistics
5. The Electricity Commission
6. Oil companies, Shell and Mobil.

I have travelled in the Highlands to get an impression about the road construction in this area. I travelled by car from Lae to Mt Hagen, via Goroka and Kundiawa.

I have used the highest figures in the costs in my calculations and even with that, the cement with local manufacture could be sold for about K70 per tonne cement (US$100). A cement plant in Papua New Guinea will also be a useful place for work for the Papua New Guinean people in their effort to develop Papua New Guinea.

In my calculations I have used K1 = A$1 = US$0.7*

All the sites mentioned in this report are marked with underlining on the general map of Papua New Guinea. (Appendix IV, page 53). All sites I have visited are marked with a cross.

* In my calculations I have used K1=A$1 = US$ 0.7

*)Note from UNIDO:
The official exchange rate pr. 19 April 1975 was K1 = A$ = 1.35 US$
or: 1 US$ = 0,74 K and
1 US$ = 0,74 A $

We believe the above exchange rate to USDollar is given by mistake and is not used in the calculations. Page 4 indicates a correct use of the exchange rate.

The three companies who are making invest[illegible] the establishment of a cement industry in Papua New Guinea.

The Hyundai Group's experience in the construction of cement plants is limited. They have however built two cement plants in South Korea. One in 1964 for 400,000 tonnes cement per year and one in 1974 for 800,000 tonnes cement per year. They have also made several successful extensions to existing cement plants in South Korea. I have travelled with the Group's experts to Madang, Vanimo, Lae and Saidor for investigation of the deposit of limestone in the areas. Furthermore, I have seen the Group's work on an extension to Lae airport and the hydro-electric power station in Ramu Scheme, where the Group have been the main contractors. The Group have applied for the main tender to build the Highlands Highway and are thought to be considering the development of the Vanimo timber area as well as having made a firm proposal to develop the Kapaluk timber area. The Group works closely with the Fuller Corporation in the United States of America and it is thought that should the Group get the contract to develop a cement industry in Papua New Guinea, then they would purchase 40% of their supplies from the Fuller Corporation.

The advantage with the Group is that they will be able to send manpower from South Korea for building work, erection and operation of the cement plant. This manpower can work closely with the local manpower as they have done successfully with the construction of the Lae airport and the Ramu Scheme hydro-electric power station. I have the impression at present that Papua New Guinea will not be able to supply the qualified manpower for the construction of a cement plant. In 1971 and 1972 I was working with the construction of a 330,000 tonne per annum cement plant in Brazil and with the building work and erection 24 months under way, there were about 1,000 labourers involved on the project.

The Blue Circle Group have been investigating the proposed cement industry in Papua New Guinea longer than anyone else. I have visited the Group's main office in Sydney and I have had discussions with the staff about their proposals. Furthermore, I have visited the Group's cement plant near Melbourne. The Group work as a consulting company. They do not actually manufacture cement making machinery. If they should get the contract to develop a cement industry in Papua New Guinea, they will probably purchase their machinery from Germany.

The Group will not be able to supply Papua New Guinea with manpower for building work and the erection of a cement plant and the Group would not be unwilling to be associated with the Hyundai Group but they want to be technical managers of the operation and also to be consulted with regard to plant design and specification.

I have travelled with the Group's senior geologist to Sankwep, Lae and Finschhafen to see the deposit of limestone in these areas. There is no doubt that the Group's proposal to build the cement plant in Sankwep or Lae is the best of the proposals today. It is the area where the demand for cement is concentrated and it is the most industrialised and populated. There are road connections with the Highlands and there is access to a wharf. Electric power could easily be supplied from Lae.

Tower Research and Development work on their proposals for a cement industry in Papua New Guinea in close co-operation with Dr Steven Gottlieb, who has a big capacity of know-how about the cement industry. Dr Gottlieb's research in the development of a shaft kiln is well known by the people working in the cement industry. I have had the pleasure of visiting Dr Gottlieb in Melbourne and I have visited his former owned cement plant where there are two shaft kilns.

I have also had a profound discussion with Dr Gottlieb about his proposal for a 130,000 tonnes per annum shaft kiln, operating with coke breeze or charcoal produced from the surrounding timber resources near Vanimo, where Dr Gottlieb proposed to build the cement plant. Vanimo is locationally well away from the main areas where cement is demanded.

If Tower Research should get the contract for a cement plant in Papua New Guinea, they would make the machinery in Australia and supply manpower from India or Japan (the two countries where Dr Gottlieb has tried to develop his shaft kiln but there are still no published epoch-making results). The main companies which are making designs of cement plants and cement making equipment have not shown very much interest in developing shaft kiln processes.

As well as the cement plant project, Tower Research work with a project for a pulp mill in Vanimo. This project will include about 3,000 employees. It is Dr Gottlieb's intention to try to use gas developed from the waste timber from the proposed pulp mill as fuel for the shaft kiln. It is also his intention to make an extension of the 130,000 tonnes shaft kiln after some years with a short rotary kiln. The main idea is that the shaft kiln and the rotary kiln should work together, that is to say, pre-calcining in the shaft kiln and sintering in the rotary kiln. The cement plant should then be able to produce 500,000 tonnes of cement annually.

My main concern with this idea is that it would be an experiment in which no other countries have had any interest and I feel that Papua New Guinea wants a well tried, well established, process and a sound company rather than an experiment.

MARKET INFORMATION

Papua New Guinea imports at present about 70,000 tonnes of cement per year, that is 30 kilos of cement per capita. All the cement is delivered in bags and the present cost is about US$120 per tonne cement. The distribution of cement imported into Papua New Guinea is shown on page 14.

About 80% of the cement is imported from Japan, the rest from various other countries. Sometimes the cement from Japan is sold to dumping prices.

Papua New Guinea is paying high prices for the import of cement and it seems that the trend will force prices up even higher. The extremely high price for cement seems to be the main reason why the consumption of cement is only 30 kilos per capita. Per capita: in Europe - 500 kilos; in South America - 200 kilos; in Asia and Africa - 50 kilos.

It is expected that, with local cement manufacturing, the selling price could be under US$100 per tonne cement in every town in Papua New Guinea. With cement more readily available it will put it in competition with other construction materials.

Under the development programme the government have made for Papua New Guinea, with extensive road construction, hydro-electric power stations, airports, development of timber areas, etc., it is expected that the local consumption may rise to some 150,000 tonnes cement per year in 1978-1980.

In the planning of the cement project in Papua New Guinea, the possibilities for export must be taken into account.

1. Pacific Islands market:
   There are markets available in a number of the islands surrounding Papua New Guinea

2. Asian market:

   Papua New Guinea is favourably located to supply several Asian countries where cement is demanded.

3. Australian market:

   It is expected that there will be, in the foreseeable future, a shortage of cement for the Australian market. Darwin and Brisbane are cities which are well located for export of cement from Papua New Guinea.

After the first feasibility study, it appears reasonable to plan for a cement plant in Papua New Guinea to produce 200,000 tonnes cement per year.

The distribution of the recent cement import in Papua New Guinea

tons cement

	1964/65	1965/66	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74 b)
1. Port Moresby	14,500	24,000	28,000	23,000	25,466	27,305	18,995	18,512	24,092	12,458
2. Lae	7,500	11,200	12,500	16,100	20,765	23,013	18,308	19,027	18,392	16,861
3. Kieta a)	90	90	90	570	1,102	9,458	31,040	20,588	11,862	4,383
4. Rabaul	7,200	8,900	9,700	11,500	12,246	13,395	11,494	10,461	8,481	12,521
5. Madang	6,600	8,000	8,800	6,600	4,937	7,087	4,635	3,719	3,333	3,927
6. Wewak	2,100	4,600	4,600	2,900	4,257	2,531	2,542	1,733	2,237	2,376
7. Kavieng	500	1,100	900	1,900	2,020	1,550	1,249	1,278	1,052	350
8. Samarai	700	900	700	1,100	893	1,029	695	394	347	322
9. Lorengau	10	10	10	30	30	35	30	10	20	4
	39,200	58,800	66,200	63,700	71,713	82,803	88,988	75,722	69,816	53,202

a) Construction of Bougainville Copper Mine 1969

b) 11 months consumption only available (for 12 months should be 58,038 tons cement)

RAW MATERIALS

An investigation is necessary in order to ascertain the feasibility of the project and to provide information on which to base the choice of the best type of process and the proper design of the plant.

Preliminary prospecting for raw materials

a) Study of existing sources of information, such as geological reports and maps, and records of previous manufacturing of cement, lime or other calcareous building materials.

b) The first visit to the deposit. Sampling of rock from outcrop for chemical analyses. Rough estimate, without premature conclusions, of the possible amount of materials.

The above mentioned procedure has been carried out for the sites that are under discussion for the establishment of a cement plant.

a)	Sankwep, Lae	: Sampling taken and analysis by Blue Circle
b)	Finschhafen	: Sampling taken and analysis by Blue Circle
c)	Saidor	: Sampling taken and analysis by Hyundai Group
d)	Vanimo	: Sampling taken and analysis by Dr Gottlieb

Geological mapping in Papua New Guinea has been undertaken by a number of workers, principally during the present century. Appendix VI, page 55, shows that there should be good quality and quantity of limestone in the areas where the above mentioned companies have made their investigations.

Requirements for the source of the raw materials

a) Proper chemical composition. Modules (SM, IM, HM, Lime index)

b) Adequate amounts

c) Low price as quarried (overburden)

d) Convenient location
e) Favourable physical properties.

One of the main sins with the establishment of a new cement plant is that many do not make sufficient investigations about the quality and quantity of the raw materials. Investigations must be clarified by drilling and these must be calculated with about 20 boreholes, each 50 metres deep. The costs for the drilling range between 50 and 100 US dollars per metre. Even if many drillings for the investigation of petrol have been carried out in Papua New Guinea, the authorities should, after the site of the cement plant is cleared up, ask for technical assistance for a systematic investigation of the quarry.

A cement plant producing 200,000 tonnes of cement per year would cost today about US$24,000,000. It would be wrong not to use about US$1,000,000 for the preliminary investigation.

