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PRELIMINARY MINING PLAN FOR
SUEZ CEMENT COMPANY'S
LIMESTONE AND CLAY DEPOSITS
SUEZ, EGYPT

Agency for International Development
Washington, D.C. 20523

June 15, 1976
Dames & Moore

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June 15, 1976

Office of Capital Development
Bureau of Near East
Agency for International Development
Washington 20523
District of Columbia
U.S.A.

Attention: Mr. Sterner

Gentlemen:

re: Suez Cement Company, Suez, Egypt

In accordance with Contract No. AID/otr-C-1304 work order No.3 dated February 27, 1976, we are pleased to submit ten copies of our final report "A Preliminary Mining Plan for the Suez Cement Company's Limestone and Clay Deposits, Suez, Egypt". The report is unchanged for the most part, from the preliminary copy sent to yourself and Mr. Philip Lewis for review.

It has been a pleasure to deal with U.S.A.I.D. staff on this interesting project. Please do not hesitate to contact us should any questions arise from this work.

Yours very truly

DAMES & MOORE

J.B. Bullock, P. Eng

for. Charles P. Gupton, P.E.
Associate

Philip S. Martin.

Philip S. Martin, P.Eng.
Mining Engineer

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encl.

A PRELIMINARY MINING PLAN

FOR THE SUEZ CEMENT COMPANY'S

LIMESTONE AND CLAY DEPOSITS

SUEZ, EGYPT

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1. INTRODUCTION

1.1 Study Objectives

This study was undertaken in order to assist the United States Agency for International Development Mission in Cairo to fully evaluate the economic viability and capital cost requirements of the Limestone Quarry development in the Okheider-Ramlia Area, south of Suez in Egypt. The operations have recently been assigned the title of Suez Cement Company. Specifically, Dames & Moore were to provide assistance to the Arab Swiss Engineering Company (ASEC) in formulating a mining plan and preparing a detailed list of technical equipment to implement the plan for mining limestone and clays in two separate deposits for the Suez Cement Company's proposed cement producing facilities some 40 km (25 miles) south of the town of Suez.

1.2 Scope of Work

As outlined in our letter of proposal dated February 24, 1976, under the provisions of Contract No. AID/otr-C-1304, Dames & Moore was to provide a mining engineer, experienced in open pit mine planning and equipment selection, to review the Suez Cement Company's preliminary mining plans prepared by ASEC, and help develop more detailed plans and equipment specifications. The scope was defined in A.I.D. work order No.3 dated February 27, 1976 as follows:

> The Contractor shall provide the services of a qualified mining engineer who shall assist ASEC in Egypt:

- develop a plan for mining the limestone and clay required for the cement project.
- prepare a detailed list of equipment, including approximate equipment cost, required to mine, crush and transport the raw materials to the plant site.
- prepare a layout showing the quarries, the location of the grinding equipment, the storage facilities, and roads.
- prepare and submit to U.S.A.I.D./Cairo an interim draft report prior to his departure from Cairo containing preliminary conclusions and recommendations.
- prepare and submit to the Project Manager, Office of Capital Development, A.I.D., Washington, ten copies of a final report containing findings, conclusions and recommendations together with an equipment list and approximate costs.

Mr. Philip S. Martin, a mining engineer with Dames & Moore, was the engineer appointed to travel to Cairo and work on this project.

1.3 Consultant Activities

Prior to departure for Cairo, the Consultant had read and familiarized himself with background data on the project available from Mr. James Furlow of Dames & Moore's Phoenix office, and Dames & Moore's "Review of Geological Investigation - Proposed Limestone Quarry - U.S.A.I.D." (See Appendix I - item I). He had also contacted a representative group of U.S. equipment manufacturers, asking them to supply copies of brochure material on their quarry equipment suitable for this type and size of operation. One set of

the brochure material was taken to Cairo and subsequently left with ASEC. A reference set was retained by Dames & Moore for follow-up purposes. Some representative prices and delivery times were also obtained.

The Consultant arrived in Cairo on the evening of Monday, April 26, 1976. On Tuesday, April 27, he met with Mr. Philip Lewis (General Engineering Officer) and Mr. Don Scarpo (Loan Officer), both of the U.S.A.I.D. Program's Cairo staff.

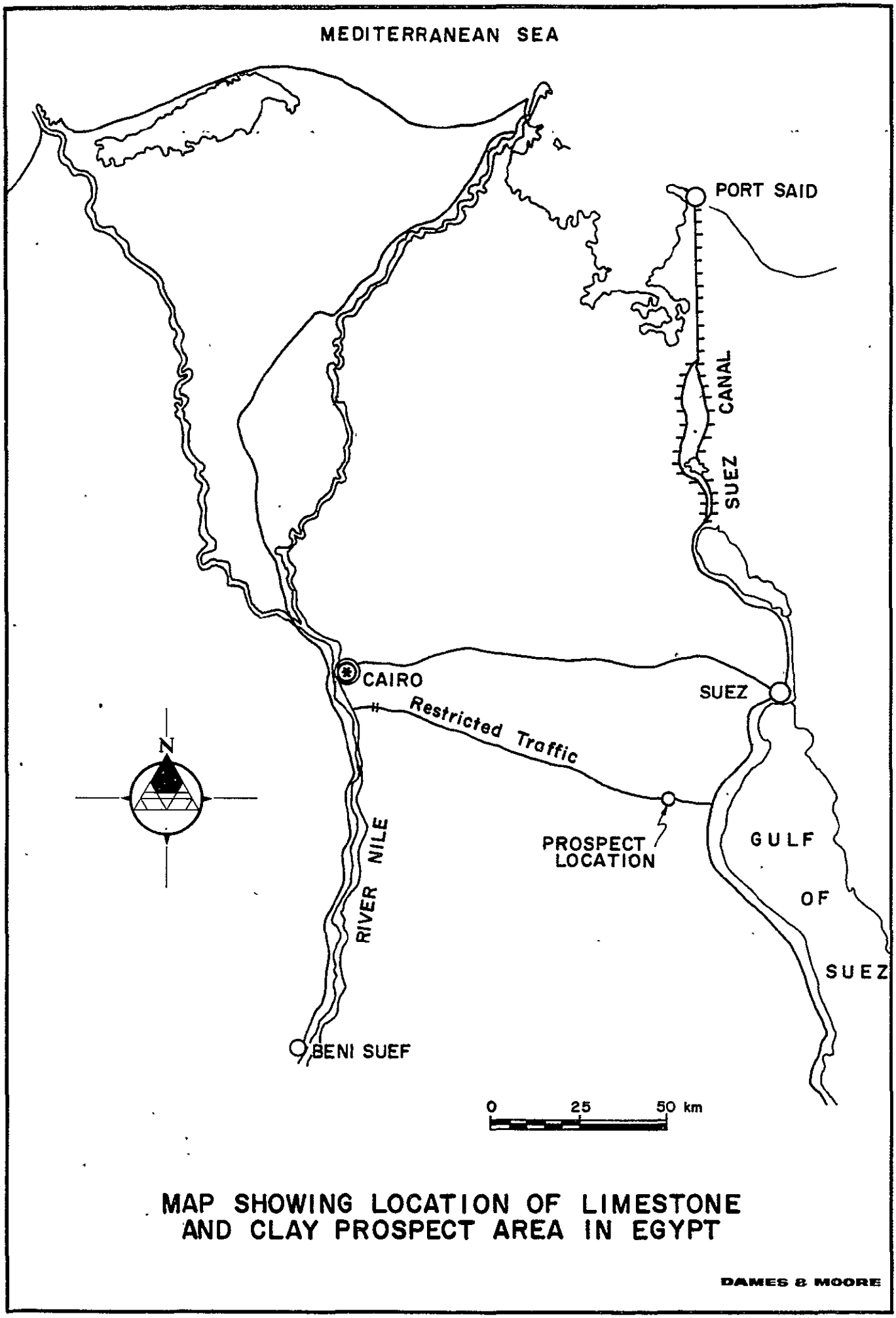
Following a brief update on the project's status, Mr. Martin and Mr. Philip Lewis went to the Zamalek Office of ASEC. Present for ASEC were Dr. Mourad I. Youssef, Geological Consultant to ASEC, and Mr. Mohamed Osman Khalil, the Company's Geologist. The conversation revolved around bringing the Consultant up to date on the geological investigation of the limestone and clay deposits. For the clay deposit, additional information not previously available to Dames & Moore was presented and discussed. Several written documents were made available (see Appendix I - items 2 and 3). The data essentially documented the clay deposit in terms of its quality, quantity and consistency. On Wednesday, April 28, the Consultant met with ASEC personnel in their newly acquired premises at 43 Kasir El Nile Street, Cairo. In addition to Mr. Mohamed Osman Khalil, Mr. Peter Maier (Technical Manager) and Mr. Nabil el Hariry (Engineer) both of ASEC, were present. The discussions were based upon the various options open for mining and exploiting the limestone and clay deposits.

A draft copy of ASEC's "Concept of opening up and Operating of Limestone Quarries" was made available (Appendix I - item 4). On Thursday, April 29

Mr. Mohamed Osman Khalil and Dr. Mourad Ibrahim Youssef accompanied Mr. Philip Martin on a visit to the Suez Cement Company's limestone and clay deposits which are located some 200 km (124 miles) from Cairo by road (See Plate 1). The various mining options available were discussed in the field and judged against the physical characteristics of the deposit. The overall height of fully developed benches or working faces was discussed in view of ASEC's desire to develop and maintain 60 metre (197 feet) benches. This point is discussed fully in the section on ASEC's initial mine concept. In view of the importance of this subject and also in order to observe at first hand Egyptian quarrying practice, a visit was made on Sunday, May 2 by Mr. Martin, accompanied by Mr. Mohamed Osman Khalil to the Tourah Portland Cement Company operations some 20 km south of Central Cairo. This quarry, which mines some 1.3 million tonnes of material per annum, operates with 50 metre (164 feet) benches, using 4½ cubic metre (6 cubic yard) electric shovels and 20 tonne (22 short ton) trucks. A subsequent visit to Tourah was made by Mr. Philip Martin and Mr. Philip Lewis, accompanied by Mr. Mohamed Osman Khalil, on Thursday, May 6, to observe blasting procedures before and after the weekly blast. The balance of the Consultant's time in Cairo was spent in formulating preliminary mining proposals for the Suez Cement Company's limestone and clay deposits, in discussing these proposals with U.S.A.I.D. and ASEC personnel and in preparing an interim draft report for U.S.A.I.D. Cairo personnel.

Upon his return to North America, the Consultant met with various equipment manufacturers to obtain:

- current price quotations
- projected delivery schedules



MAP SHOWING LOCATION OF LIMESTONE AND CLAY PROSPECT AREA IN EGYPT

DAMES & MOORE

PLATE I

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- selected performance characteristics.

The preliminary mining proposals were then prepared and presented in a draft format to U.S.A.I.D. personnel in Washington and Cairo.

1.4 Summary and Conclusions

Upon arriving in Egypt to review the geological and mine planning work performed up to that time by ASEC, the consultant found that much of the work was incomplete.

The geological studies which had been written up in two previous reports:

- Preliminary Geological Investigations
- Detailed Geological Investigations (Part I)

were being expanded and represented in a further report:

- Detailed Geological Investigations (Part II).

This report was not finished until May 7, 1976, and contained some additional information, of interest and value in preparing the mine planning, not previously available.

The most serious criticism of the geological studies is that the limestone deposit has not been drilled off, and that all the analysis, and re-analysis, to date has been based upon a series of eight channel samples. This is not to suggest that the project is unfeasible, merely that greater progress would have been expected in the development of an access road from the plains of

Wadi Bada and Wadi Hagoul, and in the preparation of a drilling program for the limestone.

Dames & Moore's main conclusions and observations on the project are:

a) ASEC have completed preliminary geological studies.

b) A program of drilling for the limestone deposit has been recommended to the Suez Cement Company.

c) Suitable quantities of limestone and clay sufficient to support the cement project have been established, subject to some noted reservations.

d) ASEC had not fully prepared mining plans sufficient for detailed technical review in Egypt.

e) Egyptian mining practices, procedures and regulations are less rigid than North American standards and hence introduce greater flexibility into mine planning.

f) ASEC has based their limestone mine concepts upon 60 metre (197 feet) benches, for which they do not have the necessary governmental authority, although this is not seen, by them, to be a problem.

g) ASEC have not developed mining schemes for the clay deposits.

h) To date, ASEC have not used the services of a mining engineer, although Holderbank were likely to supply an engineer for advisory purposes in late May for a short period.

i) ASEC had chosen a site for the Cement Plant adjacent to the Gulf of Suez, some 12 kilometres (7.5 miles) from the limestone deposit, and had received tentative military approval.

j) A conveyor system was proposed for the supply of raw materials to the cement plant from the quarries.

