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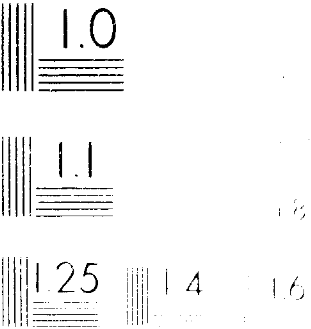
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Distr.
LIMITED

UNIDO/IOD.361
12 December 1979

ENGLISH

UNITED NATIONS INDUSTRIAL
DEVELOPMENT ORGANIZATION

ASSISTANCE TO CONSOLIDATE AND DEVELOP THE BENGHAZI CEMENT FACTORY COMPLEX

TF/LIB/75/002

LIBYAN ARAB JAMAHIRIYA

Report of project co-ordinator

Based on the work of Aly Afify, chemical engineer
and project co-ordinator

Explanatory notes

References to dollars ($) are to United States dollars.

The monetary unit in the Libyan Arab Jamahiriya is the Libyan dinar (LD). During the period covered by the report, the value of the Libyan dinar in relation to the United States dollar was $US 1 = LD 0.296.

A full stop (.) is used to indicate decimals.

A comma (,) is used to distinguish thousands and millions.

References to "tons" are to metric tons, unless otherwise stated.

The following abbreviations of organizations are used in this report:

UNIDO	United Nations Industrial Development Organization
LCC	Libyan Cement Company
GNOI	General National Organization for Industrialization
SUMIS	Souk El-Khamis General Company for Cement and Building Materials
KHD	Kloeckner Humboldt Deutz, Industrieanlagen AG - Humboldt Wedag, Federal Republic of Germany
B + B	Bilfinger und Berger, Bauaktiengesellschaft, Federal Republic of Germany
HMC	Holderbank Management and Consultancy, Switzerland
PEG	Prospective Engineering Gestion, Switzerland
IBICC	International Building Industrial Commercial Co, Greece

The following technical abbreviations are used in this report:

t/h	tons per hour
kcal/kg	kilocalorie per kilogramme
kWh/t	kilowatt hour per ton
LPS	Loro Parasini Screen

ABSTRACT

This project "Assistance to consolidate and develop the Benghazi cement factory complex" (TF/LIB/75/002) was carried out for the Libyan Arab Jamahiriya, by an expert of the United Nations Industrial Development Organization (UNIDO). The project was financed through a trust fund arrangement with UNIDO. This report covers the work of the building materials adviser who carried out a series of split missions totalling 36 months between February 1976 and October 1979, and who acted as project co-ordinator.

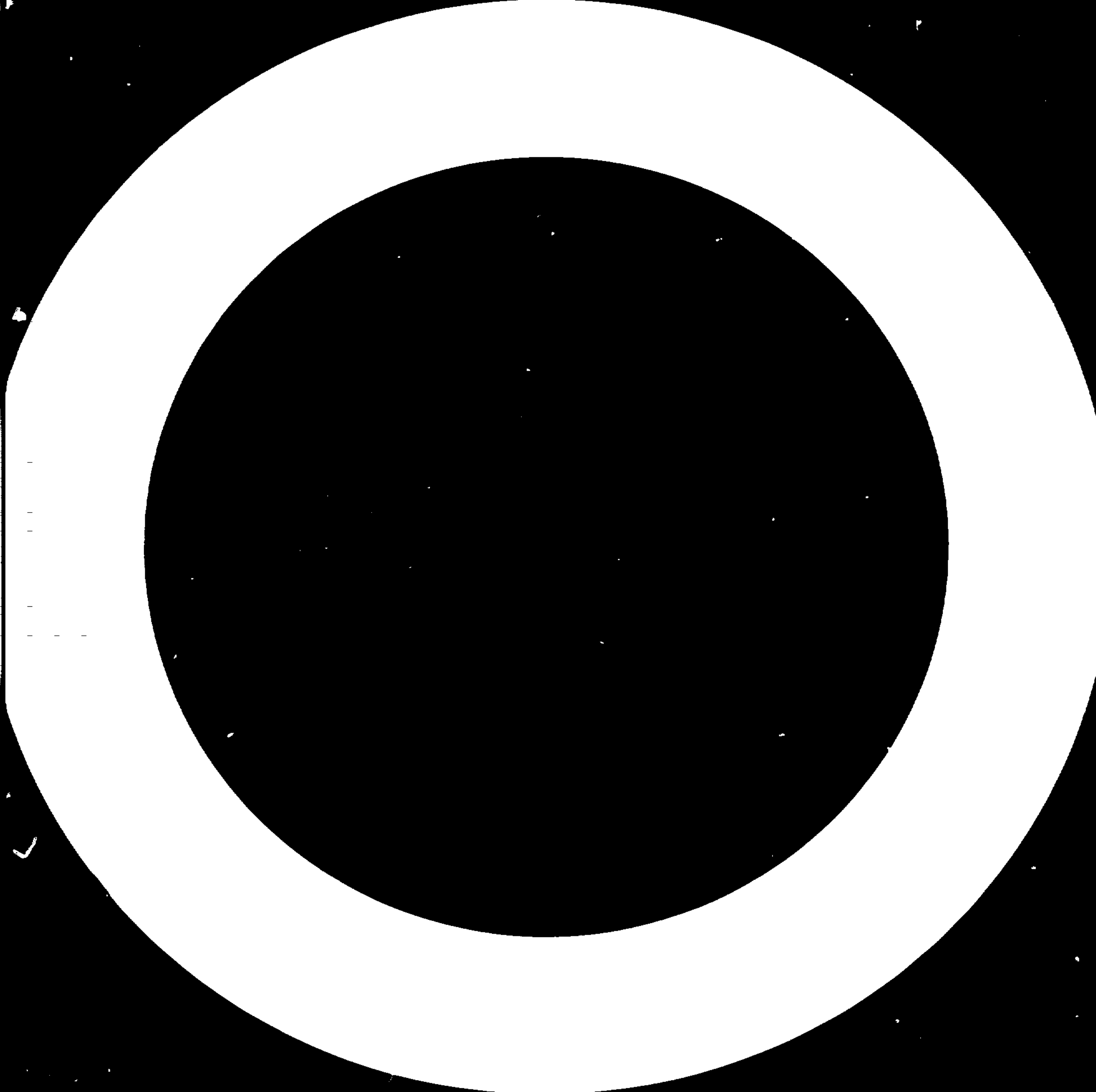
The project involves technical assistance to one of the most elaborate industrial complexes in the country's industrial development. It first started in the Benghazi area in April 1972 with one cement production line of 200,000 tons per year production capacity. Consecutive extensions over the years have brought the industry's production capacity up to 2 million tons per year of cement in 1978. Additionally, a lime factory, paper-bag works, concrete-block and ceramic-brick factories have been set up.