Systematic investigation

a) Establishment of the purpose and a first estimate of the cost.
b) Provision of the necessary technical assistance. Decision as to who should carry out the prospecting, local people or specialists.
c) Importance of maps on which to record information from the preliminary study of the deposit. Aerial maps offer a quick and good solution.
d) Sampling methods - surface sampling, pit digging, well drilling, core drilling (see page 18, Chart III.1-1)
e) The diamond core drill. Sampling of cores and sludge. Theoretical and practical know-how is necessary for operating the drill and obtaining a good core recovery.
f) The proper use of the diamond drill. Vertical or inclined holes. Use of forms for accurate logging

of all information related to the core drilling. Splitting of core samples. Filing of cores.

g) Examination of the samples. Preparation of average samples for chemical analyses. Combination of results from core and sludge analyses. Titration (calcium carbonate) and complete analyses.

h) Preparation of vertical-cut diagrams showing results of the examinations. Calculation of amount of material in the deposit (see page 18, III.1-2). Filing of the information for later use in the planning of quarry operations.

It is generally agreed that 50 years reserve of raw materials is required for the establishment of a new cement plant.

A careful investigation of the quarry must be carried out for the determination of the raw material available, with a view to selecting the production scheme and determining the dimensions of the productive units.

The company which is given the contract for the establishment of a new cement plant in Papua New Guinea should be responsible for the investigation of the quarry and its raw materials.

Chart III.1-1

Drilling in Formation with Inclined beds

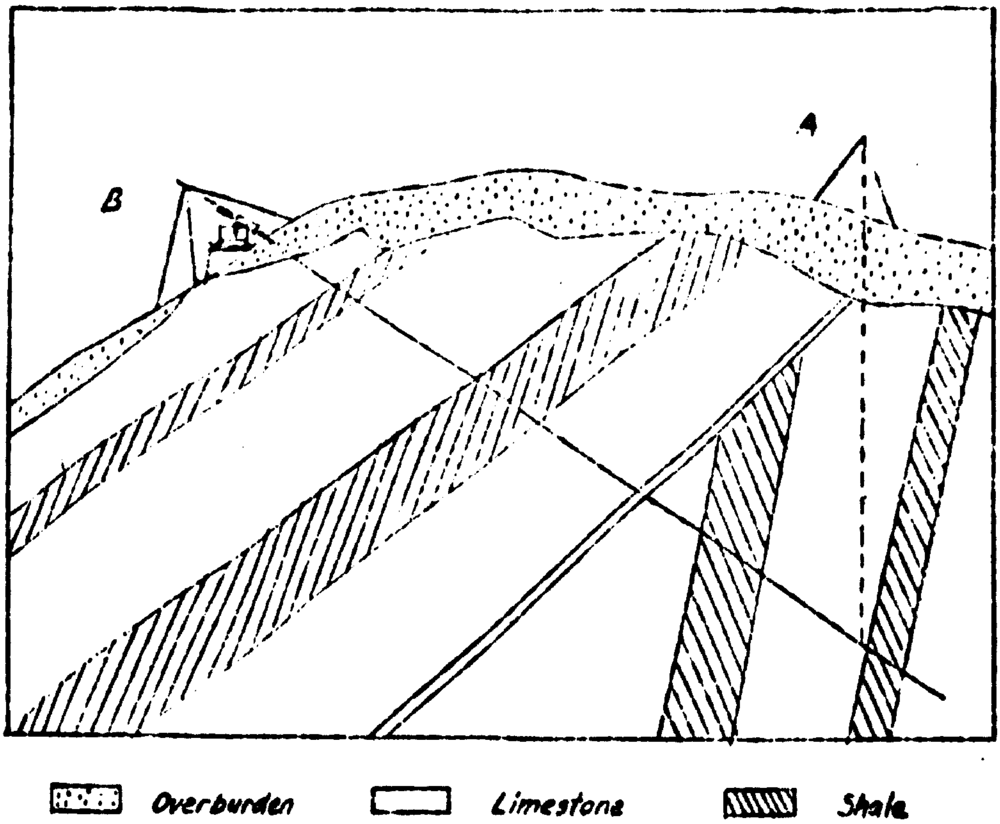
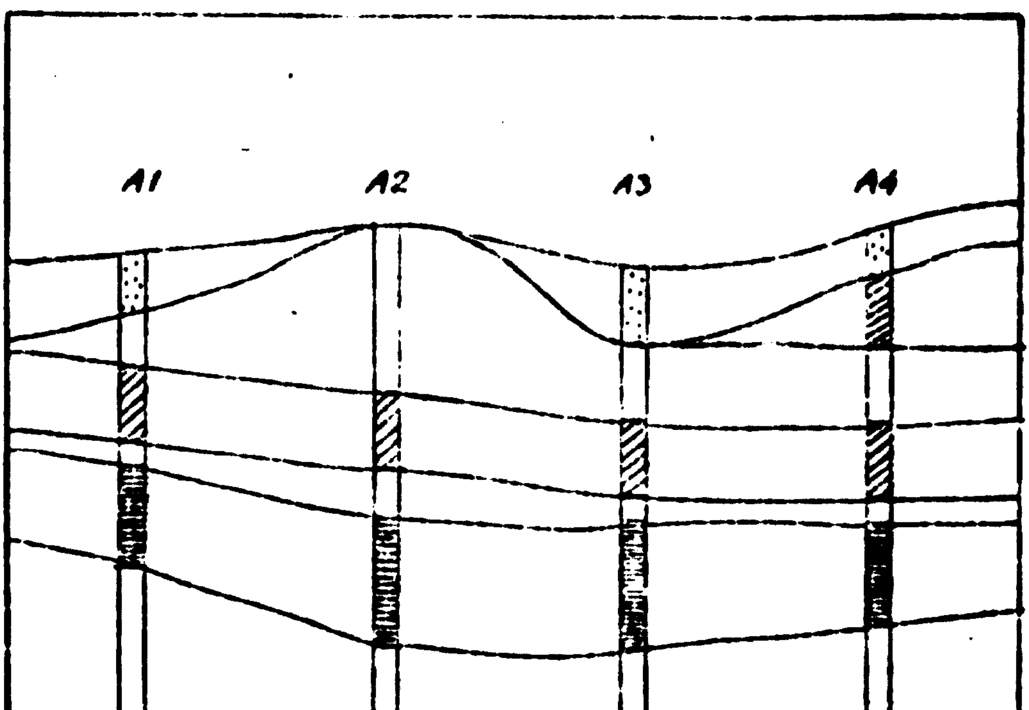


Chart III.1-2

Raw materials. Cut-diagram of Deposit



Example for investigation of raw materials

In our example we have the following materials at our disposal:

%	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Loss by Ignition
Limestone	2.9	1.1	0.8	52.4	0.3	42.0
Clay	50.4	22.2	8.5	4.3	2.1	12.5

$$CaCO_3 = \frac{CaO}{56} \times 100 = 1.8 \times CaO$$

Limestone: 1.8 x 52.9 = 94.5% $CaCO_3$

Clay: 1.8 x 4.3 = 7.7% $CaCO_3$

We want 76% $CaCO_3$ in our raw materials:

94.5 ↘ ↗ 68.3 parts too low in clay of $CaCO_3$

76

7.7 ↗ ↘ 18.5 parts too much in limestone of $CaCO_3$

Limestone/Clay = 68.3/18.5 = 3.69/1 + 3.69 of limestone for 1 clay.

%	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Loss by Ignition
3.65 Limestone	10.6	4.0	2.9	193.1	1.1	153.3
1.00 Clay	50.4	22.2	8.5	4.3	2.1	12.5
4.65 Raw material	61.0	26.2	11.4	197.4	3.2	165.8
1.00 Raw material	13.12	5.64	2.45	42.45	0.69	35.65
Raw material without loss by ignition	20.39	8.76	3.81	65.97	1.07	-

Limits for Portland cement

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO
19 to 24%	4 to 9%	1.6 to 6%	60 to 67%	to 5%

Even if the raw materials are inside the limits there must also be an investigation made to see the modules are inside the limits:

1) SM $= \dfrac{SiO_2}{Al_2O_3 + Fe_2O_3} = \dfrac{20.39}{8.76 + 3.81} = 1.62$; Limits: 1.2 to 4.0

2) IM $= \dfrac{Al_2O_3}{Fe_2O_3} = \dfrac{8.76}{3.81} = 2.30$; Limits: 1.0 to 4.0

3) HM $= \dfrac{CaO}{SiO_2 + Al_2O_3 + Fe_2O_3} = \dfrac{65.97}{20.39 + 8.76 + 3.81} = 2.00$;

Limits: 1.7 to 2.2

4) Lime index $= \dfrac{100\ CaO}{2.8\ SiO_2 + 1.1\ Al_2O_3 + 0.7\ Fe_2O_3} =$

$$\frac{100 \times 65.97}{2.8 \cdot 20.39 + 1.1 \cdot 8.76 + 0.7 \cdot 3.81} = 95.1$$; Limits 93.5 to 96.5

If the composition of limestone and clay are not inside the limits of the modules, it will be necessary to add some substitute materials - partly sand and/or iron oxide.

[illegible] Kwep, [illegible]

%	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	[illegible]	$CaCO_3$
[Lim]estone	3.4	1.6	1.0	52.6	1.0	40.0	94.68
[Cl]ay	58.5	15.9	9.4	3.2	2.5	5.3	5.76

94.68 → 70.24 parts too low in clay of $CaCO_3$

76

5.76 → 18.68 parts too much in limestone of $CaCO_3$

Limestone/Clay = 72.24/18.68 = 3.87/1 = 3.87 of limestone for 1 clay.

%	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Loss by Ignition
3.87 Limestone	13.16	6.19	3.87	203.56	3.87	154.8
1.00 Clay	58.50	15.9	9.4	3.2	2.5	5.3
4.87 Raw materials	71.60	22.09	13.27	206.76	6.37	159.1
1.00 Raw materials	14.72	4.54	2.73	42.46	1.31	32.67
Raw materials without loss by ignition	21.86	6.74	4.05	63.06	1.95	-

The raw materials are inside the limits.