As a result of these findings in Egypt, and subsequent discussions with equipment manufacturer's representatives in North America, the following recommendations are presented:

a) Sufficient geological work and physical sampling and testing remains outstanding on this project to prevent the presentation of a definitive mining program and plan for either the limestone or the clay deposits. However, preliminary mining programs are presented which use the geological knowledge available to date together with reasonable estimates for outstanding data, incorporated with performance characteristics of proven U.S.-made equipment.

b) The list of equipment envisaged as necessary for the quarrying operations has been supplemented by:

   (i) an approximate price range, second quarter 1976.

   (ii) an approximate delivery schedule, also second quarter 1976.

   (iii) examples of the type of equipment considered suitable for this particular application.

   However, it should be noted that:

   (i) delivery schedules could change quite quickly if the U.S. economy picks up in the second half of 1976.

   (ii) examples of equipment do not constitute a recommendation by Dames & Moore, and other manufacturers do make similar equipment.

c) The proposed location of the cement plant, adjacent to the coast, is a reasonable choice, provided that the required military approval is forthcoming. The most efficient movement of raw materials from the quarries to the plant over the long term would be by conveyor.

d) Limestone should be crushed to a size suitable for conveying (less than 30 cm or 12") immediately adjacent to the quarry, and stored in a stockpile from which it would be recovered for conveyor transportation to the plant.

e) The limestone quarry plans call for a conventional drill, blast, load and haul operation to feed broken limestone to the jaw crusher. The equipment specified for the operation at this stage is all U.S.-made open-pit/quarrying equipment of proven capabilities.

f) Benches of up to 40 metres (131 feet) are recommended for two distinct reasons:

(i) Most U.S. manufactureres do not produce a wide variety of drilling equipment to handle benches over 45 metres (150 feet).

(ii) Most mining and quarrying situations are regarded as less safe when excessive bench heights are used.

For these reasons, a maximum bench height of 40 metres is planned for in this initial analysis. Much of the equipment is sufficiently flexible to allow some modification to take place in any subsequent planning exercise. In the absence of Egyptian regulations limiting bench heights, planners are advised to examine successful quarrying practices in other countries using similar equipment to that proposed for Suez Cement, before departing from these recommendations.

g) Heavy equipment operator training should be introduced as soon as possible and the operating environment for each worker should be controlled where possible in view of the extremely harsh local conditions. Air conditioners and canopies for all mobile equipment may help to achieve higher productivity

and the correct maintenance of roads and haulage ways should be a priority.

h) In order to localize management control of the quarry operations, a central warehouse, maintenance shop and office complex has been incorporated into the quarry site planning, adjacent to the limestone quarry.

i) The clay quarry plans call for a mobile non-clog hammermill crusher which follows the advancing quarry face; a trench some 450 metres long being worked by front end loaders and trucks.

j) A test pit is proposed for the clay quarry in which:

(i) the diggability of the clay could be established for crusher design purposes

(ii) the rippability of the interbedded limestone could be confirmed

(iii) the swell factors for the clay could be determined

(iv) potential bank stability could be estimated for planning purposes.

k) During the limestone drilling proposed for the coming months, some expert geotechnical work should be undertaken. From the 300m x 300m grid proposed by ASEC and the additional holes proposed by Dames & Moore for the short term quarry areas, sufficient high-quality core samples should be taken, examined, preserved and subsequently tested so as to provide accurate values for physical characteristics of the limestone material.

l) In order to bring the geological data base up to the point where an unreserved decision on the project can be made, Dames & Moore recommend that:

(i) an outside geotechnical engineer be available to ASEC during a

portion of their summer geological program in the clay and limestone deposit. This would help maximize the recovery of useful data at optimum expenditure.

(ii) once the summer geological work and the chemical and geotechnical analysis has been completed, then the geologist and mining engineer should return to Cairo, together if possible, to review all additional data and discuss any modifications to the mining programs, prior to tenders for equipment being placed.

2. PROJECT DESCRIPTION

2.1 Proposed Project

The Portland cement industry in Egypt began production in 1900 with a 60,000 tonne (66,000 short ton) per year plant south of Cairo. At the present time, there are four companies producing cement in Egypt, with a combined annual output of approximately 3.5 million tonnes (3.8 million short tons).

Until recently, cement production in Egypt was adequate to satisfy domestic needs, and in addition, to provide substantial exports. However, following the 1973 war, plans were made to reconstruct damaged portions of the Suez Canal and facilities on the Sinai Peninsula. As a result of this rebuilding program, and demand from new building projects, cement requirements in Egypt are expected to exceed production rates for some years to come.

Consequently, the Egyptian Ministry of Housing and Reconstruction is planning for increased domestic cement production by building new cement plants and expanding existing plants, rather than importing large quantities of cement. On a regional basis, it has been estimated that in 1980, the cement requirements in the Suez Canal and Sinai Zone will be approximately one million tonnes (1.1 million short tons) per year, and will reach a maximum of 1.5 million tonnes (1.65 million short tons) in the year 1984. Accordingly, the desired capacity of the proposed cement plant to serve the Suez area was set at one million tonnes (1.1 million short tons) of cement per year to meet these regional construction needs.

The Okheider-Ramlia Area (See Plate 1) was selected for a limestone exploration program for three main reasons:

a) Extremely large quantities of raw materials, i.e. limestone and clay, are known to exist in the area. In addition to Portland cement, there is a possibility of quicklime and white cement production from these materials.

b) The area, which is about 50 kilometres (31 miles) southwest of the City of Suez, is close to the Suez Gulf and the Red Sea, with paved access roads and a port at Adabiya. At the present time, other limestone deposits closer to Suez are not available for evaluation or mining due to national security restrictions.

c) Limestone reserves in the required amount of 200 million tonnes (220 million short tons) are not available in any one locality near Suez, due to either excessive overburden or occupation by military forces.

The Okheider-Ramlia Areas is located about 40 kilometres (25 miles) by road southwest of the City of Suez, and 12 kilometres (7.5 miles) by road west of the Suez Gulf.

2.2 Geology (Taken from Dames & Moore's February 1976 report)

The Gabal Okheider (or Gabal El-Ramlia) mountains consist of a large uplifted fault block in which most exposed rocks consist of limestone of Eocene age. The northeastern face of the mountain range is a fault scarp that rises as much as several hundred metres above the plains of Wadi Bada and Wadi Hagoul.

Various clays and limestones of Miocene age underly the surface of the plains to the north and east of the mountains. Near the base of the mountains, alluvial material overlies the clays and fills dry washes cut down into the Miocene sediments.

Faulting and uplift of large blocks into mountain ranges probably began in late Miocene time and may have continued into the Pliocene; softer Miocene clays and less resistant sediments were eroded from underlying Eocene limestones as the fault blocks moved upward and are no longer present in the mountain areas. Within the larger uplifted fault blocks there are numerous smaller faults that may locally show vertical displacement in the order of tens of metres.

The original area selected for exploration within the Gabal Okheider-Ramlia area lay at the eastern edge of the mountain range. An extremely thick sequence of limestone exposed here appeared at first to present an excellent prospect. After further investigation, however, it was found that a bed of limestone some 11 metres (36 feet) thick near the top of the sequence contained large quantities of chert nodules. Selective mining and removal of this bed would be not only physically difficult, but also expensive. In addition, utilization of the chert-bearing limestone for cement manufacture would be expensive in terms of excessive wear and increased maintenance on crushing and grinding equipment.

Therefore, an effort was made to locate a block of limestone within the range that did not contain the chert-bearing bed. Such an area was located about 3 kilometres (2 miles) from the southeastern edge of the range, on the

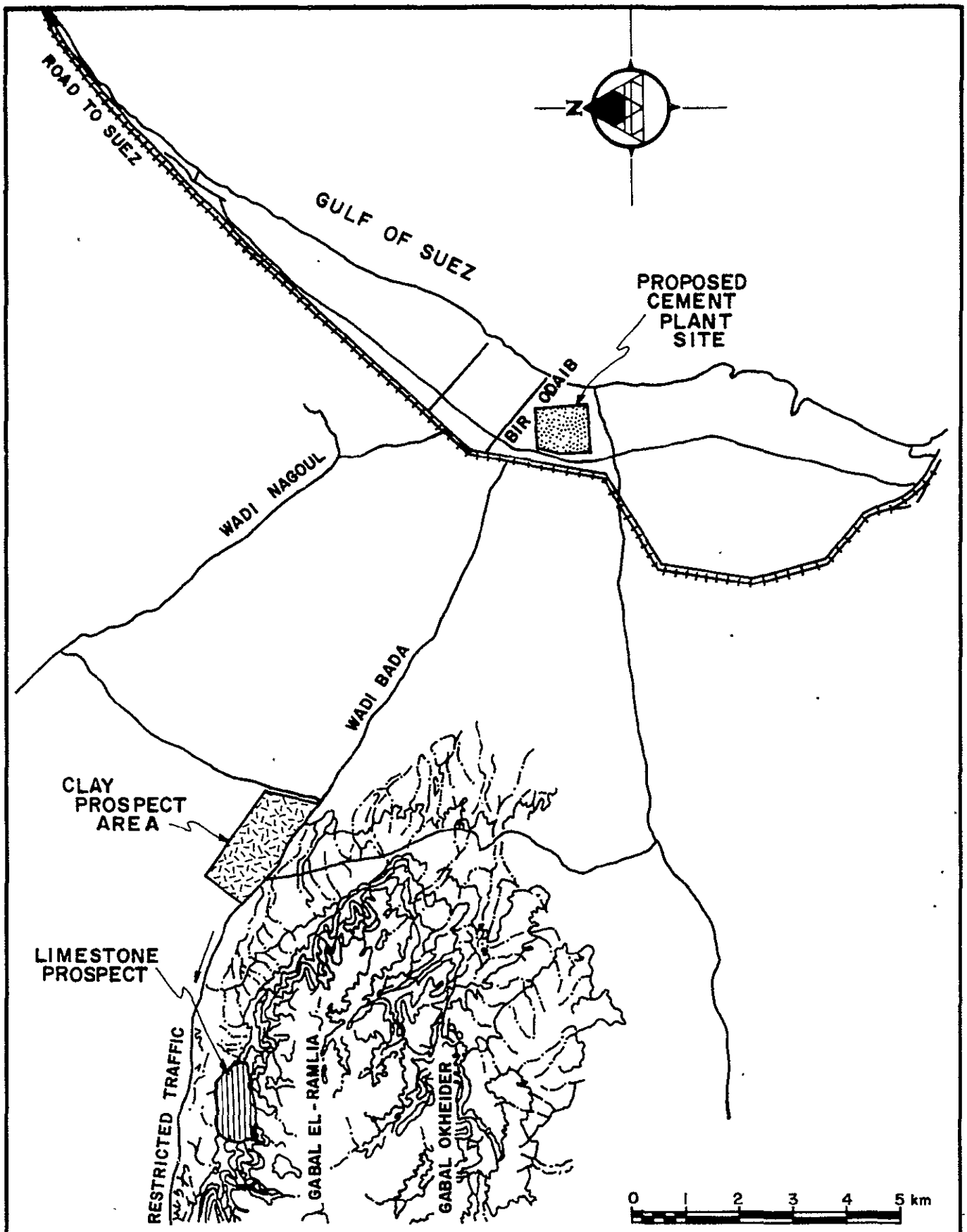
northeast face (See Plate 2). Within this area, the chert-bearing limestone has apparently been removed by erosion. The thickness of potentially suitable limestone exposed above the plain in this block ranges from 112 to 170 metres (370-560 feet). As a result of successfully locating the block of limestone devoid of the chert-bearing horizon, further evaluation efforts were concentrated on this one area.

The limestone exposed at the potential quarry site is Eocene in age, lithologically uniform, massively bedded, and contains no interbedded shales or sandstones within at least the upper 150 metres (490 feet). The limestone is white in color on fresh surfaces, moderately friable, and relatively unleached.