The UNIDO project started with the building materials adviser but, by May 1978, UNIDO assistance was extended to include 52 experts, and is now being expanded to 100 experts.

The adviser acted as technical consultant to the whole complex of industries including the Benghazi cement works, the Hawari cement project, the lime plant, the paper-bags factory, the ceramic-bricks and concrete-blocks projects, and the Souk-el-Khamis and Derna cement plants. He participated in solving day-to-day running problems, planning recruitment and training of personnel, finding solutions to the technical problems presented by the expansion of these industries, and in contractual negotiations with tenderers and machine suppliers.

A detailed account is given of the production of the Hawari Cement Plant during the year 1978, this being the main area of activity of the UNIDO technical assistance team.

Recommendations are made for further improvements which should be carried out in the cement and building materials complex.



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INTRODUCTION

The report gives the findings, conclusions and recommendations of the building materials adviser, the expert assigned by the United Nations Industrial Development Organization (UNIDO) to the project (TF/LIB/75/002) "Assistance to consolidate and develop the Benghazi cement factory complex". The project was requested by the Socialist People's Libyan Arab Jamahiriya, and was approved by UNIDO in June 1975. The adviser first completed a short mission in February to March 1976, then a series of split missions from November 1976, with a total assignment of 36 months, acting also as a co-ordinator of project activities. The project is being financed by the authorities of the Libyan Arab Jamahiriya through a trust fund arrangemen with UNIDO.

Project background

The Libyan Cement Company (LCC) started the national cement industry in the eastern part of the country and further extended its activities to cover various building materials industries. The first cement rotary kiln was installed and started up in April 1972, with a yearly production capacity of 200,000 tons of normal Portland cement. This industrial development was extended with a second production line (600,000 tons per year) which was started up in August 1974. A third production line of a similar annual production capacity (600,000 tons per year of normal Portland cement) was started up in January 1977. The next extension followed in the form of a new cement project, "Hawari", which was provisionally taken over during August 1978, with an annual production capacity of 1 million tons. This brought the total cement production in the Benghazi area to two million tons per year.

To profit from the crushing plant of the Benghazi Cement Works, a lime plant was erected and put into production in March 1975 with a production capacity of 43,000 tons of hydrated lime per year. This plant is being extended by the installation of a second identical production line.

Paper bags for cement and lime are manufactured in a paper-bag factory which was started up in June 1975 with an installed production capacity of 100,000 paper bags per day. An additiona similar production line was opened up during December 1978.

A concrete-block factory was erected with a yearly production capacity of 100,000-120,000 cubic metres per year of finished concrete blocks. It was put into operation in June 1978.

Furthermore, a ceramic-brick factory with a capacity of 60,000 tons per year was installed and was commissioned as from June 1979.

With this rapid expansion of industrial projects in diversified fields of building materials, LCC has been confronted with a greatly increased need for experienced technical personnel to cope with the dual task of operating and expanding the factories. The management of LCC is planning to introduce major training programmes for national technical personnel to meet the needs of expansion in the cement and allied building materials industries.

UNIDO was therefore requested for technical assistance to help consolidate the Benghazi cement industry and to give advice on building material industries in general. UNIDO technical assistance started with the building materials adviser. By May 1978, the technical assistance project was extended to include 52 experts. With the growing need for technical assistance, the project is now being expanded to 100 experts with diversified specializations in the field of building materials manufacture.

The adviser has been charged with the following duties and responsibilities:

(a) Examining the existing situation of construction and building materials in the region and collecting statistical information concerning production units and output;

(b) Advising on the development of the existing construction and building materials industries and suggesting adequate development plans for them;

(c) Studying the basic problems in the industry, supervising machinery and equipment installation and its initial operation, carrying out acceptance tests, and technical support to the building material industries;

(d) Planning for technical management, including development of operational processes, assessment of labour requirements, development of personnel schemes, organization charts and job descriptions;

(e) Development of training programmes for national technical personnel and follow-up on the promotion of local skills;

(f) Acting as co-ordinator for all UNIDO technical assistance activities in this field during his mission.

I. TECHNICAL ASSISTANCE PROJECT

The fairly rapid development of the Libyan Cement Company into a well-diversified complex of building material industries has caused a parallel growth of requirements for technical assistance. The development of the personnel working on this project was as shown below.

Building materials adviser
Post TF/LIB/75/002/11.01:

The mission of the chemical engineer, Aly Afify, originally planned for one year, has in fact been extended to 3 years, and his activities expanded to cover the LCC building materials industries and other developing industrial projects in the country such as the Souk-El-Khamis and Derna cement projects. The building materials adviser also acted as co-ordinator for the other project activities which developed.