(1) : $SM = \frac{21.86}{6.74 + 4.05} = 2.03$

(2) : $IM = \frac{6.74}{4.05} = 1.66$

(3) : $HM = \frac{63.06}{21.86 + 6.74 + 4.05} = 1.93$

(4) : $\text{Lime index} = \frac{100 \times 63.06}{2.8 \times 21.86 + 1.1 \times 6.74 + 0.7 \times 4.05} = 88.25$

The Lime index is not inside the norm; it would be necessary to add some substitute materials.

Sample from Finschhafen

%	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Loss by Ignition	$CaCO_3$
Chalk	2.5	1.6	0.7	51.0	0.5	42.2	91.8
Coral	5.3	1.8	0.9	50.0	1.2	41.0	90.0
Mudstone	40.3	14.4	8.6	16.7	2.5	14.4	25.9

The chalk consists of about 25 to 30% H_2O and should be avoided.

90.0 ↘ 76 ↗ 44.1 parts too low in mudstone of $CaCO_3$

25.9 ↗ 76 ↘ 14.0 parts too much in coral of $CaCO_3$

Coral/Mudstone = 44.1/14.0 = 3.15/1 = 3.15 of coral for 1 mudstone.

%	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Loss by Ignition
3.15 Coral	16.70	5.67	2.84	157.5	3.78	129.15
1.00 Mudstone	40.3	14.4	8.6	16.7	2.5	14.4
4.15 Raw Materials	57.0	20.07	11.44	174.2	6.28	143.55
1.00 Raw Materials	13.74	4.84	2.76	41.98	1.51	34.59
Raw materials without loss by ignition	21.01	7.40	4.22	64.18	2.31	-

The raw materials are inside the limits.

(1) : SM $= \frac{21.01}{7.40 + 4.22} = 1.81$

(2) : IM $= \frac{7.40}{4.22} = 1.75$

(3) : HM $= \frac{64.18}{21.01 + 7.40 + 4.22} = 1.97$

(4) : Lime index $= \frac{100 \times 64.18}{2.8 \times 21.01 + 1.1 \times 7.40 + 0.7 \times 4.22} = 95.55$

The modules are inside the norms; it should not be necessary to add substitute materials.

Sample from Vanimo - Tower Research

%	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Loss by Ignition	$CaCO_3$
Limestone	-	0.01	0.01	53.95	0.40	43.44	96.30
Clay	66.5	19.0	3.3	2.1	1.1	5.3	3.60

96.30 → 76 → 72.4 parts too low in clay at $CaCO_3$

3.60 → 76 → 20.3 parts too much in limestone of $CaCO_3$

Limestone/Clay = 72.4/20.3 = 3.57/1 = 3.57 of limestone for 1 clay

%	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Loss by Ignition
3.57 Limestone	-	0.04	0.04	192.60	1.43	155.08
1.00 Clay	66.5	19.0	3.3	2.1	1.1	5.3
4.57 Raw materials	66.5	19.04	3.34	194.7	1.53	160.38
1.00 Raw materials	14.55	4.17	0.73	42.6	0.33	35.1
Raw materials without loss by ignition	22.42	6.43	1.13	65.64	0.51	-

The raw materials are inside the limits

(1) : $SM = \frac{22.42}{6.43 + 1.13} = 2.97$

(2) : $IM = \frac{6.43}{1.13} = 5.49$

(3) : $HM = \frac{65.64}{22.42 + 6.43 + 1.13} = 2.19$

(4) : $\text{Lime index} = \frac{100 \times 65.64}{2.8 \times 22.42 + 1.1 \times 6.43 + 0.7 \times 1.13} = 93.0$

The modules are not quiet inside the norms; it could be necessary to add some substitute materials.

From Saidor we only have a weak sample.

THE TECHNOLOGY OF CEMENT PLANTS TODAY AND FOR PAPUA NEW GUINEA

It is a general rule today that the manufacture of cement is only economical if it is manufactured in a plant above a certain minimum size, particularly when considering the rotary kiln. With the enormously increased price of fuel, the minimum size has therefore increased and the majority of companies today would only recommend a cement plant which produced 1,000 tonnes of clinker per day, that is, some 330,000 tonnes cement per year. In recent years, the methods of producing cement have changed considerably. In addition, the cost of any cement plant has rapidly escalated.

The majority of the new cement plants commissioned these days are dry-process plants. The greatest advantage of the dry-process over the wet-process is the lower fuel consumption normally obtainable. Between the best wet-process plants and the best dry-process plants, there is a difference of about 400 calories per kilo clinker in favour of the dry-process.

In the case of the preliminary estimate, it appears that we should establish a cement plant in Papua New Guinea capable of producing 200,000 tonnes cement per year. The present price for heavy fuel oil in Papua New Guinea is 44.8 Australian cents per UK gallon - US$170 per tonne.

The saving in using the dry-process over the wet-process in Papua New Guinea is calculated as follows :

$$\frac{200{,}000{,}000 \times 400 \times 170}{10{,}000 \times 1{,}000} = \underline{1{,}346{,}400 \text{ US\$ per year}}$$

The total cost for fuel for 200,000 tonnes cement per year with dry-process will be about :

$$\frac{200{,}000{,}000 \times 1{,}000 \times 170}{10{,}000 \times 1{,}000} = \underline{3{,}400{,}000 \text{ US\$ per year}}$$

or US$17 per tonne cement.

An investigation must also be made into fuel, to see whether it will be cheaper to import coke breeze from Australia or India or some other country. My present information is that, with transport, the cost of coke breeze will be about US$40 per tonne. Generally, two tonnes of coke breeze have the same fuel value as one tonne of heavy fuel oil. In this case it will naturally be cheaper to use coke breeze which will only be half the cost of the use of heavy fuel oil. That is to say, US$8.5 per tonne cement.

Research is now being carried out in Papua New Guinea for natural gas which could be very useful and cheap for cement manufacture.

There exist cement plants today that are able to use the three kinds of fuel : heavy fuel oil, or coke breeze, or natural gas, depending on whatever fuel is most available and cheap at the present time. Careful negotiations must be carried out with fuel companies about the costs of fuel, transport of fuel and availability of fuel, etc. before a definite solution can be taken and even then, the fuel costs are a very variable cost.

It is generally agreed that the shaft kiln is only to be recommended for small cement plants, i.e. in the range of 100 to 200 tonnes per day, about 35,000 to 70,000 tonnes cement per year. Producing about 100,000 tonnes cement per year, the rotary kiln is definitely preferable.

Skill requirements for the operators of shaft kilns would be about the same as for the rotary kiln, dry-process. Control of the quality of the clinker produced in a shaft kiln is more difficult than in the rotary kiln. Only solid fuel can be used in the shaft kiln. Ten years ago, about 20% of the cement production in Germany was made from shaft kilns, but today they have all closed down because they were not competitive when compared with the larger rotary kilns.

It is tempting, in a country like Papua New Guinea, with a rugged formidable area and difficult transport inside the country, to recommend small cement plants in different places, but it will be more expensive to manufacture the cement in small plants. To manufacture the cement in a big plant, near a harbour, will, even with transport costs, be cheaper for the producer.

a) The cost of a cement plant for 100,000 tonnes cement per year would be about 18,000,000 US dollars, depreciation 10%, i.e. 1,800,000 US dollars, i.e. <u>18 US dollars per tonne cement</u>.

b) The cost of a cement plant for 200,000 tonnes cement per year would be about 24,000,000 US dollars, depreciation 10%, i.e. 2,400,000 US dollars, i.e. <u>12 US dollars per tonne cement</u>.

The staff in the two plants will be almost the same. For (a), <u>4 US dollars per tonne cement</u>, and for (b) <u>2 US dollars per tonne cement</u>

The efficiency of power, fuel, etc. will be lower for the small plant

An estimated cost is that (a) will be 20 US dollars per tonne cement more than (b).

In March 1975 I stayed in Niger, Africa where the cement is manufactured in a small cement plant - 30,000 tonnes cement per year, rotary kiln, dry-process, fuel oil. The distance to the main consumer was 500 kms along the road. <u>Selling price was 100 US$ per tonne cement</u>. In April 1975 I stayed in Paraguay, South America where the cement is manufactured in a cement plant for 200,000 tonnes per year, rotary kiln, dry-process, fule oil. The distance to the main consumer was 500 kms along river. Selling price 30 US$ per tonne cement. Niger and Paraguay rank as development countries. Both countries are fuel oil importers.

The next page will show the cost of dry-process cement plant with rotary kiln, ranging from 132,000 to 330,000 tonnes cement per year.

Capital Expenditure US dollars January 1975 x 1000

Estimated cash for dry-process with preheater, rotary kiln

Exclusive of: Preliminary investigation, costs of land, housing of employees, working capital.

	Capacity m ts/day/24h m ts/year/330 days	400 132,000	500 165,000	600 198,000	800 264,000	1000 330,000	%
1.	Cement making machinery	5,700	6,270	6,840	7,695	8,550	28.5
2.	Auxiliary equipment (linings, pipes, grinding media, etc.)	600	660	720	810	900	3.0
3.	Spare parts, mechanical	600	660	720	810	900	3.0
4.	Electrical equipment	1,300	1,430	1,560	1,755	1,950	6.5
5.	Spare parts, electrical	100	110	120	135	150	0.5
6.	Process control equipment	300	330	360	405	450	1.5
7.	Erection and administration	1,800	1,980	2,160	2,430	2,700	9.0
8.	Building work	6,800	7,480	8,160	9,180	10,200	34.0
9.	Roads, fences, levelling of site	200	220	240	270	300	1.0
10.	Water supply plant	100	110	120	135	150	0.5
11.	Quarry equipment etc.	600	660	720	810	900	3.0
12.	Opening of quarry	100	110	120	135	150	0.5
13.	Offices, laboratory, repair shop	200	220	240	270	300	1.0
14.	Freight and insurance	600	660	720	810	900	3.0
15.	Consulting Engineers Fee	400	440	480	540	600	2.0
16.	Contingencies	600	660	720	810	900	3.0
	Total US dollars x 1000	20,000	22,000	24,000	27,000	30,000	100.0
	US dollars/t/year	152	133	121	102	91	

INPUTS FOR THE CEMENT PLANT

The cement industry can only flourish where the necessary raw materials are available. These raw materials are as mentioned above, limestone and clay, but it could also be some similar mineral, or waste (for instance chorale, ash and slag), from which a raw mixture can be obtained of the following composition:-

65% lime (CaO), 23% silica (SiO_2), 2.5% iron oxide (Fe_2O_3) and 5% aluminium oxide (AL_2O_3), all in respect of calcined materials.