The block of limestone tentatively selected for mining is bounded on the north by the eroded fault scarp along which the range was uplifted, and on the east and west by deeply entrenched drainage gorges. The block is connected on the south to the main portion of the range by the uneroded continuation of the near flat-lying limestone beds.

Slopes on the three free sides of the block are steep, in some areas nearly vertical. The steep slopes, combined with a vertical difference in elevation of about 200 metres (650 feet) from bottom to top, make access difficult.

To the north and east of the prospective quarry site, Miocene sediments have been preserved over a large area of the Plains of Wadi Bada and Wadi Hagoul, which lie only a few feet above sea level. These sediments consist mostly of various clays, although there are some interbedded limestones and sandstones



MAP SHOWING LOCATION OF LIMESTONE AND CLAY PROSPECTS WITHIN THE GABAL OKHEIDER - GABAL EL-RAMLIA AREA, EGYPT

DAMES & MOORE

PLATE 2

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present. Dips in these sediments are near-flat. The Miocene sediments are underlain at depth by Eocene limestones similar to those exposed in the mountains nearby.

Lithologically, the Miocene clays range from sandy clay to silty clay to clay containing little or no sand or silt. The silty clays appear to be most predominant in the area.

Exposures of Miocene sediments occur locally in dry washes and on the flanks of low hills, but for the most part are covered by a thin overburden of sand, which may range in thickness from a few centimetres to several metres.

3. MINE/QUARRY DESIGN

3.1 ASEC's Initial Mine Concepts

ASEC had prepared, in very broad conceptual form, a mining program which would exploit the Suez Cement Company's limestone and clay deposits. No complete document existed, in fact some of the data were not fully documented, and only evolved during the course of conversation.

The plan called for the cement works to be located near the Gulf of Suez, some 11 to 12 km (7 miles) from the limestone deposits, and 7 to 8 km (4 to 5 miles) from the clay deposit. The factory would be adjacent to the coast for easy onward transportation of the finished product. Raw material from the quarries would be transported to the factory by means of a single belt conveyor, fed from crushing facilities immediately adjacent to the two quarries. The same conveyor would be used for both materials by allowing approximately one shift per product and having adequate stockpiling facilities at both crushers and cement plant.

The terrain between the raw material deposits and the coast is gently sloping towards the Gulf, free of water hazards and, upon first inspection, ideally suited to a conveyor belt installation.

The crushers (of non-specified dimensions) were to be permanently installed and located adjacent to the two quarries and feed the main conveyor from cross conveyors.

Power for the conveyors, crushers, power shovels and quarry workshop would be drawn from the power supplied to the main factory site from the town of Suez, 40 km (25 miles) to the North.

3.1.1 Limestone Quarry Planning Preliminary geological investigations by ASEC have shown the existence of some 146 million tonnes of limestone (160 million short tons), suitable for feeding a cement plant. Over most of the deposit the lowest level of suitable limestone is at 227 metre (745 ft) elevation, while at the eastern extreme, the lowest acceptable limestone occurs at 257 metre (843 ft). (See Appendix 1, item 5). ASEC have proposed that the quarry should begin at the Western end of the deposit along the north face and start at 227 metres. The small tonnage, 14 million tonnes (16 million short tons) in the eastern block would be left for mining at a later stage.

Mining was to be with two electric driven power shovels of $7m^3$ (9 cubic yard) capacity, both working on a single elevation at the base of the limestone and using a fleet of six 30 tonne (33 short tons) rear dump trucks to feed the jaw crusher.

The use of both shovels on a single level would be achieved by having a face height (or benches) of up to 50 metres (197 feet). When the height of exposed limestone exceeded 60 metres, a berm or working ledge of 15 metres (49 feet) was to be left for drilling purposes. The limestone above 60 metres would be drilled off from the top of the deposit. When blasted, it would be allowed to free fall to the floor of the quarry, up to 120 metres (390 feet) below. The intermediate berm would be cleared of material by using a bulldozer

of 260 to 330 hp. ASEC have worked on the premise that a single quarry face, without any berms, can be as high as 60 metres (197 feet), and they are sure that no Egyptian mining/quarry regulations exist to limit the height of a quarry face or bench.

Drilling would be with a rig of suitable capacity for producing a 150 millimetre drill hole (6") and drilling vertically to 150 metres (500 feet) depth, and two drilling rigs were anticipated as necessary for this scale of operation.

In addition to this equipment, jack hammers with mobile compressors were to be used for some development drilling purposes, and for secondary blasting of oversized rock on the quarry floor.

3.1.2 Clay Quarry Planning At the clay deposit, mining was to be with two front end loaders of 3 and 5 m^3 (4 and 6.5 cubic yard) capacity and using three trucks for hauling clay to an impact crusher, and waste material to an adjacent waste stockpile area. The trucks were to be 30 tonnes (33 short tons) capacity in order to match the fleet chosen for the limestone quarry. Although no data was available on the strength of the interbedded limestone in the clay, the assumption was made that it would be minable without blasting or at worst drilling by jack hammers driven by mobile compressors.

3.2 Alternative Mining Concepts

The various alternatives to ASEC's mining proposal were discussed by the Dames & Moore engineer with ASEC personnel.

3.2.1 General Infrastructure The location of the cement producing factory adjacent to the Gulf of Suez was seemingly ideal, since adequate flat ground exists for a factory, support facilities, port facilities, a small town site, stockpile areas and it is adjacent to existing roads.

A major problem relates to its distance from the two sources of raw material. An alternative site exists midway between the limestone and clay deposits which also offers adequate flat ground. While it is less suitable for a town site, and well removed from the Gulf, it would save on the installation of some 8 kilometres of conveyorway (5 miles) at an estimated cost of $4 million. However, the finished products would need to be transported to the port and rehandled, and all construction materials and operating supplies for the plant would need to be moved inland instead of being used at the coast. Provided the required military approval is forthcoming, the coastal site appears to be the best choice.

The choice of conveying the raw material to the factory area also offers the most economic choice when matched against road or rail transportation methods. The flat terrain from the factory site (elevation approximately 20 metres) to the foot of the limestone deposit (elevation 160 metres), 12 kilometres to the west and passing the clay deposit, should present a routine installation problem for a carefully designed conveyor system.

Conveyor systems have the advantage of lower unit operating costs, despite relatively similar capital costs when compared to trucking these volumes of material. A 0.9 metre (36") belt would appear to be the right width of belt for this application, while offering potential for increased production

through faster belt speeds, and extended operating periods.

3.2.2 Limestone Quarry Alternatives ASEC's initial proposal was to open up a 100 metre face somewhere between Channels 3 and 4 (Plate 3). By limiting the strike length they hoped to quickly develop south and west faces, which would be developed using jack hammers or wagon drills with 60 - 75 mm bits (2½-3"). While such techniques could be used to open up the quarry, it is possible that between channels 5 and 6 a better entry exists, principally because:

a) The topography between elevations 227 and 287 is less steep
b) It is much closer to the centre of mass of the whole deposit
c) The topography below 227 is quite shallow and more acceptable for onward transportation of crushed rock
d) It would allow development on a third (east) face, if desired.

For these reasons, it is recommended that the initial opening be in this vicinity and that the crusher also be located in this area. The steep topography on the north face will present development problems, in that drill access will be difficult and very little flat land exists for equipment to work from.

One possible method of developing the initial benches would be to develop a series of coyote tunnels and bring down a large quantity of material in one blast. A short description of coyote tunnels is included in Appendix 6.

The siting and choice of the limestone crusher is one of the key decisions for the operation. The main conveyor system from the plant to limestone deposit

would achieve an elevation of 160 metres (525 feet) immediately adjacent to the foot of the limestone deposit. The proposed bottom elevation of the quarry floor is 227 metres (745 feet) leaving some 67 metres (220 feet) over a distance of 400 to 500 metres (1300 to 1650 feet). This gradient of -13% is considered too steep to run trucks over.

The solution which emerged from discussion with ASEC and equipment manufacturers was that the crusher be permanently installed just below the quarry floor elevation of 227 metres (745 feet).

Trucks would feed the crusher on the quarry floor elevation, by way of an excavated hopper, and a vibrating grizzly feeder. This feeder would scalp off all undersized material, say less than 15 centimetres (6") which would bypass the crusher. Only material over 15 centimetres (6") would be fed into the crusher. A jaw crusher 1.0 metres x 1.3 metres (40" x48") is proposed, with a pedestal rock breaking system for secondary breaking of oversized material. With an opening of 20 centimetres (8"), a jaw crusher of this size would have a throughput of 400 to 500 tonnes (440 to 550 short tons) per hour, plus the undersized material (which might conservatively constitute 25% of all the feed), giving a total through put of 530 to 660 tonnes (580 to 730 short tons) per hour. The broken material would be fed onto a stockpile by 1.1 m (42") belts first by a short conveyor and then by a stacker conveyor. Plate 3 illustrates this system, and Appendix 5 gives a further breakdown of the concept.

By siting the crusher near the quarry operations, haulage costs by truck are reduced, numbers of trucks required are reduced and the need for a sep-

arately-constructed silo can be eliminated. The possibility of using a portable crushing plant was considered, but the higher level of mechanical servicing necessary argued against it. It need not be dismissed as an option in any future studies.

Since the limestone produced is to be used for the manufacture of cement and quicklime, the choice of crusher was restricted to a jaw crusher installation since hammer and impact crushers would produce a product too small, and would require considerably more maintenance.

The selection of quarrying equipment is critical to the successful planning of the whole facility.

Discussion on the choice between electric shovels and front end loaders is summarized in Appendix 4. The choice of one electric shovel and one front end loader offers maximum flexibility and maximum digging capacity for dollar outlay. It is superior to the other feasible combinations of:

a) two shovels of $7m^3$ capacity
b) two front end loaders of $7m^3$ capacity.

The calculations in Appendix 3 and experience in the field, suggests that trucks in the 45 tonne (50 short ton) capacity group offer the best match of equipment for shovels and loaders of the size range under consideration.

Based upon an average requirement of four trucks and an average mechanical availability of 67%, the fleet requirement of six units for limestone is indicated.

The use of 60 metre benches is excessive by North American standards. Normally benches in an open pit or quarry are limited by law to 13 to 20 metres (40 to 60 feet). No specific Egyptian laws are known to exist which regulate mine or quarry bench heights. At the Tourah operation, 50 metres (164 feet) benches are used with 15 to 25 metres (50 to 80 feet) berms between benches, and seemingly present no severe safety or operational problems.

Such high benches have several distinct advantages for a stratified deposit such as Suez and/or Tourah. By taking a large slice of material in one blast, a process of blending different strata together occurs in the broken rock pile. The absence of waste bands, which might have to be mined separately, means that high benches are practical in terms of maintaining access roads. Quarry planning is very much simplified by not having to have detailed co-ordination of equipment. Scheduling difficulties are minimized or eliminated. However, the safety aspects of such high benches have forced lawmakers in other countries to limit bench height and the dread of a serious accident involving life and high capital cost equipment restricts the endorsement any engineer can place on designs involving 60 metre benches.

The issue is simplified by the lack of suitable U.S. produced equipment designed for such high benches, and a more reasonable bench height of 40 metres maximum is proposed. Equipment is readily available which can handle such bench heights in relative safety.

For the present time, benches up to 40 metres have been incorporated with the mining plan, but sufficient flexibility exists for a change in working bench heights to be made without altering the equipment list.

Blast hole drills are proposed for this project with capacity to drill 150 mm to 200 mm (6 to 8 inches) holes to a depth of at least 45 metres (150 feet). The use of down-the-hole hammer bits is recommended, since they give superior drilling performances in deeper holes considered for this project. Down the hole drills would require greater compressor capacity, but this option is readily available.

Preliminary work suggests that spacing slightly smaller than the Tourah blast-hole layout would be successful. Preliminary calculations are presented in Appendix 7.

Initially, analysis of available equipment suggests that one truck mounted rotary blast hole drilling rig would be the best choice for a main drilling machine. These machines, which are essentially drill machines mounted on a heavy duty truck, have high mobility and would be available to move between benches easily and also leave the quarry for routine maintenance or emergency repairs. They are completely self-contained units.

Allowing all quarrying to proceed on one level is regarded as having dubious advantages and several real disadvantages.

Its merits seem to be;

(i) a natural mixing of the various chemical compositions

(ii) a level operation, which avoids equipment moving between benches

(iii) easier supervision.

The disadvantages appear to be as follows:

(i) a highly concentrated operation for the initial years of the project with limited space

(ii) a very high working face of up to 120 metres

(iii) a haphazard approach to blending material.