In accordance with his proposals, the following experts were also assigned to the project:

Short-term consultants

(a) Planning mechanical engineer. Post TF/LIB/75/002/11.02. The mechanical engineer, Mehmet Basman, took up his post on 14 August 1978 for a 3 months' mission which was extended for a further two months. The expert proceeded with the planning of mechanical maintenance in the Benghazi Cement Works in accordance with the duties and responsibilities set out in his job description. The planning work of this specialist was intended to form the basis for the work of the two following experts:

(b) Maintenance mechanical engineer. Post TF/LIB/75/002/11.03. The mechanical engineer, Alfred Madsen, arrived at the duty station on 9 May 1978. His activities were mainly in the Hawari Cement Works during the commissioning period. When this expert joined the project, the post of planning mechanical engineer (a) had not yet been filled so that it wa. necessary for the maintenance mechanical engineer to undertake the planning work specified for the other expert. The expert also carried out technological investigations and offered advice on all the problems which were brought before him, both in the Hawari and Benghazi Cement Works and in the paper-bag factory. The expert was able to finish the required maintenance planning work one month earlier than originally scheduled. He left the duty station on 10 July 1978 after a two months' instead of a three months' stay;

(c) Instrumentation electrical engineer. Post TF/LIB/75/002/11.05. The electrical engineer, Boguslaw Walczenko, arrived at the duty station on 25 July 1978 for a mission of one year which has since been extended for a further 6 months. His activities have been carried out in the Hawari Cement Works as technical leader for the Polish team of instrumentation and control electricians.

Team of specialists
Posts TF/LIB/75/002/11.06 to 11.19

This comprises the Polish team of technical personnel. A request was originally submitted for 54 personnel specialized in operation and maintenance for the Hawari Cement Plant. They would also train the national technical staff through co-operation on the job in this field.

In the event, 48 people joined the project in two groups. The first group consisted of 26 specialists, of whom 24 arrived at the duty station on 31 May 1978, and 2 more arrived on 23 July 1978. The second group, composed of 22 specialists, arrived at the duty station on 31 August 1978. These specialists have performed their duties and responsibilities in accordance with their job descriptions and in full co-operation with their national counterparts. The team has successfully fulfilled the dual function of consolidating the development of the industry and of training national counterparts. As can be seen from the statistical review of project personnel in annex II, the total number of the team was reduced to 31 specialists due to repatriations for family and other reasons. However the continuing need for technical assistance has recently led to a new recruitment action designed to expand the technical assistance project to 100 specialists, as detailed in chapter IV of this report.

II. PROJECT ACHIEVEMENTS

Throughout the project activities, the adviser has been consulted on diversified aspects of the building materials industries, with the main emphasis on the field of cement manufacture.

Close follow-up support has been maintained for the developing industries, the Hawari cement project, the ceramic-bricks factory, and the concrete-blocks plant. Additional care has been given to extension projects for the lime plant and the paper bags factory. The adviser drew up organization charts for the technical personnel required, and schedules for the proposed employment of national skills and the technical assistance needed.

With its group of developing industries, LCC is expanding into a complex of building materials industries. The achievements of the assistance project have consequently had to go beyond the original scope of forecasted activities and have been extended to include a number of diversified fields. The assistance project has so far always achieved its technical objectives satisfactorily.

Moreover the advisory activities were extended to other developing industrial projects such as the Souk-El-Khamis and Derna cement projects. The adviser has been dealing with technical requirements in these projects.

With the developing need for further technical assistance, a team of 48 specialists was brought in for more elaborate project activities. The adviser acted then as team leader and project co-ordinator. Confidence in the performance of the team led to a new request for further expansion of project activities and a team of 100 specialists is now being prepared.

In addition to the day-to-day activities in rationalization of production and operational procedures, the following specific tasks were accomplished:

A. Benghazi cement works

During the early stages of the project, most of the activities were concentrated on the Benghazi Cement Works. The first production line was put into operation during the year 1972 with an installed production capacity of 200,000 tons per year. Successive extensions took place involving the second and third production lines and ultimately a couple of production lines in Hawari, giving a final total production capacity of 2 million tons per year during the year 1978. The cement production volume has therefore increased ten times within seven years, in addition to newly created industries for lime, ceramic bricks, and concrete blocks. This huge volume of industrial development has imposed a sizeable burden of technical and administrative responsibility and has called for re-assessment of the labour force and of the supply of raw materials. Among the various activities in the field of technical assistance, the main ones are described below.

Organization of the labour force

The functions of technical personnel were carefully defined and the responsibilities of each individual clarified. Promotion channels for various levels of personnel have been established within sections and departments. An organization chart for technical personnel has been drawn up.

A job description has been outlined for each member of the technical departments. All particulars have been discussed in detail with the responsible technical personnel, and certain traditions governing personnel and departmental functions have also been taken into account.

Commissioning and acceptance tests

The third production line was commissioned and put into operation during the project time. The adviser participated in the initial start-up and in overcoming problems encountered by the national technical personnel. The operational facilities were reviewed and contractual deficiencies assessed. Appropriate procedures were adopted for performance of the acceptance tests. Finally the results of these tests and the outstanding contractual obligations were formulated into a comprehensive take-over procedure, with estimates for financial guarantees corresponding to the outstanding obligations.

Linkage between production lines

During the extension proceedings, the adviser participated in the planning and execution of measures for joining the new extension units to the existing plant without interruption of production. Linkage has been accomplished in various sections such as the heat-carrier oil piping of the kiln-firing system, clinker reclamation from the clinker-storage hall by vibrating extractors and rubber-belt conveyors, cement-conveying pipes from the mill house to cement-storage silos in the packing-plant section, and the gypsum-storage and conveying facilities. Possible bottlenecks were thus eliminated, and the extensions were used as a favourable opportunity for improving existing conditions.