The raw material usually contains other compounds which are generally useless, though harmless, in cement production. But it must contain harmful compounds such as phosphor (P) and magnesium (M_gO) must be under 5%. An exact chemical analysis is therefore essential.

The amount of raw material needed to produce 200,000 tonnes of cement may be estimated to 360,000 tonnes. To cover an annual production of this figure, for 50 years, a raw material supply of 18,000,000 tonnes is necessary.

Water is also needed for the production of cement, but it should not be any problem with fresh water in Papua New Guinea. The high rainfalls throughout most of the country have resulted in a great number of rivers having a large flow volume.

Electric power requirements are generally 100 kwh per tonne cement, producing 200,000 tonnes cement annually. The power requirements will be about 4,000 kw (average 2,500 kw). It should be possible to obtain power supply from the hydro-electric power station in Ramu Scheme at about 0.04 US dollars per kwh.

I have had a meeting with the Electricity Commission which has informed me that the costs of installation of power from Lae to Sankwap would be about 300,000 US dollars.

<u>Fuel</u> of one kind or another is required for the production of cement. The quantity depending on the process used - wet, semi-dry or dry, and also on the construction of the kiln. For the rotary kiln, all types of fuel can be used. The most usual being fuel oil, coal or natural gas. For the shaft kiln, only solid fuel can be used. For the production of 200,000 tonnes cement in the dry-process, 20,000 tonnes of fuel oil are needed. The quantity of coal and natural gas needed is correspondingly higher and proportional to the calorific value.

<u>Staff</u> A cement plant for 200,000 tonnes annually will need at least 150 workers, skilled workers and operational staff. The plant calls for a staff with the necessary knowledge of, and experience with, heavy machinery, electrical equipment, analysis of raw materials and the use of cement.

<u>Area needs</u> A cement plant for 200,000 tonnes annually will need an area of about 60,000 m^2 for a plant site.

<u>Natural gypsum stone</u> is used in the last stage of cement production. For 200,000 tonnes cement, about 10,000 tonnes gypsum will be needed. There is no gypsum in Papua New Guinea, but it could be imported very cheaply from Australia. Gypsum ($CaSO_4$) is mixed with clinker in the cement mill. The gypsum regulates the hardening time of the concrete. The normal supply of gypsum is 2% to 5%, depending on the quality.

<u>Consumer of cement</u> Cement is not very much used as a building material in Papua New Guinea. Construction of houses are mainly made in steel and wood. Several bridges in the Highlands Highway are made of steel and wood. The

above mentioned construction materials do not have a long life. Furthermore, steel and wood have higher maintenance costs than concrete construction would have.

The extremely high price for the import and transport of cement seems to be the main reason why cement is not used very much in construction work. The best way to make the local manufacture of cement cheaper for the consumer is to have a high consumption of cement per capita. With the rapidly rising price of steel, the cement will be more useful in competition as a building material.

The distribution of cement

To reduce the price of cement for the consumer, the transport costs need an investigation. The present transport costs in Papua New Guinea given by the Department of Transport seem to be too high.

In Niger, Africa, where I had my last duty in March 1975, the transport costs per tonne cement, 500 km on road, were 20 US dollars. For the same distance in Papua New Guinea, the transport costs are about 80 US dollars per tonne cement.

Most of the cement in Papua New Guinea is distributed by vessel and the Department of Transport at present transport about 37 US dollars per tonne cement from Lae to the main towns in Papua New Guinea.

With a specially built vessel for bulk cement and with packing plant on board, there could be a strong reduction in the transport costs of cement. Also, the cement plant could have depots in the main towns in the Highlands and with the cement plant's own lorries supplying these depots with cement.

INFORMATION NECESSARY FOR DESIGN OF MAIN MACHINERY FOR THE PRODUCTION OF CEMENT

1. General layout

   Topographical map of plant site, giving roads, river, harbour, etc.

   Temperature, altitude, wind direction, water precipitation, etc.

2. Crushing section, raw mill section

   Samples of all the raw materials to be utilized.

   Information about natural humidity in raw materials.

3. Raw Meal Storage

   Information about the qualities of cement to be produced.

4. Kiln section and fuel preparation

   Desired capacity of plant.

   Samples of fuel or technical characteristics of same.

5. Cement mill section

   Qualities of cement to be produced (type, finenesses) and desired output of each.

6. Packing plant

   Quantity to be despatched in bags and in bulk.

   Size of bags. Quantity to be despatched by truck or vessels.

7. Electrical equipment

   Characteristics of power supply (voltage, cycles).

8. Any special information

STUDIES PRIOR TO ORDERING

It is generally not advisable to rely on a single contractor for the purchase and installation of equipment and the execution of the project.

The government or the owners should form a local organisation, preferably with the assistance of a consultant, who should be carefully selected to co-ordinate the activities of the various contractors entrusted with different aspects of the project.

The question of penalites for non-fulfilment of the contract must be clear. In most cases, penalties are considered symbolic, since they may not exceed ten percent of the value of the contract.

The establishment of a cement plant involves certain industrial risks and it is desirable that such risks should be shared by the supplier and the buyer.

For training of local personnel, it would be advisable for suppliers to arrange first for the training of personnel in an advanced country, in addition to training them in their own plants. The most satisfactory training programme would be that personnel receive in-plant training by foreign experts in Papua New Guinea first, followed by additional training in an advanced country.

EXAMPLE FOR SPECIFIC CAPACITY, GUARANT[illegible] FOR A CEMENT PLANT PRODUCING 200,000 TON[illegible] CEMENT PER YEAR

Clinker production 600 tonnes per day, need about 1000 tonnes raw materials. 75% limestone, 25% clay.

1. Crusher

Working 40 hours per week : 130 tonnes per hour

Guarantees : Maximum size of feed materials 0.6m^3
Crushed material 0-25 mm with maximum 10% residue on 25 mm square mesh.

Test time: 2 x 8 hours

Penalties : For every tonne/h of under-performance - 1%
For every 1% over 10% + 25mm - 0.5%

2. Store of raw materials

Raw materials for 2 weeks : 14,000 tonnes
Clinker for 4 weeks : 14,400 tonnes

3. Grinding of raw materials

Raw mill 120 hours per week : 60 tonnes per hour

Guarantees : Feed materials < 30 mm
Moisture content < 10 percent
Fineness 10% + 0.09 mm
(residue on the 4900 mesh screen)
Final moisture 1 per cent

Test time : 2 x 24 hours

Penalties : For every 1% of under-performance with fineness of grinding set at 10% + 0.09 (10% residue on the 4900 mesh screen) - 1%
For every excess kwh/tonne - 0.5%

4. Homogenisation silos and storage silos

The homogenisation silos should be built on top of the storage silos. There should be two storage silos with enough storage for four days production : 2 x 2000 tonnes raw material. The homogenisation silos should

contain 2 x 500 tonnes raw material [illegible]
silos could be ø10m, height 26m. [illegible]
silos should be ø10m, height 7m.

<u>Homogenisation of raw materials</u>

Guarantee : Homogenisation time maximum 2 hours
Raw material from raw mill maximum $\pm$ 5 per cent $CaCO_3$
Homogenised raw meal maximum $\pm$ 0.25 per cent $CaCO_3$

Test time : 24 hours

Penalties : Suppliers to submit proposals for the guaranteed performance of the system offered.

5. <u>Rotary kiln with preheater</u>

Require raw meal with < $\pm$ 1 per cent variation in $CaCO_3$ content.

Guarantee : 900 Kcal/kg clinker, tolerance of +3 per cent

Test time : 3 x 24 hours

Penalties :
- for every 1% of under-performance - 1 %
- for every 25 Kcal over-consumption per kg clinker - 1 %
- for every excess kwh/tonne - 0.5%

6. <u>Cement grinding mill</u>

Working 120 hours per week : 35 tonnes per hour

Guarantee : Feed stock < 30 mm
Fineness of grinding 8-10 percent + 0.09 mm (Residue on the 4900 mesh screen) with 2 weeks old clinker.

Test time : 2 x 24 hours

Penalties :
- For every 1 per cent under-performance with fineness of grinding set at 8 per cent + 0.09 mm (8 per cent residue on the 4900 mesh screen) - 1 %
- for every excess kwh/tonne - 0.5%

7. Cement silos
The silos should consist of 2 x 3000 tonnes cement corresponding to 10 days production. The cement silos could be ø12m, height 27m.

8. Packing plant
Capacity 75 tonnes per hour
Bulk loading points for 120 tonnes cement per hour.

9. Transport of raw meal, clinker and cement
Transport screws, elevators, chains and pneumatical transport should be built with by-pass.

a) The supplier must prepare to carry out the acceptance tests at the latest three months after starting.

b) The company reserves the right to reduce the duration of the tests.

c) A repetition may be required in the case of unsatistactory results or bare fulfilment of requirements.

d) The measurements to be made shall be agreed upon with the supplier by a commission of company representatives before the acceptance tests are carried out.

e) After the acceptance tests, a joint report will be made and submitted to the company for certification.

f) The plant shall be taken to be accepted as soon as the report has been certified by the company.

TERMS OF PAYMENT

1. Cash payment to supplier, paid out of company's available funds.

   Example: 30 per cent at time of ordering,
   30 per cent 6 months after order,
   30 per cent successively against shipping documents (for instance, 10 to 15 months after order),
   10 per cent after fulfilment of production guarantees.

2. Cash payment to supplier financed locally.
   Local financing from commercial banks, development banks, etc.

3. Cash payment to supplier, with credit from international organisations.

   Example: International Bank for Reconstruction and Development (World Bank)
   International Finance Corporation
   Inter-American Development Bank.

4. Credit granted by suppliers
   Such forms of credit are generally supported by government agencies of the supplier's country.