It would be better to allow the development of three separate working levels at 40 metre (131 ft) intervals which allows for real blending to take place by truck count from two or three separate broken rock sites. The high working face is avoided, and so too is the potential problem of congested traffic in the quarry.

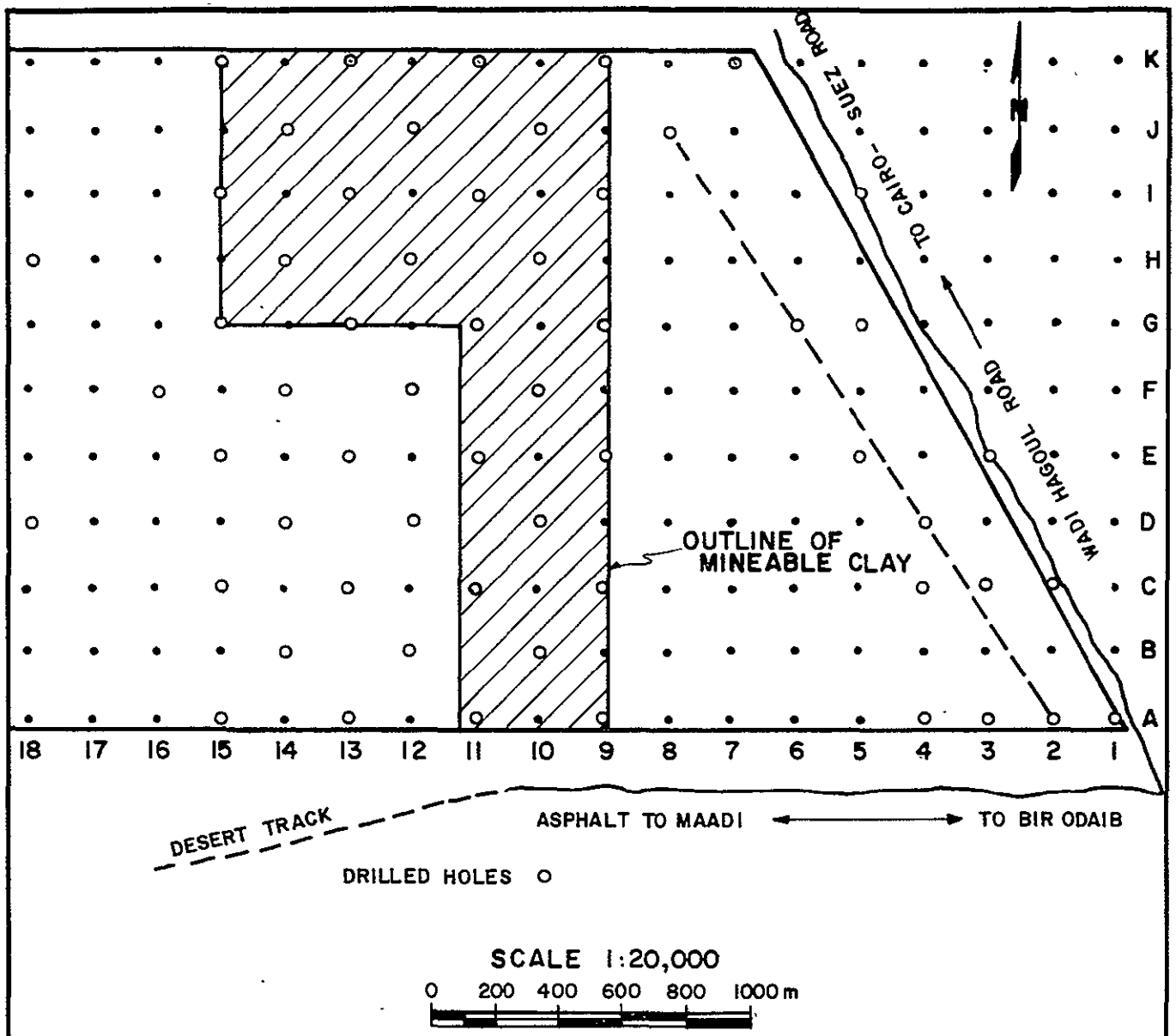
These advantages are reinforced by having a backup loading machine with high mobility.

3.2.3 Clay Quarry Alterations The clay deposit is fairly extensive (over 88 million tonnes (97 million short tons)) spread over an area several kilometres square, and selective quarrying needs to be practised.

By opening up a trench some 400 to 500 metres (1300 to 1640 feet) long in an east-west direction, and by advancing the face in an north-south direction, the clay deposit can be mined efficiently and in a compact manner.

Plate 5 illustrates the clay area considered minable and also the typical stratigraphy.

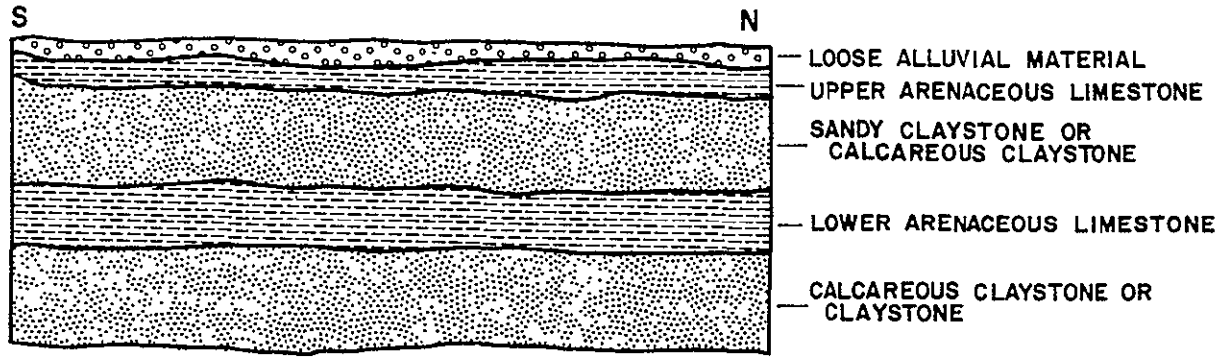
Plate 6 illustrates a possible mining program for the clay, using front end loaders and trucks.



SCALE 1:20,000

0 200 400 600 800 1000 m

TYPICAL STRATIGRAPHY
(NOT TO SCALE)



SKETCH MAP FOR THE CLAY AREA OKHEIDER

DAMES & MOORE

PLATE 5

REVISIONS BY _____ DATE _____

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BY L.S. DATE 6/2/76

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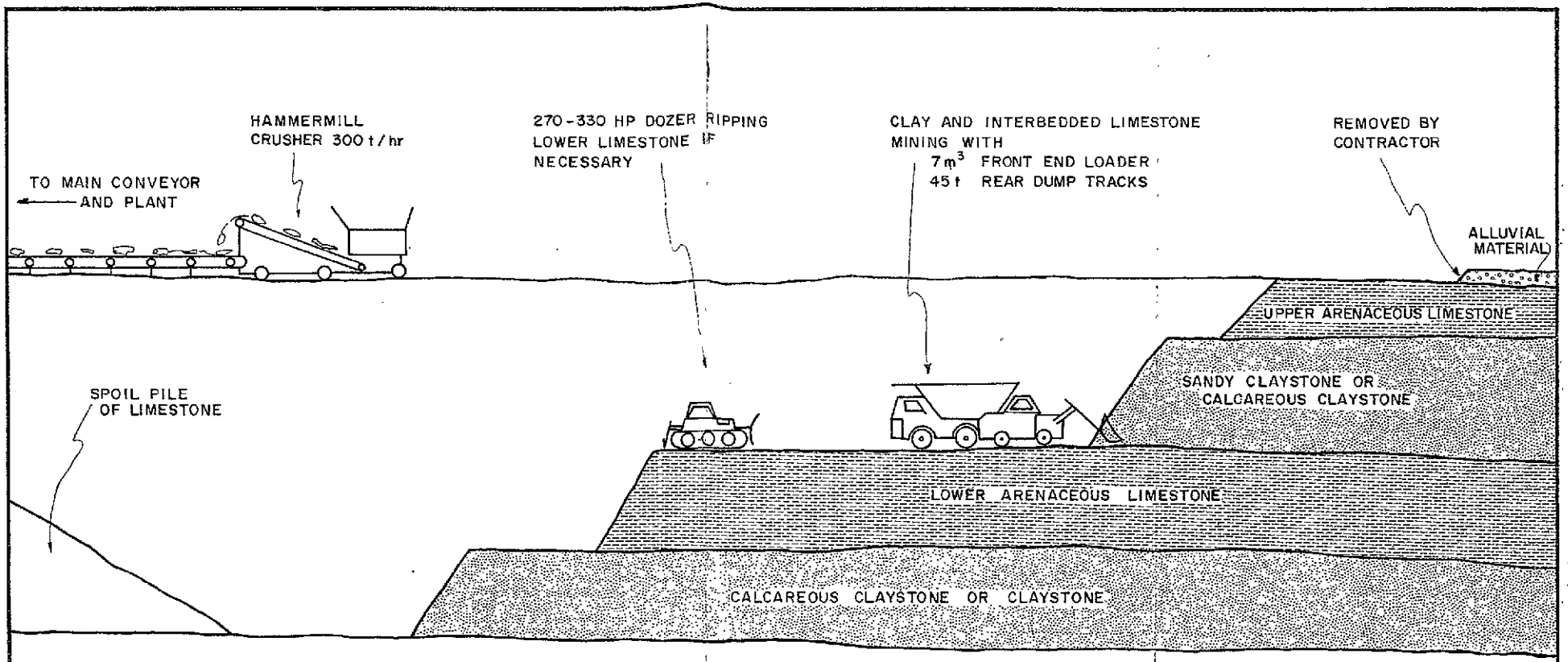


COMPOSITE SECTION

NOT TO SCALE

SUEZ CEMENT COMPANY	
POSSIBLE MINING PROGRAM FOR THE CLAY DEPOSIT	
DESIGN BY: P.S.M.	DATE: MAY, 1976
DAMES & MOORE	JOB: 9079-003-26

PLATE 6

It is proposed that a mobile crushing unit (non-clog hammer mill type) be used for the clay. These units are designed to handle wet or sticky feed directly from a shovel or loader.

A mobile unit would have several advantages:

(i) Short haulage distances from clay mining location to the crusher would be maintained.

(ii) It would avoid stability problems associated with constructing a permanent crusher on clay (portable crushing units can be built with low ground pressure)

(iii) Front end loaders might be available to haul to crushers themselves with only limited truck assistance on some occasions.

Since stockpiling of clay after it is crushed is not recommended, the crusher must be capable of handling the daily tonnage requirement in a single shift. Calculations in Appendix 2 suggest a capacity of 300 tonnes per hour (330 short tons per hour).

The quarrying operation should be preceeded by the removal of the alluvial overburden by a sub-contractor using a scraper operation. The initial limestone layer is thought to be sufficiently weathered to be broken up by a dozer with a ripper. The clay horizons can be mined using a front-end loader, and in order to standardize fleet requirements, and provide maximum fleet mobility, a single $7m^3$ unit has been selected. The loader for the limestone deposits would provide back up for this machine and vice versa. The loader will be matched with two 45 tonne (50 short ton) rear dump trucks which match the limestone fleet. These units will also handle the movement of

both limestone horizons, the lower of which is of undetermined strength. While it is probable that it can be ripped, the portable drilling capacity on-site allows for drilling and blasting of this limestone where necessary. Once an initial box cut has been developed, any waste material can be dumped back into the fully excavated quarry.

3.2.4 General Facilities As with any quarry operation, the service facilities for the two quarries need to be centrally located. See Plate 3.

It is proposed that the power lines and permanent road parallel the conveyor from the cement plant to the quarries, for easy access and maintenance. The explosives storage should be well removed from the other buildings, the electrical supply system, and the conveyor, while still serving the quarry. All the quarry warehouse facilities, maintenance shop and quarry offices should be located together. A site some 500 kilometres (1640 feet) north of the limestone quarry has been initially suggested as a potential site. All maintenance would be handled here and the equipment working the clay would be moved to this site for servicing.

A fuel tank farm should be established adjacent to the common facilities, and a water tank should be established up grade from these facilities in order to provide enough head of water for domestic and industrial purposes in the office warehouse, maintenance shop complex.