Review of the gypsum situation

With the increasing capacity for cement grinding, the adviser reviewed the state of the raw gypsum reserves, taking into consideration the gypsum requirements of all the planned extensions. The adviser recommended further detailed investigations into gypsum deposits to ensure ample reserves. Meanwhile he organized gypsum quarrying from available resources. The available gypsum from the Ragma quarries was not sufficient for the cement production. The problem was one of transport owing to difficulties in the use of the connecting side road to the new Ragma gypsum quarry. Lorries had to follow a longer bumpy track in the desert off the paved main road, and this, together with special local restrictions in the area, was reducing the productivity of the gypsum plant.

To secure the gypsum necessary for cement grinding without a shortfall and consequent interruption of production, the adviser designed a plan for using the old Ragma quarry during a transitional period in which there would be ample time for building up an adequate gypsum stock on the factory site and solving the problems of additional road length to the new Ragma quarry. To carry out the plan, a new entrance was blasted and limestone barriers cleared to make a short, convenient passage to the neighbouring asphalt road. Meanwhile the access road to the new Ragma quarry was established after comprehensive specifications were drawn up for taking pipes across the valleys.

In addition a plan for opening up the Hawa-El-Barag gypsum quarry was developed by the adviser, involving the removal of clay, limestone overburden and waste materials in the quarry bottom so as to give a clear quarry front with the full height of the whole gypsum stratum revealed. Access to the quarry bottom was ensured by a road extending from the paved main road down to the quarry bottom on a suitable slope and surfaced with crushed limestone excavated from the quarry opening, with drainage pipes laid adjacent to the paved road for disposal of rain water.

The quarry was opened, and the gypsum obtained played an important role in preventing possible shortages. However, the lowermost level of the gypsum formation in Hawa-El-Barag is so deep below ground level that the quarry bottom is subject to considerable accumulation of rain water which hinders extraction during the winter time. Gypsum supplies should therefore be co-ordinated between both sources, Ragma and Hawa-El-Barag quarries, to ensure a continuous flow of material all the year round.

Rationalization of cement-testing procedures

This question was thoroughly investigated. One of the most important problems that worried personnel in charge of quality control was the remarkably low results of compression-strength tests performed in the LCC physical laboratory. Most cement samples had strength figures that did not comply with the requirements of the British Standard Specifications (BSS 12/1958). After detailed investigations of the procedures of quality control and a general survey of the processes involved, the testing conditions were carefully revised. The quality of testing sand and the quantity of gauging water were first checked. The hydraulic compression strength testing machine was calibrated by an external pressure gauge belonging to the concrete crushing machine of Bilfinger and Berger (B and B). The speed and rate of vibration of the standard vibrating machine were checked and its worn out springs were replaced by a new set that could be manufactured in the workshop of a sister cement factory. Meanwhile the mortar mixer was provided with a modified mixing paddle with an adjusted clearance. Ultimately, the ideal testing conditions were established and the proper test results were attained.

In general, various questions and problems arose which were tackled through discussion and systematic investigation. The adviser was kept informed on the operation of particular processes through close co-operation with the national counterparts, and suitable solutions to problems were consequently found and adopted.

B. Hawari cement plant

The Hawari cement project is one of the largest operations in recent Libyan industrial development. On 18 January 1975, a turnkey contract was signed between the General National Organization for Industrialization (GNOI) and a consortium composed of two firms from the Federal Republic of Germany, Kloeckner Humboldt Deutz Industrieanlagen AG (KHD) and Bilfinger and Berger AG (B+B), for the supply and erection of a complete set of machinery and equipment for a cement plant with a production capacity of 2 times 1,500 metric tons of clinker per day, using the most modern cement-making technology. The supplier undertook the supply of spare parts covering two years requirements at the maximum installed capacity in addition to providing technical know-how, process and maintenance documentation and engineering drawings for efficient operation. Within the scope of the contract the supplier arranged for training the national personnel free of charge, either in similar works in Europe or on the spot during commissioning and further operation. The supplier also provided a basic team of five experts in the fields of process technology and mechanical and electrical maintenance as technical assistance to ensure proper performance during the two years following the provisional take-over of the plant. This project (TF/LIB/75/002) is directly related to the Hawari Cement Plant. Initially the technical requirements of the plant guided the project adviser to draw up an organization chart of personnel needed. The proposed composition of the technical assistance team was then based on this and on basic information about the available national skills. Thereafter, the technical assistance offered has developed and changed as a function of progress and development within the Hawari project. In addition to close technical support and continuous follow-up, special reference should be made to the following services:

Forecasts for technical personnel

The project adviser developed a comprehensive schedule for employment and training of technical personnel. This was based upon forecasts for requirements of various production units and maintenance systems. An organization chart was first drawn up, in which various possibilities were outlined for filling the required posts, either from national labour potentials, contractual technical assistance, or from foreign resources. A detailed study was made of various sources of technical assistance which suggested the advantages of co-operation with UNIDO in this concern. Further investigations ended in the present trust fund agreements through which the existing team was brought in to oversee the operation and maintenance of the Hawari Cement Plant and to train national technical personnel.

Improvements in the execution of the project

The adviser followed the execution of the project closely and regularly attended the general co-ordination meetings held between LCC, representatives of the consultant PEG and delegates of the consortium partners (KHD and B+B). Through these meetings, many proposals were submitted by the project adviser for the improvement of project execution.

Among the improvements achieved were the introduction of technical documentation for linking up servicing facilities between old and new cement plants, development of lubrication charts for preparation of initial fillings and break-in refillings of lubricant oils and greases, and the application of operational guides and instruction manuals to the training of technical personnel. It was proposed to interlink the two production lines, enabling sufficient flexibility to ensure a constant flow of materials even if one of the units is subject to maintenance or repair. Special provision was made for raw-mix transport from the raw mills to any of the homogenization silos, from the latter to the storage silos, and further to the kiln feed.