Staff for [illegible] tons cement per year

1	work manager	=	20,000 US dollars/year
1	mechanical engineer	=	15,000 US dollars/year
1	works [illegible]	=	15,000 US dollars/year
1	cost accountant	=	15,000 US dollars/year
4	for management	=	65,000 US dollars/year

Mechanical works

1	foreman, mechanical workshop	=	5,000 US dollars/year
1	foreman, electrical workshop	=	5,000 US dollars/year
10	mechanics : 10 x 2450 US dollars/year	=	24,500 US dollars/year
10	electricians : 10 x 2450 US dollars/year	=	24,500 US dollars/year
3	bricklayers : 3 x 2450 US dollars/year	=	7,350 US dollars/year
2	carpenters : 2 x 2450 US dollars/year	=	4,900 US dollars/year
10	unskilled for workshop : 10 x 1600 US dollars/year	=	16,000 US dollars/year
37	for mechanical works	=	87,250 US dollars/year

Production

(a) Laboratory

1	foreman works laboratory	=	5,000 US dollars/year
4	laboratory assistants : 4 x 2450 US dollars/year	=	9,800 US dollars/year
4	special skilled workers : 4 x 2050 US dollars/year	=	8,200 US dollars/year
9	for laboratory	=	23,000 US dollars/year

(b) Quarries

1	foreman quarries	=	5,000 US dollars/year
5	drivers : 5 x 2050 US dollars/year	=	10,250 US dollars/year
3	workers (unskilled) : 3 x 1600 US dollars/year	=	4,800 US dollars/year
9	for quarries	=	20,050 US dollars/year

(c) General shift

3	foremen general shift		
	: 3 x 5000 US dollars/year	=	15,[illegible] US dollars/year
4	raw mill (skilled)		
	: 4 x 2050 US dollars/year	=	8,200 US dollars/year
8	kiln (skilled)		
	: 8 x 2050 US dollars/year	=	16,400 US dollars/year
4	cement mill (skilled)		
	: 4 x 2050 US dollars/year	=	8,200 US dollars/year
5	raw materials silos (unskilled)		
	: 5 x 1600 US dollars/year	=	8,000 US dollars/year
4	cement silos (unskilled)		
	: 4 x 1600 US dollars/year	=	6,400 US dollars/year
28	for general shift	=	62,200 US dollars/year

(d) Packing plant

1	foreman packing plant	=	5,000 US dollars/year
15	workers (unskilled)		
	: 15 x 1600 US dollars/year	=	24,000 US dollars/year
16	for packing plant	=	29,000 US dollars/year

(e) Yard gang

1	foreman yard gang	=	5,000 US dollars/year
20	workers (unskilled)		
	: 20 x 1600 US dollars/year	=	32,000 US dollars/year
21	for yard gang	=	37,000 US dollars/year

Costs accounts

1	Storekeeper	=	2,450 US dollars/year
1	stock accounts	=	2,450 US dollars/year
1	wage accounts	=	2,450 US dollars/year
1	ordinary accounts	=	2,450 US dollars/year
12	clerks : 12 x 1600 US dollars/year	=	19,200 US dollars/year
10	workers (unskilled)		
	: 10 x 1600 US dollars/year	=	16,000 US dollars/year
26	for costs accounts	=	45,000 US dollars/year

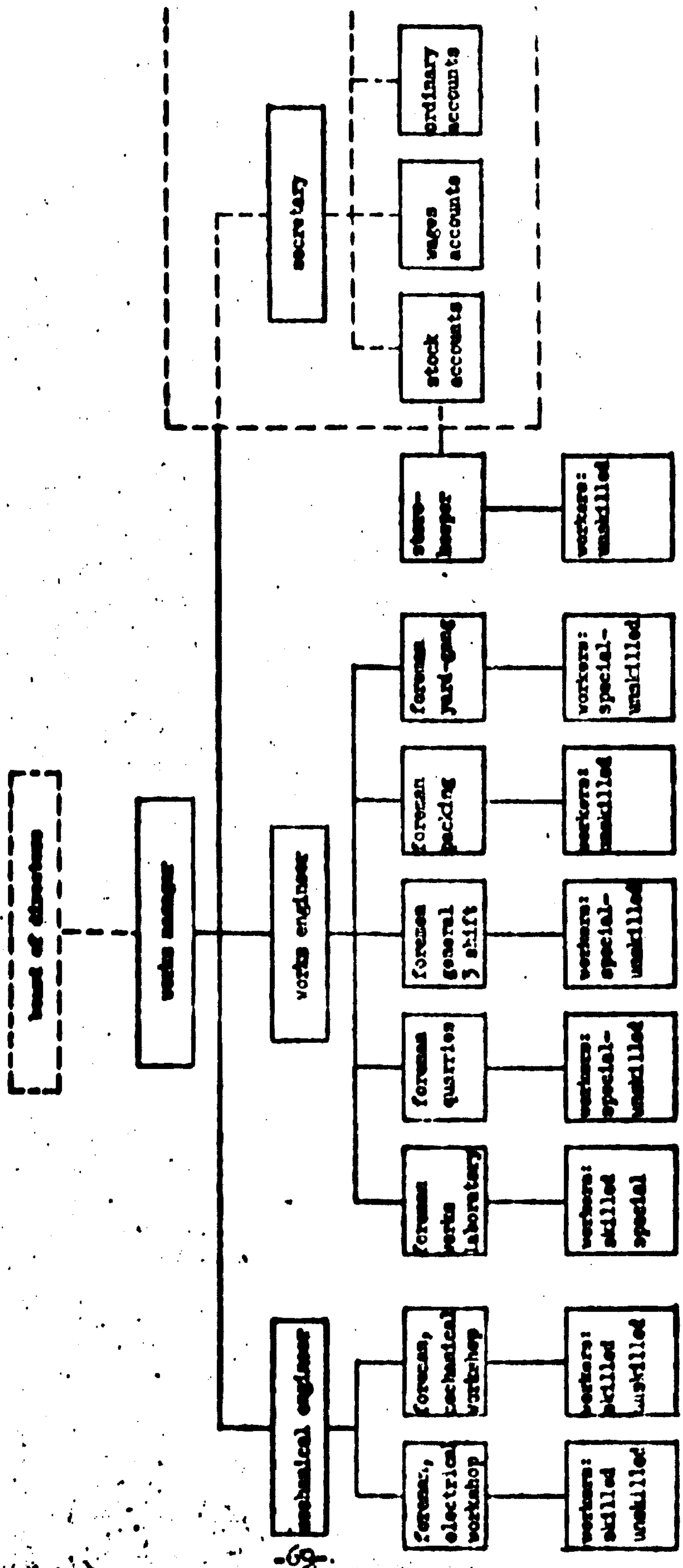
Total costs for staff

Management	:	65,000 US dollars/year	4 manpower
Mechanical works	:	87,250 US dollars/year	37 manpower
Laboratory	:	23,000 US dollars/year	9 manpower
Quarries	:	20,050 US dollars/year	9 manpower
General shift	:	62,200 US dollars/year	28 manpower
Packing plant	:	29,000 US dollars/year	16 manpower
Yard gang	:	37,000 US dollars/year	21 manpower
Cost accounts	:	45,000 US dollars/year	26 manpower
Total salaries	:	368,600 US dollars/year	150 manpower

Per ton cement : $\frac{368,500}{200,000}$ = 1.80 US dollars

Chart VI.1-2

Plan of Organization



Costs of production for 200,000 tons cement per year

a) Depreciation of capital expenditure

See capital expenditure page 28

Points 8, 9, 10 and 13 with 5% of 8,760,000		=	438,000 US dollars
Points 1, 4, 6 and 11 with 10% of 9,480,000		=	948,000 US dollars
Points 2, 3, 5, 7, 12, 14, 15, 16 with 20% of 5,760,000		=	1,152,000 US dollars
	24,000,000		2,538,000 US dollars

$\frac{2,538,000}{200,000}$ = 12.70 US dollars per ton cement (a)

b) Fuel Costs

For 200,000 tons cement about 20,000 tons fuel oil is needed.

Present price of heavy fuel oil in Papua New Guinea = 170 US dollars per ton.

Fuel costs = 17 US dollars per ton cement (b)

c) Salaries

See pages 38 and 39 = 1,80 US dollars per ton cement (c)

d) Power Costs

Energy charge 1.4 toea/kWh	=	0.02 US dollars/kWh
per ton cement 100 kWh	=	2.00 US dollars/ton cement
Demand charge		
K850/100 kW/month	=	1214 US dollars/100 kW/month
$\frac{600 \times 100}{24}$	=	2,500 kW
25 x 1214	=	30,350 US dollars per month
$\frac{30,350}{600 \times 30}$	=	1.70 US dollars/ton cement
Energy charge		2.00 US dollars/ton cement
Demand charge		1.70 US dollars/ton cement
Total for power		3.70 US dollars/ton cement (d)

e) Bags Costs

About 6 US dollars per 20 bags = 6 US dollars per ton cement (e)

f) Raw Material Costs

It is assumed to be 3 US dollars per ton cement (f)

g) Lubricants, Spares, Water, etc.

It is assumed to be 3 US dollars per ton cement (g)

h) Overheads

It is assumed to be 2 US dollars per ton cement (h)

Total costs per ton cement

a)	Depreciation	:	12.70	US dollars/ton cement	26%
b)	Fuel costs	:	17.00	US dollars/ton cement	35%
c)	Salaries	:	1.80	US dollars/ton cement	3%
d)	Power costs	:	3.70	US dollars/ton cement	8%
e)	Bags costs	:	6.00	US dollars/ton cement	12%
f)	Raw Material costs	:	3.00	US dollars/ton cement	6%
g)	Lubricants, etc.	:	3.00	US dollars/ton cement	6%
h)	Overheads	:	2.00	US dollars/ton cement	4%
Costs per ton cement		:	49.20	US dollars	100%

To above mentioned costs must be added about 10 to 15% for tax, social service, salaries for direction, reserve funds, etc., about 5.80 US dollars/ton cement.

Total production costs 55 US dollars per ton cement.