3.3 Proposed Mine Equipment Requirement

Tables 1 and 2 represent a preliminary analysis of the equipment required

for successful exploitation of Suez Cement Company's limestone and clay deposits. All prices quoted are U.S. manufacturer's list price F.O.B. factory, for the second quarter of 1976, and make no attempt to predict inflation. Inflation on large mining equipment has been running at 1% per month, i.e. 12% per annum. In extrapolating these figures forward to an approximate delivery date, it would be more conservative to use 10% per annum rather than ASEC's 5% per annum.

U.S.A.I.D. Cairo staff provided guidance in developing an estimate of 20% of F.O.B. price for shipping, insurance and unloading from U.S. east coast and gulf ports to Egypt. Spare-part purchases recommended have been set at 10-20% of the F.O.B. price.

3.4 Proposed Future Work

At the Dames & Moore consultant's request, ASEC began on the preliminary design work on a road to the west of the limestone block sufficient to identify a possible route to the top and an eleven hole core drilling program on a 300 x 300 metre grid (984 x 984 feet) was recommended by ASEC as further work in the Part II geological investigations.

This drilling program would:

a) allow the limestone quality to be evaluated throughout the deposit

b) enable the recovery of samples from the main mass of the deposit of sufficient quality (in terms of representing in-situ characteristics) to permit meaningful evaluation of the limestone's physical and chemical properties.

TABLE 1

PRELIMINARY EQUIPMENT LIST - COST PROJECTIONS

EQUIPMENT DESCRIPTION	EQUIPMENT SPECIFICATIONS	PRICE PER UNIT FOB U.S.$'000	NUMBER OF UNITS REQUIRED	PRICE FOB U.S.$'000	SHIPPING AND INSURANCE $'000 AT 20%	LEVEL OF SPARES %	COST OF SPARES INC. $'000	DELIVERY INFO REPRESENTATIVE FOB PLANT	ERECTION COSTS $'000
LIMESTONE QUARRY									
Crusher	550 t/hr or 605 t/hr (-300 mm or -12")	200	1	200	40	10	24	3-6 months	up to 100
Electric Shovel	$7m^3$ capacity	1100-1200	1	1100-1200	240	15	220	6-9 months	up to 100
Front End Loader	$7m^3$ capacity	250-300	1	250-300	60	20	72	0-3 months	-
Bulldozer	270-330 H.P.	140-180	1	140-180	36	20	40	3-9 months	-
Drill	Truck mounted rotary blast-hole 250 psi air hole range 150-225 mm	200-250	1	200-250	50	20	60	3-6 months	-
Drill Bits	Down the hole hammer 150-175 mm	5	2	10	2	100	12	-	-
Anfo Truck	Custom built on 5 tonne truck	30-40	1	30-40	8	15	7	6-12 months	-
Trucks	Rear dump with body liners 50 short ton capacity	180-220	6	1080-1320	264	10	150	3-9 months	-
Vibrating Grizzly Feeder and Hopper for Crusher		40	1	40	8	10	18		-
Stacker	42" stacker	60	1	60	12	10	8	3-6 months	-
Rock Breaking Systems	Secondary Breaking at crusher	30	1	30	6	20	7	6 months	-
CLAY QUARRY									
Crusher	Portable mounted non-clog hammermill	75-90	1	75-90	18	10	11	3-6 months	up to 30
Front End Loader	$7m^3$ capacity	250-300	1	250-300	60	20	72	0-3 months	-
Trucks	Rear dump with body liners 50 short ton capacity	180-220	2	360-440	88	10	52	3-9 months	
Bulldozer	270-330 H.P. with ripper	140-180	1	140-180	36	20	40	3-9 months	-
GENERAL									
Crawler Mounted Drill	Heavy duty 125 mm (5")	60-80	1	60-80	16	20	18	0-3 months	-
Flatbed Truck	35 tonne (40 short ton) capacity	90-100	1	90-100	20	10	12	3-6 months	-
Mobile Crane	Rough terrain 15-20 tonne	90-100	1	90-100	20	15	18	0-2 months	-
Portable Crane	50-60 tonne	------One large crane will need to be hired during the construction phase----------							
Mobile Compressor	1000-1200 cfm	70	1	70	14	20	17	0-2 months	-
Mobile Compressor	500-650 cfm	40	2	80	16	20	19	0-2 months	-
Grader	Flywheel H.P. 135	55-65	2	110-130	26	20	31	3-6 months	-
Water Truck	Special body on 10-15 tonne truck	20-25	1	20-25	5	15	5	3-6 months	-
Service Truck	Services mobile equipment	25-30	1	25-30	6	15	6	3-6 months	-
Miscellaneous	Tools for workshop	150-175	1 set	150-175	35	-	-	0-3 months	-
Workers' Bus	Mine only buses	35	3	105	21	15	20	0-3 months	-
Pick Up Trucks	Supervisor - 1 ton pickups	7	5	35	7	10	4	0-3 months	-
Anfo Silo	Prefab Anfo silo 20-30 tonnes (50,000 to 80,000 lbs) capacity	8	1	8	2	0	0	6 months	-
CONVEYOR									
Main Unit	12 km (7.5 miles) at 0.7-0.9 m wide (30-36" wide)	4500-5000	1	4500-5000	1000	8	400	18-24 months plus 12 months erection	1500-2000
Limestone Unit	500 m of 0.9 m (36") belt	200	1	200	40	10	24	6-12 months	50-75
Clay Unit	800 m of 0.9 m (36") belt	360	1	360	72	10	42	6-12 months	75-100
TOTALS		-	-	9868-1178	2228	-	1357	-	2000-3000

NOTE: That this capital cost estimate does not include:
a) Cost of building office and service facilities at quarry location
b) Cost of road building and initial mine development

TABLE 2

PRELIMINARY EQUIPMENT LIST - REPRESENTATIVE MODELS

EQUIPMENT	ADDITIONAL INFORMATION	REPRESENTATIVE MODELS
LIMESTONE QUARRY		
Crusher	Jaw crusher 550 tonne/hr (605 short tons/hr) pws 200 H.P. motor	Allis Chalmers Al-4248 Pennsylvania C.C. 4248 Nordberg 4048 Telesmith 4248
Electric Shovel	Power shovel - $7m^3$-$9m^3$ (9-11 cubic yards)	P & H 1900 AL Bucyrus Erie 155B Marion 151M or 181M
Front End Loader	Wheel type $7m^3$-$8m^3$ capacity rock bucket	Caterpillar 992B Terex 72-81 Hough(International) Payloader H400C
Bulldozer	Track type 270-300 H.P. Ripper, Cab, Semi U Blade, Winch and Air	Caterpillar D8K Fiat Allis 21C International TD25C
Drilling Machine	Truck mounted rotary blast hole drill, high pressure air 250, hole size 150 mm, depth 150 ft	Bucyrus Erie 2450R Ingersoll Rand T4 Drillmaster Smith Industries Portadrill TG 600 or TM6 Joy Robbins RRT 50 or 60
Drill Bits	Down the hole hammer drill with 150-160 mm bit (6-6½")	Ingersoll Rand FURY I Mission A53-15
Anfo Truck	Custom built on 5 tonne truck, stainless steel body - side auger	Amerind Mackissic
Stacker	42" belt, 150 foot boom	Barber Greene Telesmith PW-80
Truck	Rear dump, off highway, 50 short ton capacity with body liners	Caterpillar 773 Mack M50AX Wabco 50 International 350 Euclid R50
Vibrating Grizzly Feeder and Hopper	To scalp off undersized material and increase jaw crusher's throughput 1m x 6m (4 x 20 ft)	Nordberg Dynactuator Telesmith No name or number Allis Chalmers Heavy duty Vibrating feeder
Pedestal Rock Breaking System	For secondary breaking system, all hydraulic rock breaker 18ft vertical reach	Allied Steel and Tractor - System 6
CLAY QUARRY		
Crusher	Non-clog hammermill(portable mounting) plus electric motor 300t/hr (330 short tons/hr)	Pennsylvania Crusher Corporation 36-50
Front End Loader	Wheel type $7m^3$ capacity	As above
Bulldozers		Catterpillar D8K Fiat Allis 21B International TD25C
Trucks	Off highway rear dump trucks 50 short ton capacity	As above
GENERAL EQUIPMENT		
Drill	Crawler mounted heavy duty drill 100-150 mm capacity approximately	Gardner Denver HDCF Joy Mustang VCR280
Flat Bed Truck	35 tonnes (40 short tons) capacity for movement of heavy equipment	
Mobile Crane	Rough terrain - 15-20 tonnes (16-22 short tons)	Bucyrus Erie 320C/SP or 360C/SP P & H R200
Portable Crane	Normal crane 50-60 tonnes (55-66 short tons)	Bucyrus Erie 30BSC P & H 670TC
Mobile Compressor	1000-1200 cfm. (30-34 m^3/m) mobile diesel driven compressor	Gardner Denver SP1050 or SP1200 Joy RPS1050
Mobile Compressor	500-650 cfm (15-18 m^3/m) mobile diesel driven compressor	Gardner Denver SP500 or 600 Joy RPS650
Grader	Flywheel H.P. 135, hydraulic blade, power shift	Caterpillar 130G or 12G Fiat Allis 150C Wabco 444
Water Truck		
Miscellaneous Tools and Workshop Fitout		Black and Decker Ingersoll Rand
Service Truck	Equipped with lube, and fuelling systems	Ford GMC
Personnel Carriers	Buses, school bus type. pick up trucks, 1 ton units	Ford GM Standard models Chrysler
CONVEYORS		
Main Unit Limestone Unit Clay Unit	All conveyor systems would need to be custom built to suit Suez Cement Company's particular requirements.	Robins Engineering and Construction Joy Conveyor Systems

To date, ASEC have had a series of "specimens" taken from a single channel sample, analyzed for specific gravity and compressive strength.

These tests, performed by Holderbank, gave a range of values as follows:

Specific gravity (in-situ)		2.289 - 2.522 gm/m^3 or $tonnes/m^3$
	or	3860 - 4250 lbs/cubic yard
Compressive Strength		323 - 687 kg/cm^2
	or	4600 - 9800 lbs/in^2

Holderbank, in a report to ASEC and quoted by them in their Part II report, stated that these results indicated a limestone of medium strength.

Unfortunately, it would be misleading to assume these physical properties were truly representative of the whole deposit. They are, at best, indicative of what values can be expected, particularly the specific gravity. Compressive strengths could generally be assumed to be somewhat higher than the range quoted, simply because rock in the centre of the deposit would be less weathered than the near-surface material from the channel samples.

Provided that a suitable schedule can be arranged for drilling the limestone which allows a test-pit in the clay to be dug simultaneously, then it would be useful and highly beneficial to have a geotechnical engineer observe and monitor both of these programs. In the drilling program, he could observe drilling results, examine the core for vugs, voids and discontinuities, and select and preserve specimens for laboratory test work. Such tests would include strength test, swelling analysis, and confirmation of specific gravity, in addition to the proposed chemical analysis determinations.

In the test-pit for the clay, the workability of the clay and its reaction to digging could be assessed, as could the strength of the interbedded limestone. Estimates of clay size ex-quarry could be made to aid in crusher installation designs, and the friability and plasticity could be determined from properly preserved samples.

In addition to the proposed drill holes on 300 metre spacing, it is recommended that additional holes be drilled in the area where limestone quarrying is most likely to begin. A much closer drilling pattern in the general area of the first 5-10 years quarrying would provide useful data for more detailed quarry planning purposes.

Much additional data on the limestone's strength and composition could be revealed by the geotechnical engineer mapping the structure of the exposed limestone. This analysis would include an examination of all exposed rock cuts. The petrofabrics and discontinuities of the limestone mass would be identified, and together with additional data from the core samples would provide information of use in the quarry planning process. Examples of such data are bank stability analysis, blasting layouts and site preparation and comminution (crushing and secondary breaking).

If additional drilling on a 100m x 100m grid were to be approved for the initial quarrying area, then up to a further 20 holes might be necessary. A possible grid for these holes has been laid out on Plate 3.

4. CONCLUSIONS AND OBSERVATIONS

The visit of Dames & Moore's mining engineer to Egypt was, to some extent, premature. ASEC had not fully completed the documentation of their geological work, nor had they developed any mining plans, merely mining concepts.

ASEC had apparently not used the services of a mining engineer, although one partner in ASEC, Holderbank, had access to the services of fully experienced engineers in Switzerland. Holderbank delayed bringing over their mining engineer to Egypt until the Dames & Moore engineer had visited the site, prepared plans and presented a report.