The whole system of water circulation was reviewed and detailed procedures for filtration, sterilization of drinkable water, treatment for industrial purposes, and purification of sewage water were worked out. The possibility of using the emergency power supply for water and compressed air, and perhaps to provide an alternative means for partial operation of the packing plant, was investigated.

A study was devoted to the lining of the hopper over the apron feeder of the limestone crusher. Adequate levelling marks were fixed to the main foundations, especially those of rotary kilns. Special attention was given to the collection of alignment data during the erection period so as to provide ample information on which to base future checking work and realignment procedures. Provisions were made for the safe installation of the four storage silos to avoid the risk of uplift, which could arise from internal pressure due to silo overfilling, which in turn may result from failure of the electrical alarm equipment.

Commissioning and performance

The project adviser participated in the work of commissioning and putting the plant into operation. Activities were co-ordinated with the old works especially over the quarrying of raw materials, packing and despatch, resources of labour, electrical energy and fuel supplies. Special attention was given to co-ordinating common services such as installation of workshops, quality control work, storage and transport facilities. Daily problems which arose were solved in full co-operation with national counterparts and the contractual commissioning group. The UNIDO team of specialists was introduced to the work processes and was able to familiarize itself with all the details of the new project.

Performance tests were carried out in accordance with procedures which had previously been agreed in mutual discussions between all the parties concerned including the project adviser. The procedures went into operation as from the contractual date of "readiness for acceptance tests", and were mainly concerned with the principal machinery and equipment specified in the official list of guarantee figures. The project adviser participated in the organization and realization of these performance and acceptance tests, which checked the products under contractual guarantee in terms of quantity and quality as well as electrical and heat energy consumption rates.

Formalities for provisional take-over

The project adviser took part in the proceedings leading to the provisional take-over of the plant. With the fulfillment of the main guarantee figures within the contractual time limit, the provisional take-over was due. However, the limestone crusher had shown some defects. A considerable number of grate bars were broken several times. The last time, the rotor axle was shifted aside and the bearing-guard clamps were also broken. These incidents were judged as defects to be remedied without affecting the test results, as the crushing capacity was still kept at the standard level. In addition, the roto-packing machines were not tested by the contractual date due to some defects which were still under repair. However the guarantee figures for the packing plant are given in additional statements and therefore do not form a part of the main guarantee list. In the end, it was agreed to postpone the date of provisional take-over from 20 June 1978 to 27 August 1978 to allow ample time to the supplier to replace the defective parts in the limestone crusher, to perform the necessary adjustments to the packing machines, and to tackle any electrical faults which materialized before that date. The project adviser took part in discussions held within the general co-ordination meeting during the period 6-16 September 1978, at which the defects were listed and adequate financial guarantees were worked out to cover these defects until their correction within the contractual year of guarantee. However during this year various other faults occured, most important of which were the breakage of hammers in the clinker crusher in production line No. 2 and cracks in the shells of both cement mills (No. 1 and 2). A lot of argument went on about the design for fixing the electrodes in the electrostatic precipitators, abnormal breakage of lining plates in the cement mills, and non-fluidity of the cement hindering its extraction from the cement silos. These major points, in addition to other supplementary points, will provide subjects for strong debate during the forthcoming general co-ordination meeting to be held at the end of the contractual year of guarantee.

C. Lime plant

The technical advice of the adviser was sought on questions relating to lime manufacture. In addition to helping solve daily problems which arose, the adviser gave the following specific technical assistance:

Promotion of production capacity

Lime production was hampered from the beginning by a lack of sized limestone and was suffering from a shortage of raw materials which frequently led to reduced lime production and sometimes to a complete standstill. This problem was studied by the adviser and his findings contributed to a solution by solving the problem of sized limestone.

The limestone preparation was designed to treat limestone of 30-60 mm, sorted out by Mogensen sizers and Loro-Parasini vibrating screens (LPS). These screen the crushed limestone from a WEDAG hammer crusher with a crushing capacity of 270 tons per hour which feeds the first and second LCC production lines. The screening is done through a pair of Mogensen sizers set with mesh widths of 100, 80 and 50-25 mm. Grain sizes bigger than 30 mm are separated from the material flow and conveyed to the lime plant where LPS vibrating screens separate out the limestone lumps below 30 mm and over 60 mm.

These rejected lumps were then conveyed to the limestone storage hall of the cement plant. The limestone lumps of the required size were led to the raw storage silo which has a working capacity of 1,500 cubic metres. The silo has a maximum content of 2,250 tons of limestone with a bulk density of 1.5 tons per cubic metre. The full content of the raw storage silo represents a maximum working reserve of 275 hours running of the lime kiln, i.e. 2,250 tons storage capacity divided by 8.75 tons which is the hourly consumption of the kiln at normal output.

The adviser made a series of process analyses and developed a group of particle distribution curves. Appropriate modifications were made to the chutes and new sieves were locally manufactured which could sort out stone down to sizes 15% smaller and up to 30% bigger than in the original system. This procedure resulted in a 25% increase in the amount of raw sized limestone, which contributed considerably to the elimination of the raw matrials bottleneck without any reduction in quality which still complies with the requirements of British Standard Specifications.

Development of parameters for plant extension

A study was made by the project adviser to determine the main principles to be followed in the extension of the lime plant.

With the vast development programmes scheduled under the national development plan, an increasing demand for lime was envisaged. The plan called for an increase in the existing lime production capacity of LCC by 33,000 tons per year of quicklime, equivalent to 43,000 tons per year of slaked lime for building purposes.