Distribution of [illegible] tonnes cement in Papua New Guinea [illegible] comparison with the present demand

The freight rates are given by the Department of Transport and is from Lae to [illegible]

For [illegible] is delivered in Goroka and another 30% is delivered in Mt. Hagen

Cement plant in Lae area

		Tonnes Cement	Freight Costs US$ per tonne Cement	Production Costs US$ per tonne Cement	Freight & Production US$ per tonne Cement	Total Cost US$
1.	Port Moresby	70,000	34	55	89	6,230,000
2.	Lae	(51,900)	-	55	55	857,175
3.	Kieta	34,000	38	55	93	3,162,000
4.	Rabaul	24,000	36	55	91	2,184,000
5.	Madang	10,000	34	55	89	890,000
6.	Wewak	6,000	38	55	93	558,000
7.	Kavieng	3,000	38	55	93	279,000
8.	Samarai	1,100	36	55	91	100,100
9.	Lorengau	-	-	-	-	
10.	Goroka	15,585	46	55	101	1,574,085
11.	Mt. Hagen	15,585	79	55	134	2,088,390
	Total	200,000				17,922,750

$$\frac{17,922,750}{200,000} = \text{90 US dollars per tonne cement (K63) produced in Lae}$$

Cement plant in Port Moresby area

There have not been any investigations made in the Port Moresby area.

<u>Cement plant in Finschhafen or Saidor or Vanimo</u>

For a cement plant built in above mentioned areas, almost all the cement would have to be shippped and transported to the main towns.

1.	200,000 tonnes cement shipped at 37 US dollars per tonne i.e.	7,400,000 US$
2.	30,000 tonnes cement to the Highlands at 60 US dollars per tonne, i.e.	1,800,000 US$
3.	Production costs at 55 US dollars per tonne cement, i.e.	11,000,000 US$
4.	Construction of power station 2,000,000 US dollars dep. 10%	200,000 US$
		20,400,000 US$

$\frac{20,400,000}{200,000}$ = <u>102 US dollars per tonne cement (K71) produced in:</u>

<u>a) Finschhafen</u>

<u>b) Saidor</u>

<u>c) Vanimo</u>

<u>Cement plant in Chimbu area</u>

1. 20,000 tonnes fuel oil from Lae to Chimbu :
2. 10,000 tonnes gypsum from Lae to Chimbu :
3. 170,000 tonnes cement from Chimbu to Lae :
4. 155,000 tonnes cement shipped to main towns :

a)	Production costs 55 US dollars per tonne cement, i.e.	11,000,000 US$
b)	Fuel transport - 20,000 x 50, i.e.	1,000,000 US$
c)	Gypsum transport - 10,000 x 50, i.e.	500,000 US$
d)	Cement transport to Lae - 170,000 x 50, i.e.	8,500,000 US$
e)	Cement transport from Lae - 155,000 x 37, i.e.	5,735,000 US$
f)	Construction of power station - 2,000,000 US dollars dep. 10%	200,000 US$
		26,935,000 US$

$\frac{26,935,000}{200,000}$ = <u>135 US dollars per tonne cement (K95) produced in Chimbu</u>

SMALL PLANT SIZES

NIDA has asked me to give a view of small plant sizes, with simple technology, that could be useful in the government's Eight Point Programme which, among other things, prefer decentralisation of economic activity.

Cement making is a very simple process and has always been open to newcomers and process patents and secret know-how have never played a significant part in it.

Everyone can make his own cement when he has calcoreus materials. The process is only to heat the calcoreus materials to about 1450°C for a certain time and the cement is ready. This can be done in any kind of quantity in our kitchen, in the garden, or we could build a simple kiln and mix wood and calcoreus materials. We do not need special skilled personnel to do it for us but if we make our own cement in this way we do not know very much about the quality of the cement. There are however many building works made 1000 years ago with cement made in the above mentioned way.

But we must say that this kind of cement making hardly exists today. If we have to use the cement for practical purposes we must know the composition of the raw materials and the strength of the cement.

In cement making, heavy raw materials have to be handled and some kind of equipment will have to be used.

There is hardly a company today that would make equipment for a cement plant less than 100 tonnes cement per day. i.e. 30,000 tonnes per year and these kinds of small plant sizes are likely to be found only in developing countries at an early stage of industrialisation.

RECOMMENDATIONS

I The size of the cement plant and the method of process

1) The cement plant should be built for 200,000 tonnes of cement per year.

2) The process should be dry-process, rotary kiln with preheater.

Motive:

a) The present consumption is only half a bag of cement per capita, i.e. 70,000 tonnes cement per year. The extremely high price of imported cement is the main reason why many avoid the use of cement in construction. With local manufacture of cement, the cost of cement will be about half the present cost. One or 1.5 bags of cement per capita is equal to 150,000 to 225,000 tonnes cement per year. In Europe, each capita consumes ten bags of cement per year.

b) The manufacture of cement is only economical if it is manufactured in a plant above a certain minimum size.

c) The companies involved in the investigation of the cement industry in Papua New Guinea (Blue Circle Southern, Australia and Hyundai Group, South Korea) will be able to guarantee export of surplus cement from Papua New Guinea.

d) The process should be dry-process, rotary kiln with preheater - the most economical process with the high fuel costs. Also, the most usual process today is dry-process and this is important for the training programme of local people.

II <u>The most suitable site for cement manufacture in Papua New Guinea</u>

1) The most suitable site for the cement industry will be the Lae area.

<u>Motive</u>:

a) It is the centre of Papua New Guinea

b) It is the area where the demand for cement is concentrated and it is the most industrialised and populated.

c) There are road connections with the Highlands

d) There is access to a wharf

e) Electric power could easily be supplied from Lae.

From a cement plant built in Finschhafen or Saidor or Vanimo, all the cement will have to be shipped, power plants have to be constructed.

The deposits of limestone is in Sankwep which is about 15 miles from Lae. There are 10 miles of good road and five miles of road in bad condition.

The best will be -

1) to build the cement plant near to Lae and arrange transport of limestone to the plant in a conveyor. Other possibilities could be

2) to build the cement plant in Sankwep near the deposit of limestone and transport the cement in a conveyor to Lae.

3) to build the clinker making plant in Sankwep and the clinker grinding plant in Lae. The weight of clinker is about half of the weight of the raw materials used to make clinker.
The company which is given the order should be asked to give a feasibility study about the three proposals.

For cement plant in Finschhafen or Saidor or Vanimo, the plant site could be near a deposit of limestone and harbour.

III **The companies which should be invited to submit a feasibility study on the cement industry in PNG**

The government of Papua New Guinea should invite Blue Circle Southern, Australia and Hyundai Group as associated partners.

Motive:

Blue Circle has had extensive experience in plant design and operating of cement plant in Australia, Mexico and Africa, where they also take care of the marketing of cement.

Hyundai Group would be able to send manpower for the erection of the plant. Furthermore to make the most cement making equipment in South Korea. The Group has done successful work with the hydro-electric power station in Ramu Scheme.

The advantage with the two groups is that they will guarantee the export of surplus cement produced in Papua New Guinea and the two groups will also be able to raise capital for the establishment of a cement industry in Papua New Guinea.

NIDA has already had a comprehensive list of consulting companies in the cement industry, but NIDA should rather have a company that will take care of the raising of working capital, operating of the plant and marketing of the cement.

IV **FOLLOW-up activity of UNIDO expert**

After the government has invited companies for tender for the cement industry in Papua New Guinea, they should request the UNIDO expert to set out a project for the safeguarding and training of local personnel.

UNIDO 17 April 1975

Request from the Government of Papua New Guinea
for Special Industrial Services

JOB DESCRIPTION

IS/PNG/75/010/11-1/03

Post Title: Adviser in establishment of cement industry

Duration: Two months

Date required: As soon as possible

Duty station: Port Moresby with travel in the country and overseas

Duties: The expert will be assigned to the Government of Papua New Guinea to assist and advise the National Investment and Development Authority (NIDA) in evaluating different schemes for the establishment of a cement industry. Specifically the expert will be expected to:

1. assist in appraising different raw materials for cement production and advise on their suitability for different production processes;
2. assist in evaluating the cement market taking into account future growth of consumption;
3. advise on the elaboration of tender specifications for international bidding and assist in establishing a list of companies who should be invited to give proposals for the establishment of the cement industry;
4. assist in the evaluation of company proposals and participate in technical negotiations.

Language: English

Qualifications: Industrial Engineer with extensive experience from establishment and operation of cement factories.

Background Information: The manufacture of cement in Papua New Guinea has been under discussion for many years and the National Investment and Development Authority is at present examining the possibility of realising some of the ideas. Factory proposals ranging from 10,000 tonnes per year to 1,000,000 tonnes per year have been suggested for various localities, but the government has no specialists with suitable technical experience to evaluate the proposals technically. The country has extensive limestone resources and will have hydro-electric power from the Ramu Scheme.

LIST OF PERSONS MET IN CONNECTION WITH CEMENT PROJECT

PORT MORESBY, PAPUA NEW GUINEA

UNDP : Mr T M Unwin, Resident Representative
Mr T Jones, Programme Officer

NIDA : (National Investment & Development Authority)
Mr T Allen, Executive Director
Dr Vern Harvey, Deputy Executive Director
Mr Tony Winterbottom, NIDA officer (1)
Mr Moi Kanat, NIDA officer (1)
(1) main contact during the mission.

LAE, PAPUA NEW GUINEA

Hyundai Construction Co.
Mr Y M Baik, Manager of Lae office
Mr Kim, Manager of cement project

SYDNEY, AUSTRALIA

Blue Circle Southern
Mr A M M Spurr, Director-Technical Services
Mr M Robinson, Senior Geologist

Tower Research and Development
Mr L Anderson, Chairman

MELBOURNE, AUSTRALIA

Dr Steven Gottlieb, specialist in shaft kiln.