Based upon this review, Dames & Moore has reached the following conclusions and observations on the project to date:

a) In accord with ASEC's contract with Suez Cement Company, they have concentrated on developing a firm geological knowledge of the limestone and clay deposit. The release of their "Detailed Geological Investigations Part II" indicates that their preliminary work is coming to an end.

b) ASEC have developed a preliminary road design which would allow access to the top of the limestone deposit. Further to this, a program of core drilling has been recommended to the Suez Cement Company. The program calls for 11 holes up to 150 metres in depth on a grid 300 metres square over the top of the limestone.

c) ASEC's work has indicated sufficient quantities of limestone and clay, suitable for the manufacture of cement at an annual rate of 1 million

tonnes per annum, to justify the continued planning and development of a cement plant. Therefore, it is reasonable to continue planning for the development of a limestone and clay quarry complex, subject to the following reservations:

(i) The proposed drilling program for the top of the limestone needs to be undertaken as soon as possible, to prove out the quality (and quantity) of limestone available.

(ii) A test pit proposed for the clay to provide bulk samples should also be used to confirm the earlier drilling program results.

d) ASEC had begun to develop adequate mining concepts for the limestone deposit, but had not developed a mining concept for the clay. The whole mining program was not adequately documented to form a full report suitable for discussion.

e) Mining practices and regulations governing mine and quarry operations in Egypt are not highly developed. The absence of a single regulatory document to which reference could be made, for safety standards and guidelines, makes the mine planning procedures more ad-hoc than in better regulated countries. Mine regulatory authorities apparently have a great deal of flexibility in their approval of plans and concepts.

f) ASEC had based their planning for the limestone quarry on the premise that 60 metre benches would be acceptable to the authorities. They have not sought detailed discussion with the authorities to date, partly from a lack of documented data and partly because until now they had not

finished the geological investigations.

g) ASEC were still thinking about mining schemes for the clay deposit.

h) It is possible that a mining engineer from Holderbank will be visiting Egypt during the second half of May to give ASEC technical input in addition to that provided by Dames & Moore.

i) Whatever mining plans are agreed upon, discussion with Egyptian mine regulatory authorities would be a useful next step.

j) ASEC's preferred site location for the cement plant was adjacent to the Gulf of Suez some 12 kilometres (7.5 miles) from the limestone deposit. The site has been tentatively approved by Egyptian military personnel.

k) Raw material from the quarries was to be moved to the plant by a single conveyor system.

5. RECOMMENDATIONS

The bulk of this report has been concerned with documentation of the input to quarry planning and equipment selection considered necessary at this stage in the development of the Suez Cement Company's operations.

Provided that outstanding geological work considered essential to the project is completed satisfactorily, and that the raw materials still meet the necessary specifications for portland cement manufacture, then the plan can proceed to preproduction planning stage.

a) The absence of firm geological data on the internal composition of the limestone means that any choice of where to start the quarry is subject to review, but the gentlest slopes appear to be around channel sample 6. It is proposed that the limestone quarry be opened up here over a relatively short face of 200 to 300 metres. (Plates 3 and 4).

b) Providing that the cement producing plant location remains scheduled to be built near to the coast, the most efficient method of transporting raw materials from the quarries to that site (some 12 kilometres east) would be by conveyor.

c) The best method of supplying limestone to this conveyor would be to crush the material as close to the mine face as possible and to deliver it onward by means of a cross-conveyor. Some storage capacity needs to be built for crushed rock prior to delivery on to the main conveyor belt. One means of achieving this would be to install a permanent crusher just

to the east of initial quarry opening, have a storage area prepared to the north of the crusher, fed by a stacker conveyor and have a cross conveyor run from under this stockpile, out through a steel tunnel to the valley floor and across to the conveyor.

d) Mining the limestone could best be achieved through a conventional type of operation, with blast hole drills and down-the-hole hammer bits of 165 mm (6½"), drilling off benches up to 40 metres, blasting down to three separate quarry levels of up to 100 metres width where $7m^3$ loaders and shovels would load the broken material into 45 tonne trucks. Equipment of this capacity is recommended because of its proven ability in similar conditions.

e) The possibility of separate quarry operations on three bench levels is allowed for by having two loading units. The front end loader would be available for working off the higher benches, and adds mobility to the equipment fleet.

f) In view of the capital intensive nature of the proposed quarries, a program of operator training should be planned for the heavy equipment. All mobile equipment for the quarries should be fitted with a roll over protection cab or canopies. The shovels, loaders and drills should be supplied with air-conditioned cabs, and it would be advantageous for the truck fleet also to be air-conditioned. The hot conditions which influence workers' behaviour, suggest that workers' morale, and hence productivity, would be enhanced by having a cool environment in which to operate. The correct maintenance of quarry equipment and haulage ways should be a high priority

and suitable equipment for these functions needs to be provided from the outset of the project.

g) A quarry warehouse, maintenance shop, office complex, sufficient for this size of operation, should be built at the limestone quarry site in order to decentralize management of the quarries from the whole plant complex.

h) For the clay deposit, a mobile hammer crusher which can follow the advancing quarry face would be best. Preliminary planning suggests opening up a trench some 400 to 500 metres long in an east-west direction and advancing the trench in a north south direction, using front end loaders of $7m^3$ capacity and two trucks of 45 tonne capacity (matching the limestone fleet). Initial overburden removal could be contracted out so that a strip some 500 metres by 2,000 metres would be cleared of the overlying waste material.

i) In the course of excavating the proposed test pit, rippability of the interbedded limestone could be confirmed. A site for initial waste disposal still needs to be located away from the clay deposit, but once clay operations have reached a certain stage, all waste materials could be dumped back into the bottom of the excavated trench.

j) During the core drilling of limestone (once the road has been established) the opportunity should be taken to obtain preliminary rock mechanics data which could influence the alternate bench heights in limestone. It is recommended that core drilling in addition to ASEC's proposed 300 x 300 metre grid be undertaken in the area where limestone quarrying is expected

to be initiated. Holes should be drilled on a 100 x 100 metre pattern where drill access allows in these areas. See Plate 3.

k) During the core drilling of the limestone, and the test pit excavation for the clay, a fully qualified geotechnical engineer should visit the site to advise on sample selection and preservation, and to map the structure of the limestone block from the exposed rock cuts. The data resulting from this analysis would be incorporated in any modified quarry planning.

l) Once the drilling program and the test pits have been completed, the geologist and mining engineer should return to Egypt to review all additional data and discuss any modifications to the mining plan and program. Once a concensus of opinion has been reached, tenders for equipment can be placed in confidence. This assumes that all future work confirms earlier limestone tonnage and quality projections.

APPENDIX I

PUBLICATIONS AND MAPS MADE AVAILABLE TO PHILIP S. MARTIN OF DAMES & MOORE

1. "Review of Geological Investigation, Proposed Limestone Quarry Cement Plant, Okheider-Ramlia area, Egypt for U.S.A.I.D." by Dames & Moore, February 1976, made available February 26, 1976.
2. "Cement Plant at Suez, Preliminary Geological Investigations" by ASEC December 1975, made available April 27, 1976.
3. "Cement Plant at Suez, Detailed Geological Investigations, Part I" by ASEC, February 1976, made available April 27, 1976.
4. "Concept for Opening up and Operating Limestone Quarries" by ASEC, April 1976. Draft made available April 28, 1976.
5. "Cement Plant at Suez, Detailed Geological Investigations, Part II" by ASEC, April/May 1976, made available May 8, 1976.

APPENDIX 2

SUMMARY OF BASIC ASSUMPTIONS

1. Initial capacity of cement factory 1,000,000 tonnes per annum (1.1 million short tons per annum)
2. Limestone requirements* of cement and quicklime 1,500,000 tonnes per annum (1.65 million short tons per annum)
3. Clay requirement* 450,000 tonnes per annum (495,000 short tons per annum)
4. Cement kiln operates 24 hours per day - 330 days per annum
5. Quarry operates 2 shifts per day, 6 days per week, say 300 days per annum
6. Shifts in Egypt are 7 hours per shift for a 42 hour week
7. Quarrying rates are then:

Limestone	5,000 tonnes per day (5500 short tons per day)
Clay	1,500 tonnes per day (1650 short tons per day)

8. Crushers are assumed to operate for only 6 hours per shift

Limestone	2 shifts per day x 6 x 550 tonnes per hour (605 short tons per hour) gives 6,600 tonnes per day (2 million tonnes per annum (2.2 million short tons per annum)
Clay	1 shift per day x 6 x 300 tonnes per hour (330 short tons per hour) gives 1,800 tonnes per day (540,000 tons per annum (594,000 short tons per hour).

*includes a 10% contingency for losses, waste, etc.

Note: that the limestone crusher can operate on both shifts, since storage capacity will be incorporated into the system after this crusher, but the clay crusher can only operate for one shift since plans at present call for no silo capacity.

APPENDIX 3

SIZING OF LIMESTONE QUARRYING EQUIPMENT

Production Requirements 5,000 tonnes per day (5,500 short tons per day)

Material Characteristics

Assumed specific weight - 2,400 kg/m^3 - 4,050 lbs/cu.yd.

Anticipated swell %	65%
swell factor	60%

Broken/loose weight of material - 1,440 kg/m^3 - 2,430 lbs/cu.yd.

Operating Characteristics

Each Egyptian working day; two shifts of 7 hours each.

Operating efficiency	shovels, front end loaders, trucks	75%
Mechanical availability	shovels	75%
	front end loaders	70%
	trucks	67%
Bucket fill factors (average material)		
	shovels	75%
	front end loaders	70%

Assumptions
(i) Shovel/F.E.L. load truck in 5 passes
(ii) Cycle time for trucks - 10-15 minutes
(iii) In one hour (45 minutes at 75% operating efficiency) truck cycles per hour (average) 3.5 cycles/hour.

EQUIPMENT SIZING CALCULATIONS

	Front End Loader		Electric Shovel	
Equipment Size	$5m^3$ 6.5 cu.yd.	$7m^3$ 9 cu.yd.	$7m^3$ 9 cu.yd.	$9m^3$ 12 cu.yd.
Production required per day	5,000 T	5,000 T	5,000 T	5,000 T
Producing hours 14 x 75%			10.5	10.5
14 x 70%	9.8	9.8		
Estimated Dipper Load	$3.5m^3$	$4.9m^3$	$5.25m^3$	$6.75m^3$
Estimated Bucket Cycle Time	40 sec	40 sec	30 sec	30 sec
Estimated Truck Load Time	3.3 min	3.3 min	2.5 min	2.5 min
Maximum Truck Loads per hour	13.6	13.6	18	18
Material moved per hour	$238m^3$	$333m^3$	$472.5m^3$	$607.5m^3$
Material moved per day	$2332m^3$	$3265m^3$	$4962m^3$	$6379m^3$
or	3358t	4702t.	7144 t	9185 t
Truck Capacity Indicated	$17.5m^3$	$24.5m^3$	$26.25m^3$	$33.75m^3$
Truck Size Equivalent	35 s.t.	50 s.t.	50 s.t.	75 s.t.
Truck Capacity per hour	88 tph	123 tph	132 tph	170 tph
Truck Capacity per day	825 tpd	1154 tpd	1238 tpd	1595 tpd
(N.B. 1 day = 14 hours x 67% = 9.38 hours)				
Trucks needed for 5000 tpd	6.1 trucks	4.3 trucks	4.0 trucks	3.1 trucks

This analysis suggests that:

One electric shovel of $7m^3$ capacity (9 cubic yards) operating with four 45 tonne or 50 short ton trucks ($24m^3$) would capably manage 5,000 tonnes of limestone production.

However, due to the remote site location, a certain amount of backup equipment is essential. Therefore, it is recommended that:

In addition to the one $7m^3$ shovel, a $7m^3$ front end loader also be purchased. Either machine would be capable of maintaining full production on its own in

the event that the other machine were not available.

In addition to the four 45 tonne (50 short ton) trucks, a further 2 trucks should be ordered as backup capacity for the operation.

The size of clay quarrying equipment should be matched to the limestone fleet in order to balance the total fleet maintenance and application. Consequently one $7m^3$ (9 cubic yard) loader, and two 45 tonne (50 short ton) trucks are recommended at this time.