Further good prospects exist for lime in industrial works. The last expansion of the limestone-crushing capacity demonstrated the feasibility of expanding lime production by installing a second lime production line similar in capacity to the existing plant, and of establishing a secure supply of limestone, crushed to proper industrial sizes, for both the present and proposed lime plants.

The study went on to examine the bottlenecks in storage and raw material facilities. A solution to the problem was found by connecting the old and new storage areas in such a way as to eliminate bottlenecks and secure smooth performance even in the event of a crusher stoppage. The study also covered undesirable ingredients of limestone, such as the magnesia content, which is so harmful in the cement industry but would be tolerated in lime manufacture where the maximum limit of magnesia content is 10%. The quarrying process could therefore be organized in a convenient manner.

In conformity with the principles outlined in this study, the consulting firm Holderbank Management & Consultancy (HMC) developed a proposal for the extension of the Benghazi Lime Plant.

Rationalization of the extension project

The project adviser participated in technical discussions held to investigate the main parameters for the extension project. In the light of experience obtained from the existing lime factory, details of the proposal were discussed with local technical personnel and representatives of HMC. Precautionary measures were suggested for inclusion in the tender documents with the aim of avoiding difficulties encountered in the old lime plant and of eliminating bottlenecks which hinder the production process. The following, in brief, are representative examples of modifications and improvements which were decided on and included in the design work during the development of technical specifications:

(a) The quantity of sized stone in the store was to be increased to avoid lengthy interruption of lime production during the modifications;

(b) A loading device for quicklime was to be provided to make possible the disposal of half-calcined fragments in case of emergencies;

(c) A passage for quicklime trucks was designed, with adequate room to manoeuvre through an increase in free space between the slaked lime silos;

(d) Replacement of burner beams should be done by monorail cranes specially designed for easy manipulation;

(e) Passage among production sections must be facilitated by gangways and platforms between towers and silo roofs including junctions between the original and new production units to simplify operational and maintenance processes;

(f) Sufficient storage capacity must be provided to eliminate bottlenecks in handling materials in the event of a stoppage in a particular unit;

(g) Control of the material level within storage silos to be achieved by equipping them with proper control devices, including continuous level indicators and maximum filling alarms;

(h) Capacity of the packing section should be increased so as to pack the production of both lines within the morning shift. Despatch facilities to be provided with two loading bays and an ample conveyor belt for a regular flow of bags. The old packing machine may be considered as a standby for emergencies;

(i) Filter equipment was specified with sufficient capacity to eliminate and recuperate dust from various sections effectively;

(j) Ample paper-bag storage to be furnished, based on the storage of multiple collections, each composed of 5 x 4 bags, with a height of 40 packets of 50 bags each. Stores to be provided with an opening for the hoisting equipment and a monorail crane of 4 tons capacity;

(k) Compressed air to be distributed into two separate networks, one for services and the other for kilns, silos and measuring instruments. The production network was stabilized with a monostat-air-vessel which starts the standby compressor in the event of a pressure drop;

(l) Water filtration system to be installed at all air intakes to avoid contamination of water with undesirable dust ingredients;

(m) Sedimentation of lime suspension to be carried out by passing the water from the hydration process through multi-stage basins to precipitate the hydrated lime particles and avoid blockage of the drains.

D. Paper-bag factory

The project adviser participated in studies on the expansion of the paper-bag factory. The production capacity of this factory amounted to 100,000 paper bags per working day. Its normal production rate was actually reckoned as 80,000 paper bags per day over 260 working days per year, yielding approximately 20 million bags per year. This could be increased to 30 million bags by operating 2 shifts. The project adviser reviewed the expansion plans of the consumer plants (Benghazi, Hawari, and Souk-El-Khamis cement and lime plants) to assess market prospects for Benghazi paper bags. The estimate came to a total requirement of 67 million bags per year. A recommendation was therefore made to extend the paper-bag factory by introducing a second production line with a production capacity of 100,000 paper bags per working day which would bring the production up to 200,000 bags per day. The rationalization of production processes would ensure efficiency over 300 working days per year, yielding 60 million bags per year, which could be increased to 90 million bags per year by 2-shift operation. The proposed expansion project was intended to profit from rationalization of the processes and to ensure full efficiency of operation. A study was made to see if the bottlenecks experienced in the old operational procedures could be eliminated through modifications in the new production line and proper linkage to the old plant. Among the aspects tackled in this respect were:

(a) Interlinks between the two production lines, with the possibility of joining the activities of tubers and bottomers so as to absorb any eventual stoppages;

(b) Providing the tubing machine with various cylinders for different bag sizes to give easy shifting between cement and lime requirements. For the same purpose, a printing distance control was provided for quick adjustment whenever the batch was changed;

(c) Comprehensive contractual stipulations for technical assistance and on-the-job training of national personnel during the first year of operation. Principles were outlined for achieving economies in paper bag production and use by elimination of bag rupture or reduction of the percentage of torn bags;

(d) Planning spare-parts supply adequate for 2 years consumption. The scheme included the provision of a complete spare parts list, with basic data for wearing parts, data for average wearing time, ordering and minimum stocks, so as to enable systematic ordering of spare parts

The implementation of these proposals was entrusted to the representatives of BMC on the site. They kept in close touch with the project adviser to discuss any problems which arose during the course of the work up to the time of the acceptance tests and the provisional take-over.

E. Ceramic-brick factory

The installation of the ceramic-brick factory was entrusted to the French firm CERIC on 13 February 1973, on a turnkey basis as a complete plant for the production of 60,000 tons of ceramic clay bricks. The total cost of LD 1,430,373 included the study of raw clays, civil construction, supply of mechanical and electrical machinery and equipment, material accessories, spare parts for two years operation at maximum output, erection, start-up, take-over tests, and management assistance. The time schedule originally envisaged the completion of the entire plant within 30 months from the date of the contract coming into force, but the execution was much delayed due to unforseen circumstances. The project adviser followed the operation closely and participated in solving problems which threatened further delays.