PAPUA NEW GUINEA : BASIC DATA

Area (square miles) ______ 184,000

Estimates of total midyear population:

1971 ______ 2,510,000

1980 ______ 3,370,000

Percentage of urban population in 1974 ______ 12%

Annual rate of growth of total population:

1960-70 average ______ 2.8%

Gross domestic product (millions of 1968/69 US dollars):

1969 : 453 - 1970 : 504 - 1971 : 557

1972 : 571 - 1973 : 621 - 1974 : 696

N.D. Income per capita (1970 US dollars) 1971/72 ______ 157

Rates of annual growth:

Total GDP in 1971/72 - 1972/73 : 8.8%,

1972/73 - 1973/74 : 12.1%

Gross investment (millions of 1970 US dollars)

1972/73 : 128 - 1973/74 : 100

Trade (million of US dollars)

Export : 1972 : 143 - 1973 : 292 - 1974 : 531

Imports: 1972 : 359 - 1973 : 290 - 1974 : 301

Exchange rate (units of the national currency per US dollars)

June 1975 : K0.7

Per cent change in consumer price during 1973 : 13.6%

Central Government tax revenue

1973/74 : 43.6% of total revenue

Percentage of total Government expenditures for:

Education (1973) ______ 17.4%

Public health (1973) ______ 8.3%

Housing (1973) ______ 5.5%

Birth rate per 1,000 inhabitants (1974) ______ 44.2

Mortality per 1,000 inhabitants (1974) ______ 16.3

Infant mortality per 1,000 live birth (1974) ______ 96.0

Years of life expectancy at birth (1970-75) ______ 52.0

Percentage of literacy (1974) ______ 15%-25% (poor statistic)

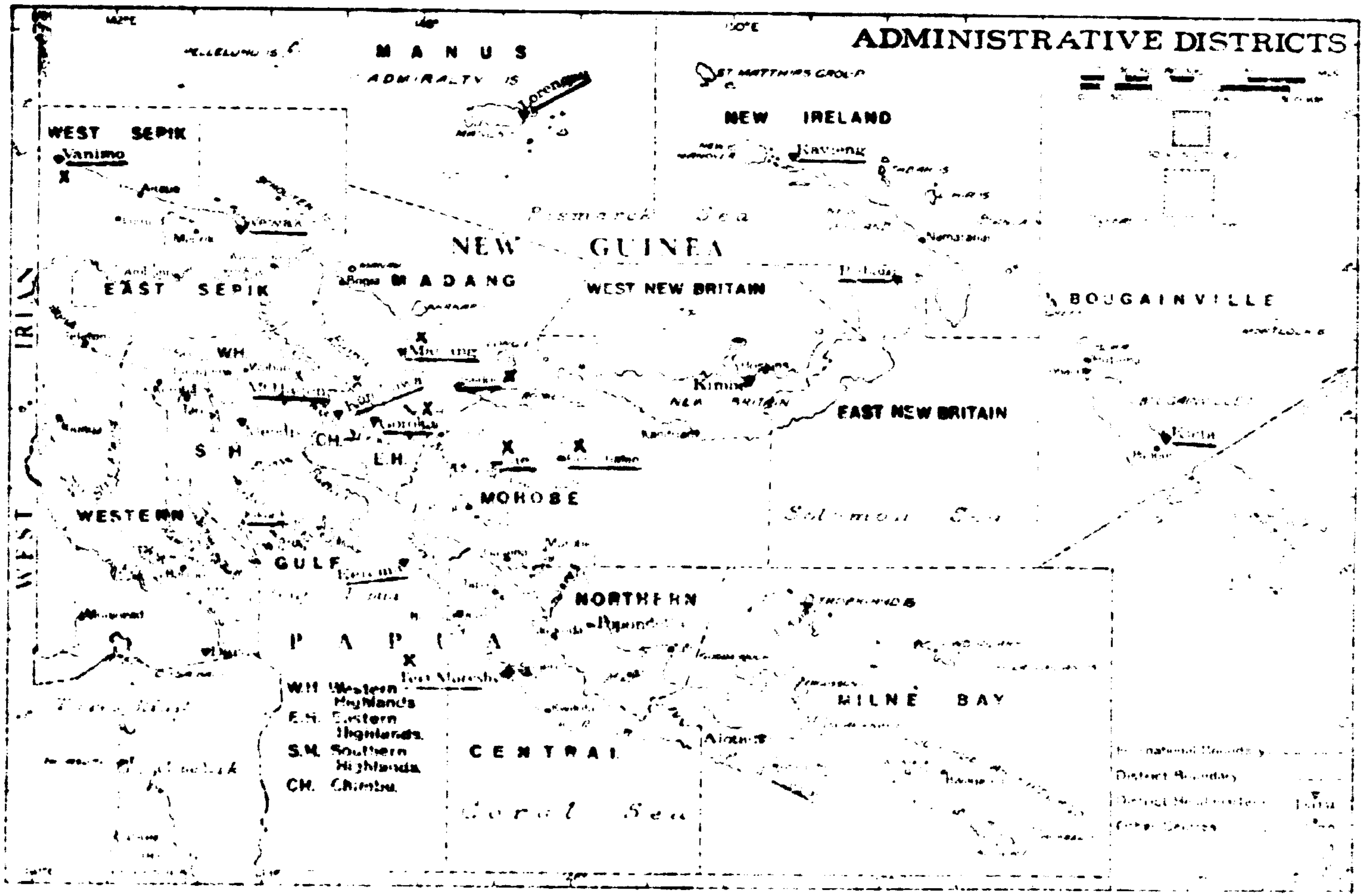


Fig. 1 General political map of Papua New Guinea

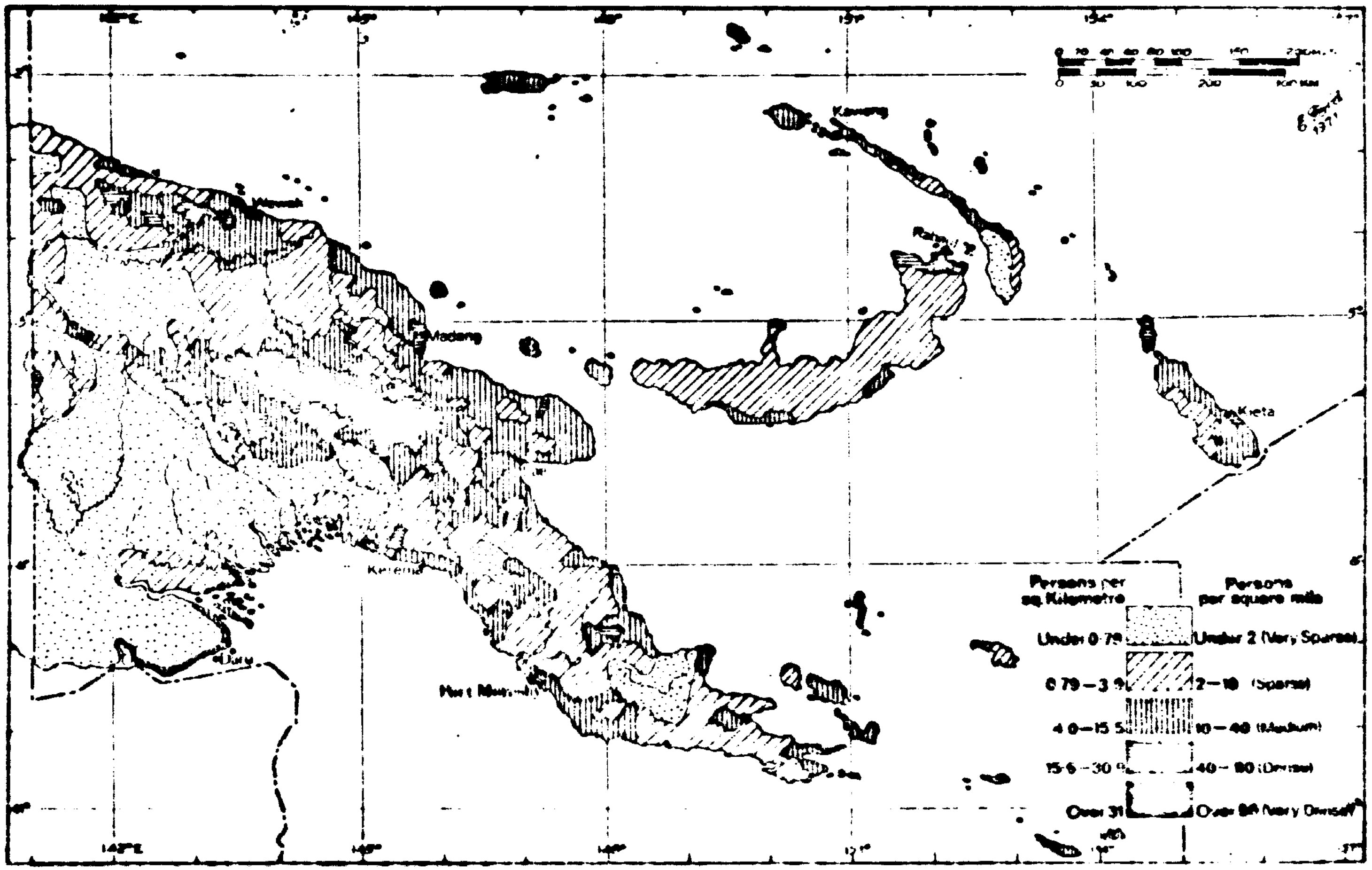
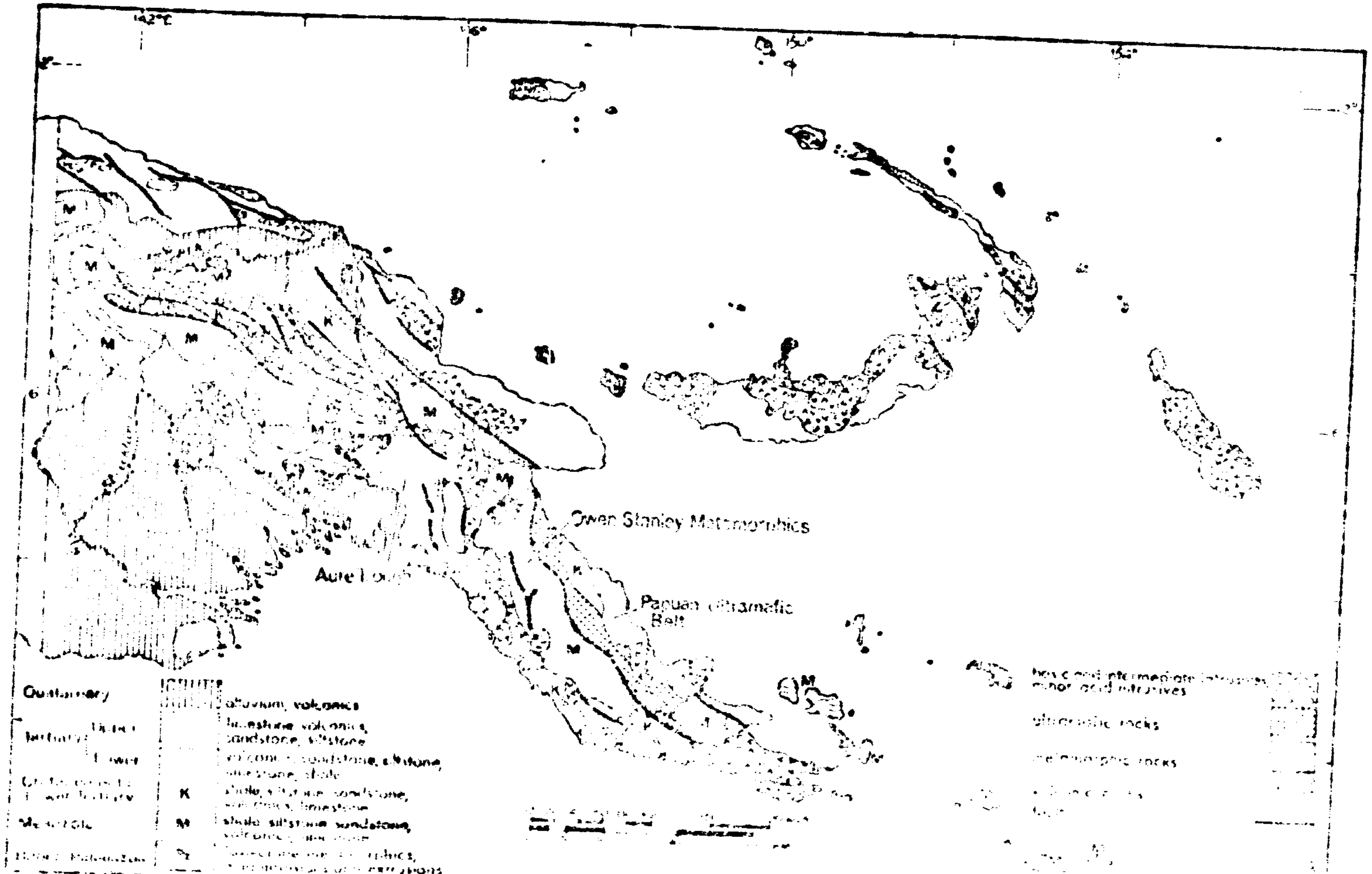