APPENDIX 4

CHOICE BETWEEN ELECTRIC DRIVEN POWER SHOVELS AND RUBBER-TYRED FRONT END LOADERS

In the initial design concept, ASEC had chosen to plan on using two electric powered shovels for the limestone quarry. Their reasoning was along the following lines.

With high faces (benches up to 60 metres) in the quarry, very little mobility would be required since each blast would release significant quantities of broken material.

Electrically driven shovels have significantly less maintenance problems than diesel driven units, and a shortage of skilled labour for maintenance is a local problem.

The Egyptians have considerable experience of electric shovels in other limestone quarries.

Power will be supplied to the quarry site to feed the crusher and hence will be readily available.

The choice they restricted themselves to was diesel driven versus electric shovels. What was apparently not considered fully was rubber tyred front end loaders.

In recent years, front end loaders have been widely used instead of, or to

replace shovels in situations where bucket capacity requirements are up to $8m^3$ (10 cubic yards). The demise of the small shovel at the expense of front end loaders has even gone as far as causing some U.S. manufacturers to stop production of small shovels in North America, and where they are produced it is usually by a licensed associate or affiliate in some overseas location. The reasoning behind this switch is a function of the following benefits.

(i) Loaders have far greater mobility than shovels, in that, after a blast, they can clean up the working area often without bulldozer assistance.

(ii) During the working shift, front end loaders require little or no cleanup assistance.

(iii) They can move oversize rocks away from the work area by themselves (shovels move them aside for shifting later)

(iv) They can be used as a haulage unit over relatively short distances.

(v) They can be used as a towing unit for compressors and other ancillary equipment.

(vi) They can be moved to a workshop for repair and maintained more easily than shovels.

On the other hand, for some hard digging conditions, shovels offer the better economic proposition, in that they are somewhat sturdier machines.

Shovels, because of their different digging action, can generally get more into the same size bucket than front end loaders. Shovel maintenance costs are usually lower than front end loaders but the real difference comes in capital costs. It is reasonable to assume that for the same bucket size

(say $7m^3$), the price of a front end loader is about one third of a comparable shovel unit. A $7m^3$ shovel would be approximately $1.2 million F.O.B. factory whilst a front end loader would be $300,000. While the shovel might last 10-15 years as compared with the front end loader's 8-12 years, the capital cost difference is enough to justify the slightly shorter working life, which itself is very dependent upon the type of maintenance given and the way the equipment is generally looked after. One point which emerged from the visit to Tourah Portland Cement Company operations was the impression that locals had not mastered the importance of controlling the electrical cable supplying the shovel. At Tourah, the cables snaked their way across the quarry floor and were generally not well maintained. Also the quarry floor was scattered with small rocks, suggesting limited cleanup requirements.

These points, added to the earlier discussion, led to the conclusion that for this operation the selection of one electric power shovel of $7m^3$ capacity (9 cubic yards), together with one front end loader of similar capacity, would provide the best combination at this stage in the planning of the quarry.

APPENDIX 5

STORAGE CAPACITY FOR LIMESTONE AT THE QUARRY

ASEC's original flow sheet called for construction of a silo-storage bin at the quarry for 6,000 tonnes (6,600 short tons) of crushed limestone. (-0.3m or -12"). The volume necessary for this would be 6,000 ÷ 1.44 or 4,200 cubic metres (5,500 cubic yards).

(Broken limestone assumed to weigh 1,440 kg/m^3 - See Appendix 3).

The alternatives for rock storage arrangements would be to:

1. Place a storage silo adjacent to the main conveyor, fed by a cross conveyor, up to 400-500m (1,300-1,650 feet) from the crusher as per the ASEC concept.
2. Place storage facilities adjacent to the crusher so that it discharges directly into the storage space.
3. Avoid need for any storage space by dumping rock adjacent to crusher and feed the crusher only one shift per day.

The least attractive option would be to rely on a system without storage or surge capacity because;

1. The conveyor system may break down and thereby the crusher has to stop.
2. By limiting the crusher to a single shift, its capacity (throughput) would need to be increased.

By placing the jaw crusher as close to the quarry as possible, thereby reducing haulage distances, it would be feasible to do either of the following:

(i) Open up an underground storage area below the crusher, feeding down on to a cross-conveyor.

(ii) Arrange for broken rock to be discharged on to an open stockpile, from which it could be reclaimed.

To allow the crusher to feed directly into an excavated storage area would require the development of a tunnel and raise system for which preliminary cost projections indicate high construction costs.

A better system appears to be a discharge arrangement whereby the undersized product from the vibrating grizzly feeder, and the crushed rock from the jaw crusher are collected on a short conveyor belt under the jaw crusher. This belt in turn discharges onto a stacking conveyor, which discharges onto a prepared site and builds a cone of broken material. From beneath the cone, two reclaim chutes would feed onto a surface conveyor which in turn feeds the main conveyor.

Belt sizes of 4.1 m (42") are recommended for the initial conveyor and stacking conveyor, while the cross-conveyor and the main conveyor would be 0.9 m (36") wide.

Such a scheme has several advantages over a separately constructed silo or underground excavation:

(i) It uses gravity throughout to feed the main crusher (as would the underground excavation)

(ii) It is cheaper to install than either a silo or underground excavation.

(iii) Because it is constructed in the open, it would have far greater cap-

acity than a silo or underground storage area.

There would be some dead storage volume to be built up once in the cone, but the cost of using broken rock to form the surge capacity is far cheaper than the alternatives. Also the local weather conditions suit the introduction of such a scheme.

Initial calculations give the total capacity of the stockpile as 77,000m^3 (100,000 cubic yards), or 110,000 tonnes (121,000 short tons), and the live capacity, or the material which can be reclaimed without dozing as 32,000m^3 (42,000 cubic yards), or 46,000 tonnes (50,600 short tons).

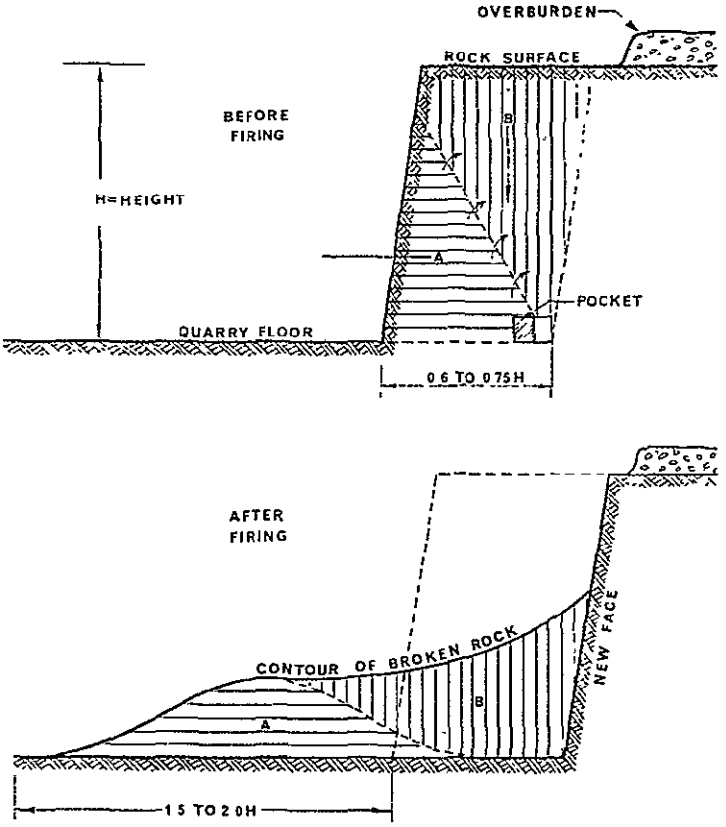
APPENDIX 6

COYOTE TUNNELS AND THEIR APPLICATION AT SUEZ

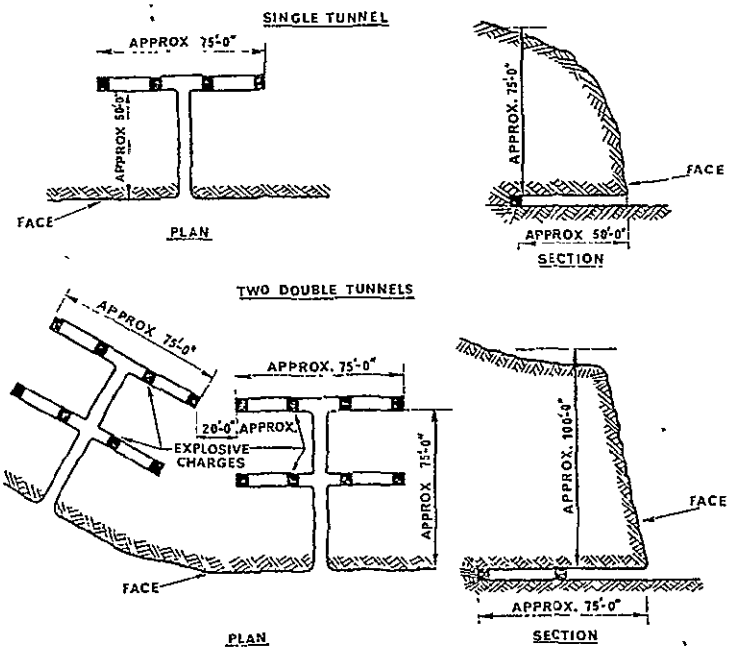
This method of quarrying can be used in hilly areas where the nature of the terrain makes it difficult to employ conventional drilling methods. It is suggested that this technique is one possible means of developing the initial quarry faces.

The method involves the distribution of a series of substantial charges at grade level beneath a relatively high face in "pockets", and at intervals, along branch tunnels or "T's" which are driven in a carefully designed pattern from access tunnels or adits. When the charges are detonated, the entire burden is lifted, promoting a crushing or fragmenting action, while the whole block is sheared at the quarry floor. Relief of burden must be toward the face of the bank rather than straight upward to ensure effective shearing of the floor, and to accomplish this, the height of the bank must be greater than the distance from the toe to the innermost charge. Too great a departure from these principles will result in unsatisfactory shearing at grade and insufficient disruption of the broken material.

The mechanics of a coyote blast are illustrated in Plate 7A. Since only a small percentage of the rock brought down is close enough to the charges to be directly affected by the explosive, fragmentation must depend almost entirely on the jointing and general nature of the rock formation. Ideal conditions are where the jointing is cubical or the structure columnar in nature. The most adverse conditions are where the bedding planes are almost horizontal and the face of considerable height. This particular set of



A. Mechanics of a coyote or tunnel blast.



B. Representative layouts of coyote or tunnel blasts for various face heights.

Ref: Canadian Industries Limited Blaster's Handbook

DAMES & MOORE

PLATE 7

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circumstances applies at Suez, but the benefits would appear to favour further investigation of the system.

Where the face is 60 to 80 feet high, one set of wings or "T's" is usually sufficient, the main adit being driven in a distance of approximately 40 to 50 feet. Where the face is 100 to 125 feet high, two sets of wings or "T's" should normally be used with the main tunnel (or tunnels) driven in a distance of 70 to 90 feet. Large blasts of this type may require several adits along the face with individual tunnel systems driven from each, since it is seldom practical to drive the cross "T's" from each adit more than 50 to 60 feet in either direction because of their small cross sectional area (usually 4 feet wide by 5 or 6 feet in height). An accurate survey should always be made before attempting to design a coyote blast so that the main tunnels and wings can be property located with respect to the existing face. Representative coyote layouts are shown in Plate 7B.

The loading factor used in a coyote blast will be influenced by the end use of the blasted material as well as the ground characteristics. Only one such blast is envisaged as necessary to establish the quarry, before switching to conventional drilling and blasting techniques.

APPENDIX 7

PRELIMINARY ANALYSIS OF DRILLING REQUIREMENTS, BLAST HOLE LAYOUT AND EXPLOSIVES

On the assumption that 40 metres (131 feet) benches are adopted in the initial stages of the quarry and that 10% sub-grade drilling would be necessary, then 44 metre (144 feet) holes will be drilled.

Drill hole size should be 165 millimetres (6.5") and the top 5 metres (16.5 feet) should not be charged (left as stemming). Such a drill hole system would be best combined with an ammonium nitrate fuel oil type of explosive (ANFO). For the bottom of the hole or toe blast, an explosive with powdered metals, known as metallized blasting slurry, is recommended, for the lowest 10 metres (33 feet). On top of this would be a pneumatically loaded ordinary anfo explosive (double primed). Gravity loaded values are included for comparison purposes.