Raw materials were supposed to be supplied from the neighbouring Hawari clay areas, which were investigated by the French machine supplier CERIC. The project adviser gave all possible assistance with the geological investigations in the field and with preparation for pilot tests to be performed in the suppliers' laboratories.

While the project was being carried out, the adviser drew up a proposal for essential technical personnel, with an organization chart for operation and maintenance staff giving numbers and specializations required and whether the personnel could come from national resources, contractual technical assistance, or from supplementary sources of labour.

F. Concrete-block factory

The project was originally entrusted by GNOI, to the American firm INTERKILN as general contractors. The plant was designed for a yearly production capacity of 100,000-120,000 cubic metres of finished concrete blocks. The guaranteed minimum capacity can be expressed in an equivalent net production of 6,200,000 standard non-load-bearing concrete blocks per year (ASTM No. C129) or 4,665,600 load-bearing blocks (ASTM No. C90 - 70). When INTERKILN gave up the project, the supervision was taken over by LCC and the Swiss firm PEG undertook completion of the engineering work and supply of missing items. Civil construction was entrusted to the firm B + B, and the mechanical and electrical work to the Greek firm IBICC.

It was therefore evident that turnkey responsibility was no longer possible and that the divided responsibility for supervision would necessitate especially close co-operation from the project adviser. The adviser acted as co-ordinator of activities in support of LCC management in dealing with all the necessary technical and administrative matters. Through mutual co-operation, problems were solved and a continuous supervision was maintained over the progress of the project and the supply of materials. In particular the following main questions were settled by the adviser:

Safety regulations for explosives stores in the quarries

Aggregrate requirements were planned to come from the Magzaha quarries where an aggregrate-crushing plant had to be installed. Hoisting and transport of machinery and equipment belonging to this section was organized in preparation for the erection work. In the course of construction of the plant, adequate storage had to be prepared for the explosives needed in the quarrying process. The consultant Prospective Engineering Gestion (PEG) proposed a design according to Swiss specifications. The local safety regualtions stipulate only a limited number of requirements.

The project adviser prepared a design for adequate safety precautions taking into account that more stringent local safety requirements may be issued in the future and indicated where the store should be located on the site to comply with safety regulations on proximity to neighbouring activities.

Planning for labour force requirements

The project adviser was responsible for drawing up employment and training schedules including an organization chart of technical personnel. The plan was based on the local personnel available at that time and was divided into two stages. The first stage included personnel needed immediately for opening the quarry, constructing the access ramp and running the aggregate plant. At the same time, quality control personnel had to be sent for local training in LCC laboratories. The second stage involved the gradual recruitment of mainplant personnel up to the commissioning date, with special priority for the mechanical and electrical maintenance personnel to take part in erection and commissioning proceedings.

Laboratory studies for concrete-mixing design

These were essential for planning the production processes and for procuring the necessary concessions.

The previous drilling investigations had shown the most suitable aggregate resources to be in Magzaha (Gasr Guheish), where the aggregate-crushing plant had to be located. The top stratum in the area was composed of hard limestone, generally brownish in colour, whereas deeper quarrying would reveal soft limestone characterized by a white, chalky appearance.

A test programme was developed to determine the optimum percentages of various constituents in the composition of concrete. It aimed to:

(a) Determine the compressive strength of the aggregate, mixed to the required proportions specified by the block-machine suppliers;

(b) Determine optimum sand or at least acceptable sand proportions;

(c) Use actual block well water to determine if any reaction occurs.

The adviser organized the performance of these tests in LCC laboratories, supervised them and assessed the results.

It was concluded that the hard limestone gives stronger aggregate resistance with better concrete compressive strength. However, satisfactory results can be obtained through the use of both hard and soft limestone aggregate provided that the mixture is improved by the addition of sand. A higher fineness modulus allows the percentage of sand to be reduced, while giving better comprehensive strength and reducing the cost of the concrete components. More precise details of composition were then determined through practical experience in the production process and quality control data. These laboratory tests and larger scale industrial results were of great value in obtaining appropriate qualities and well-defined cost standards.

G. Souk-El-Khamis Cement Plant

The adviser was delegated on several occasions to Souk-El-Khamis General Company for Cement and Building Materials (SUMIS) to give technical assistance in solving problems that occured during the course of construction. The SUMIS project consists of a cement works with two production lines of 1,500 tons per day capacity each (equivalent to one million tons per year of normal Portland cement). The plant was entrusted to a consortium composed of KHD and B+B, and was to be erected on a turnkey basis on a site near Souk-El-Khamis town, about 60 kilometres south of Tripoli. The project is similar in layout characteristics and process design to the Hawari cement project. The most important questions tackled by the adviser are described below.

Planning for geological investigations

These were necessary to solve the raw material problem. In early prospecting work a quarry front was opened up in the southern part of the limestone deposit. This showed a different lithological profile of layers from what was expected. This part was checked by comprehensive investigations which showed a very complicated geological structure and much less limestone than expected.

Following advice given by the adviser and agreed in subsequent detailed discussions, the Polish consultant POLSERVICE was asked to carry out geological investigations throughout the whole deposit, and to provide comprehensive data for each section in respect of quality and quantity. The adviser co-operated closely in the various stages of pilot prospecting, detailed geological work, chemical analyses and physical tests of the cores of investigated boreholes, pilot tests of representative samples to determine mineralogical characteristics, and finally the proposed design for the new quarry front. In this way, a full survey of available raw materials in the neighbourhood was carried out and a clear picture of the availability of good quality limestone was obtained.