Fig. 17 The approximate average density distribution of population in Papua New Guinea, based on statistics for the census divisions in 1966



[illegible] map of Papua New Guinea [illegible]
By courtesy of [illegible]

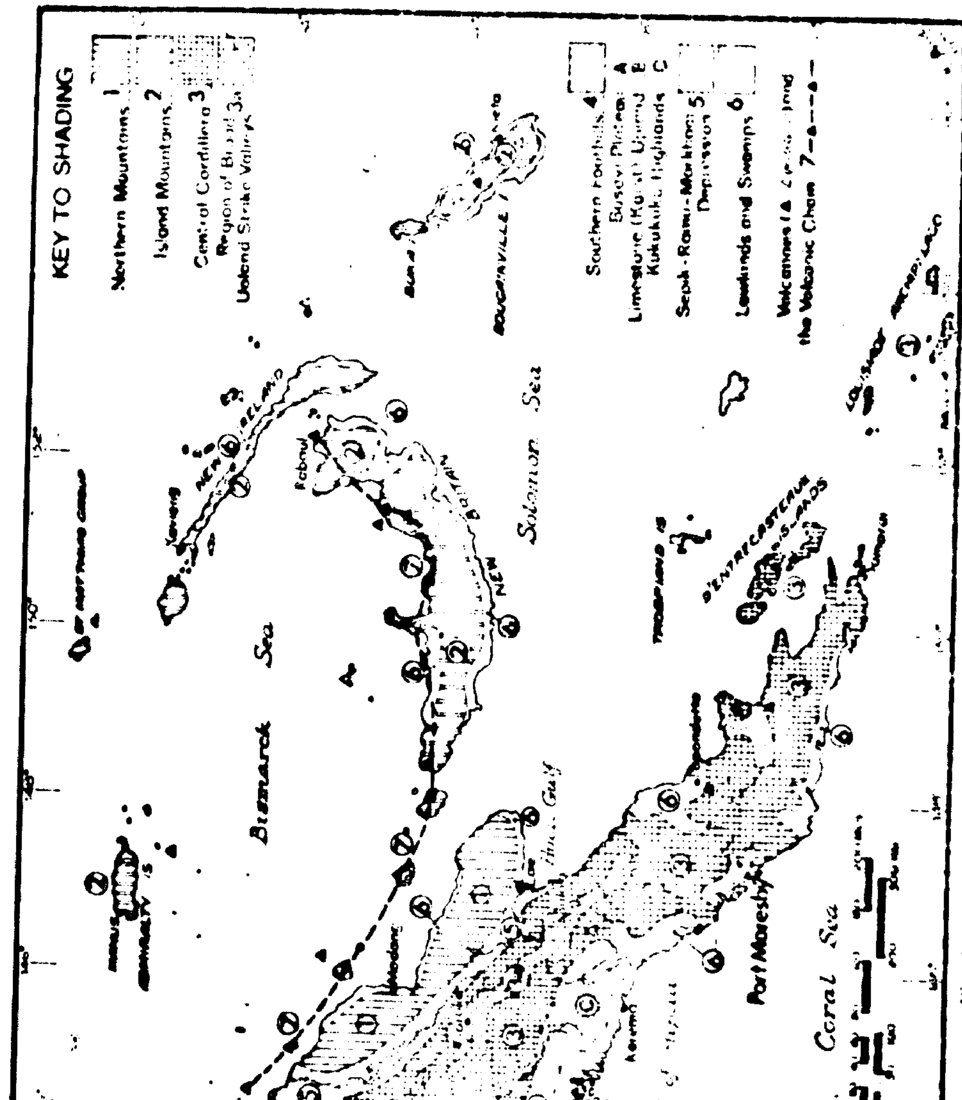


Fig. 4 The principal landforms of Papua New Guinea

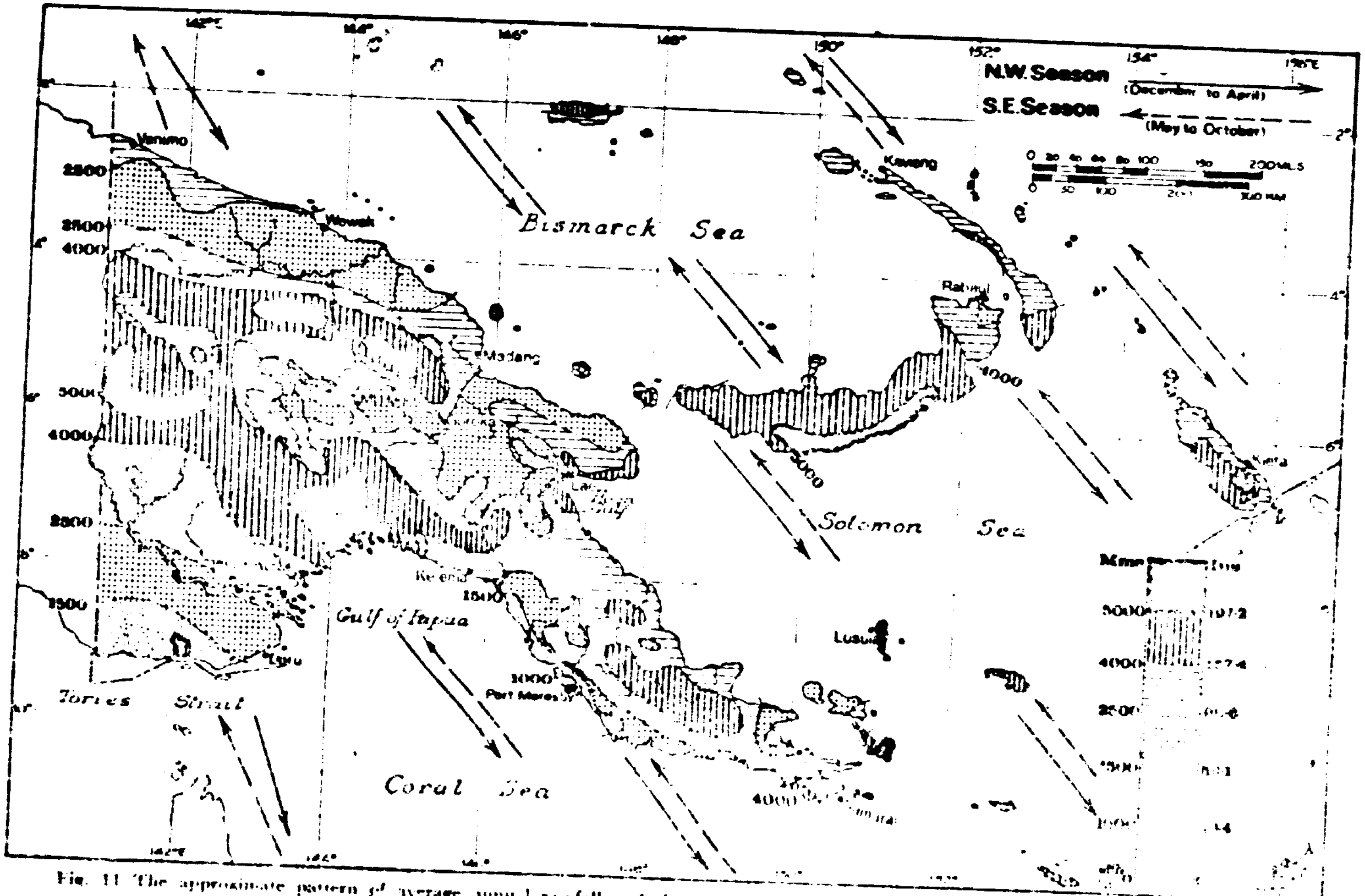


Fig. 11 The approximate pattern of average annual rainfall and the seasonal wind streams throughout Papua New Guinea [illegible] from records supplied by the Bureau of Meteorology, Melbourne)

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