Based on a target of 0.6 kg of explosive equivalent per bank cubic metre (1 lb per bank cubic yard), then:

Load per metre (foot) of explosives:

a) Metallized slurry (Density 1.5) 10m x 21.42 kg/m^3 x 1.5 = 321 kg
33 ft x 14.39 lb/ft x 1.5 = 712 lbs

b) Anfo (pneumatically loaded) (Density 1.0) 29m x 21.42 kg/m = 621 kg
94.5 ft x 14.39 lb/ft = 1,360 lbs

c) Anfo (gravity loaded) (Density 0.84) 29m x 21.42 kg/m x 0.84 = 522 kg
94.5 ft x 14.39 lbs/ft x 0.84 = 1,142 lbs

Total load per hole is:

Pneumatically loaded 321 + 621 kg = 942 kg (or 712 + 1360 = 2072 lbs)
Gravity loaded 321 + 522 kg = 843 kg (or 712 + 1142 = 1854 lbs)

Volume Calculations:

(i) 7 metre spacing (23 feet) x 6 metre burden (19.7 feet)
gives 7m x 6m x 40m = 1680m^3 (23' x 19.7' x 131' = 2198 cubic yards)

Load factors are 942 ÷ 1680 = 0.56 kg/m^3
2072 ÷ 2198 = 0.94 lbs/cubic yard

(ii) 6.5 metre spacing (21.3 feet) x 60 metre burden (19.7 feet)
gives 6.5m x 6.0m x 40m = 1560m^3 (21.3' x 19.7' x 131' = 2036 cubic yards)

Load factors are 942 ÷ 1560 = 0.60 kg/m^3
2072 ÷ 2036 = 1.02 lbs/cubic yard

(iii) 6.5 metre spacing (21.3) x 5.5 burden (18.0 feet)
gives 6.5m x 5.5m x 40m = 1430m^3 (21.3' x 18.0' x 131' = 1860 cubic yards)

Load factors are 843 ÷ 1430 = 0.59 kg/m^3
1854 ÷ 1860 = 0.99 lbs/cubic yard.

This analysis suggests that using Anfo type explosives in 165 millimetre (6.5 inch) holes would require a 6.5m x 6.0 m spacing and burden (21.3'x 19.7') if the explosives are pneumatically loaded. If gravity feeding is used, the pattern must be closed up by 0.5 m burden (1.6') to allow for the less densely packed explosive.

If drill patterns are laid out in 10 holes in a single row per blast, then 10 holes or 1 blast would break:

(i) Pneumatic loading 40m x 6.5m x 6.0m x 9 = 14040m^3 x 2.4 t/m^3 = 33696 tonnes
(131' x 21.3' x ;9.7' ÷ 27 x 9 = 18373 cubic yards x 2.025 st/yd
= 37104 short tons

(ii) Gravity loading 40m x 6.5m x 5.5m x 9 = 12870m^3 x 2.4 t/m^3 = 30888 tonnes
(131' x 21.3' x 18.0 ÷ 27 x 9 = 16742 cubic yards x 2.025 st/yd
= 33902 short tons

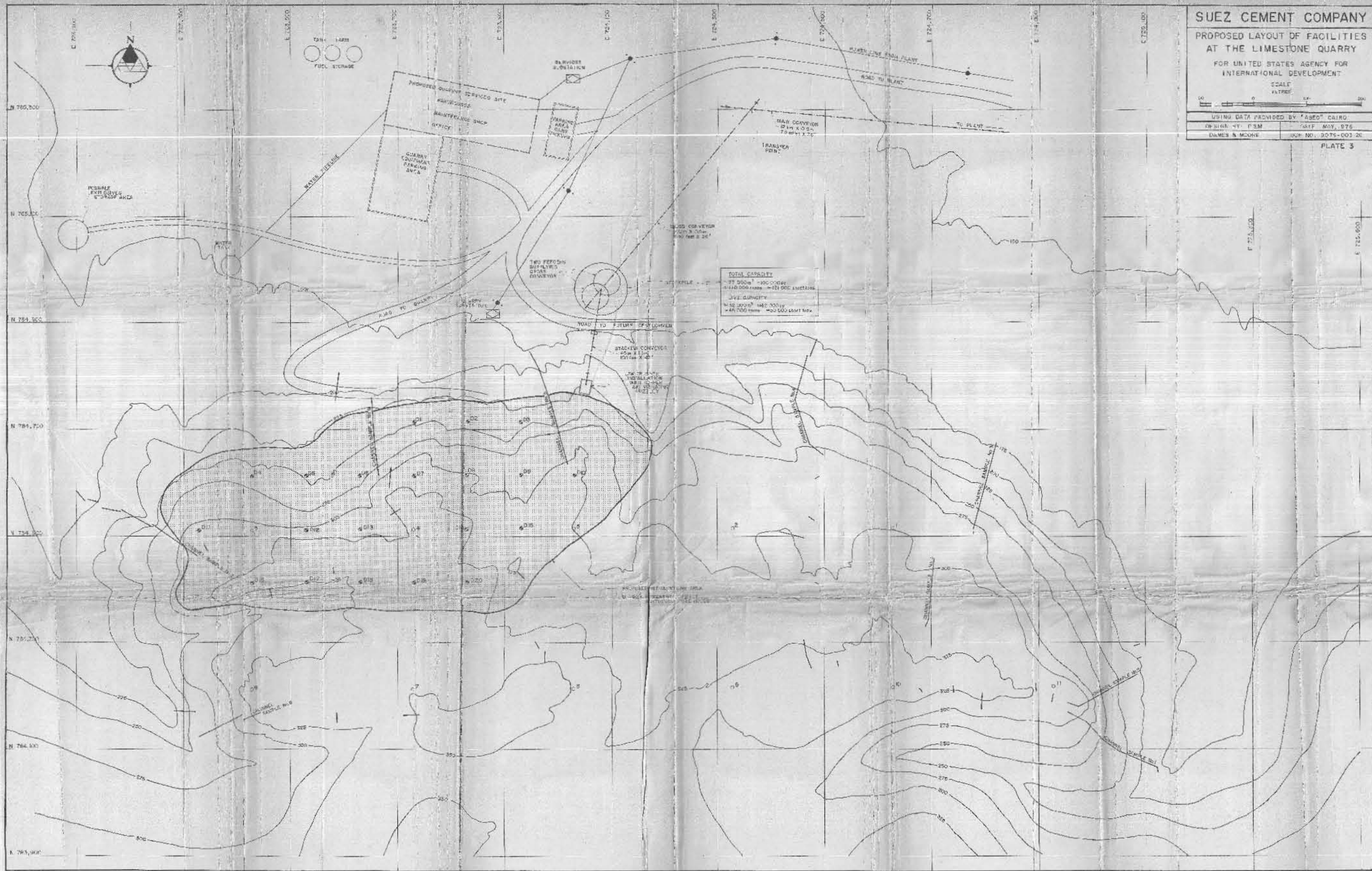
Which would be sufficient for 6.74 or 6.18 days production of 5,000 tonnes per day (5500 short tons per day).

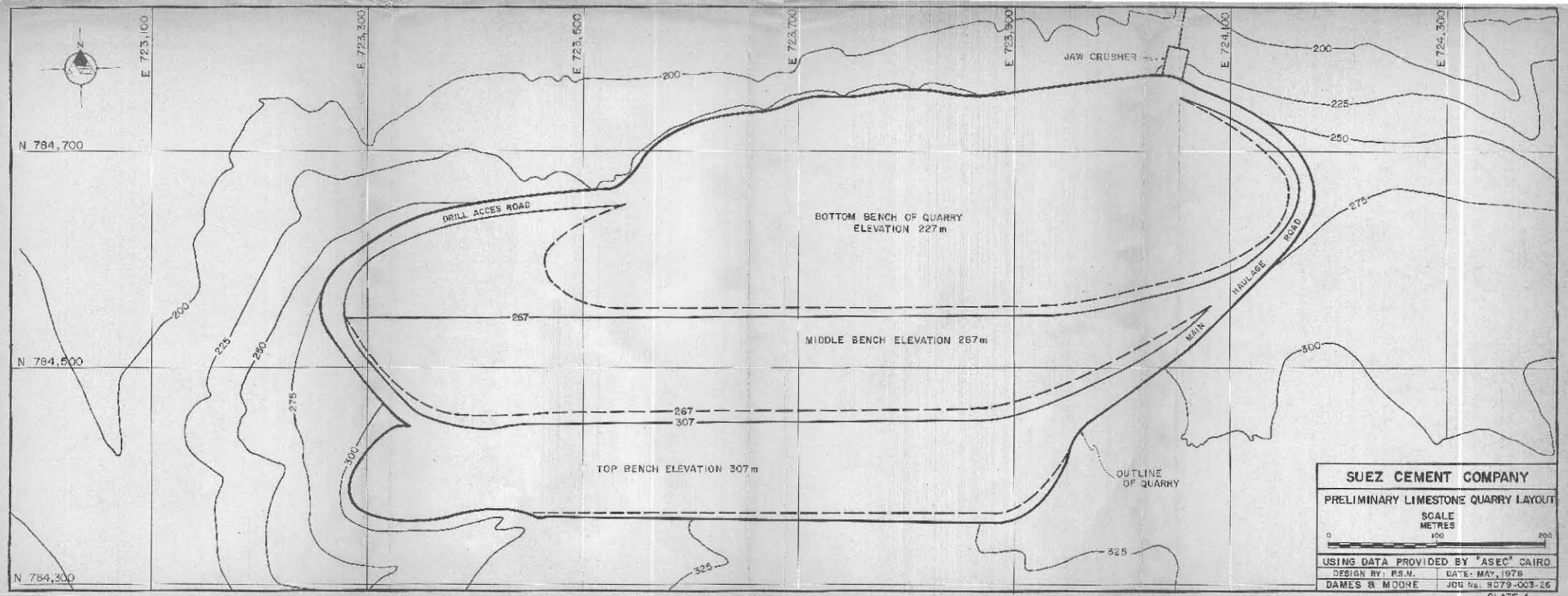
Therefore, daily drilling requirements would be:

(i) 10 x 44m ÷ 6.74 = 66 m/day (216 ft/day) (Pneumatic Loading)

(ii) 10 x 44m ÷ 6.18 = 71 m/day (234 ft/day) (Gravity Loading)

One large drilling machine should be capable of drilling 12m (39 ft) per operating hour, which indicates a working requirement of 5.5 - 6.0 hours. One shift on drilling and one on maintenance would appear to be a possible drilling program. Back up drilling capacity would be available from the rough terrain drill with up to 12.5 mm (5") capacity. This drill will service any limestone drilling requirement in the clay deposit, and some secondary drilling where required in the limestone deposit as its normal duties.


SUEZ CEMENT COMPANY
PROPOSED LAYOUT OF FACILITIES AT THE LIMESTONE QUARRY
FOR UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
SCALE
USING DATA PROVIDED BY "ASEC" CAIRO
DAMES & MOORE
PLATE 3
N
TANK FARM
FUEL STORAGE
SERVICES SUBSTATION
PROPOSED QUARRY SERVICES SITE
MAINTENANCE SHOP
OFFICE
QUARRY EQUIPMENT PARKING AREA
PARKING AREA
WATER PIPELINE
POSSIBLE EXPLOSIVES STORAGE AREA
ROAD TO PLANT
TO PLANT
MAIN CONVEYOR
TRANSFER POINT
TWO PERSONNEL
ROAD TO QUARRY
ROAD TO FUTURE DEVELOPMENT
STOCKPILE
TOTAL CAPACITY
STACKER CONVEYOR
CHANNEL SAMPLE


E 723,100
E 723,300
E 723,500
E 723,700
E 723,900
E 724,100
E 724,300
N 784,700
N 784,500
N 784,300
JAW CRUSHER
DRILL ACCES ROAD
BOTTOM BENCH OF QUARRY
ELEVATION 227m
MIDDLE BENCH ELEVATION 267m
TOP BENCH ELEVATION 307m
HAULAGE ROAD
MAIN
OUTLINE OF QUARRY
200
225
250
275
300
325
267
307
SUEZ CEMENT COMPANY
PRELIMINARY LIMESTONE QUARRY LAYOUT
SCALE
METRES
0
100
200
USING DATA PROVIDED BY "ASEC" CAIRO
DESIGN BY: R.S.N.
DATE: MAY, 1978
DAMES & MOORE
JOB No. 8079-003-26
PLATE 4