Proposal for raw-mix design

The adviser proposed a practical raw-mix design. The Polish consulting group POLSERVICE proceeded with detailed geological investigations in the quarry area. Drilling, trenching and digging of pits was carried out to try and discover exploitable raw materials sufficient for at least 50 years consumption at the original installed production capacity of the plant (one million tons per year of normal Portland cement). These investigations indicated that the composition of limestone in the area varies from one spot to another and that the exploitation of the limestone quarry would require careful selective quarrying to avoid any of the dolomitic stone which is strongly intercalated into the limestone strata in some of the regions.

The chemical composition of limestone from the investigated area and clay from the Bu Ghaylan clay quarries showed a silica ratio somewhat higher that the recommended level. This would require more intensive burning, involving higher calorific consumption and excessive wear upon the refractory lining of the rotary kilns. The high silica ratio tends to reduce the clinker coating in the burning zone and consequently shortens the lifetime of the exposed firebricks.

These phenomena called for correction of the raw-mix composition by the addition of proper proportions of ferric oxide and alumina, using iron ore and bauxite as additives for the reduction of the silica ratio. As SUMIS had difficulty in procuring the bauxite within the short time allowed by the schedule for putting the plant into operation, the adviser proposed a raw-mix design based upon correction with only iron ore as additive, using 81 per cent limestone, 17.1 per cent clay, and an iron ore component of 1.9 per cent ferric oxide. The resulting clinker was satisfactory in quality with a lime saturation factor (0.93) and an alumina modulus (1.00) in full compliance with the British Standard Specifications. The compound contents (C_3S = 61.60%, C_2S = 17.41%, C_3A = 4.03%, C_4AF = 12.68%) were within reasonable limits.

Negotiations with machine suppliers

During the erection of the plant, KHD proposed to use the tuff of the limestone quarry front instead of clay in the raw mix, although it would display different burning characteristics from the clay of Bu Ghaylan owing to different mineralogical composition.

A correction was recommended through addition of iron oxide (0.4-0.8% Fe_2O_3) to lower the relatively high silica ratio and alumina modulus. This raw-mix design reflected the situation at the existing quarry front which was subject to change as the work proceeded. KHD eliminated the limestone stratum of undesirable M_gO content, and the remaining accessible limestone then proved to be hardly sufficient for two years' production.

With respect to the remaining limestone reserves, KHD asked for additional check drillings to be made within the area previously investigated. Finally, KHD proposed mutual negotiations to modify the contract in the light of the new circumstances, with a revision of the price and time schedule. The adviser assisted in the negotiations, trying to avoid modifications which would cause extra expense and additional delay. He emphasized that long-term investigations should be made by extending the drilling work out into the neighbourhood, starting with the areas to the south of the cement quarry and in the plains. He added that reserves of raw materials should be assured for at least 25 years of production at the scheduled rate, plus 25 years more to provide for possible future extensions of the plant.

In the end the adviser recommended that the preparation of the new quarry front should continue as previously scheduled after correcting the method of quarrying to suit the actual dip of the limestone stratum. He established that it was unnecessary to make modifications involving additional machinery and time for a quarry front that could change within a few months or for reserves that might suffice for two years only according to the latest estimate. In this way, complications which had seemed to threaten a loss of money and time were eliminated.

Comparison of experiences with the Hawari project

As the Souk-El-Khamis project is quite similar to the Hawari cement works both in layout and in process design, both factories having the same suppliers, there was a good chance to compare experiences on the two sites. Visits were made on both sides and points of view discussed to the benefit of all parties concerned. The Souk-El-Khamis project was started at an earlier date and it was therefore always ahead in all stages of execution. Profiting by this, the delegates from Benghazi could advise the Souk-El-Khamis staff about necessary procedures and could draw their attention to various defects. On the other hand, many troubles which occured in Souk-El-Khamis could be avoided in Hawari. The adviser played the role of co-ordinator in this respect. He analysed the reports of delegates, decided on the appropriate action and gave the necessary advice.

H. Derna cement project

Assistance activities also included technical advice for the new cement project in the Green Mountain area. According to a decree issued by the Minister of Industry on 14 April 1976, the adviser was appointed a member of the committee to oversee this project. A major part of the technical advice was therefore entrusted to him in this connection. The adviser's main contributions were in the following fields:

Advice on geological investigations

In February 1974, The General National Organization for Industrialization (GNOI) contracted with the Swedish consulting firm UNICONSULT (Architects and Consulting Engineers) for studies on the establishment of a cement plant in the Marj/Derna region. The investigations indicated limestone deposits of ample quantity and quality in the main region of Marj and Derna. However the clay prospecting was not promising. Some areas were entirely under agricultural cultivation, while in others the clay was unsuitable for the project, being bedded in huge strata of dolomitic limestone, or not homogenous, containing percentages of undesirable ingredients such as magnesia, sulphate, alkalies and chlorides occuring irregularly at various levels which would be difficult to avoid. These investigations had not therefore disclosed any appreciable amount of accessible clay suitable for cement manufacture. Renewed investigations were then entrusted by GNOI to the Polish consulting firm POLSERVICE. Prospecting procedures were rationalized to use contractual meterage in the most fruitful manner. Advice was given by the project adviser during the various stages of geological prospecting work, surveying and topographic map-making, industrial tests and development of quarry design. In the end, ample raw material reserves were found, limestone at kilometre 19 on the Derna to Tobruk highway, and clay in the Masaliquon area, all sufficient for more than 50 years continuous operation at full production capacity of one million tons of normal Portland cement per year.

Rationalization of industrial project design

The adviser participated in technical studies for the industrial project design, taking into account local circumstances and the results of mineralogical tests on raw materials. Some examples of improvements incorporated in the design of the industrial project are given below:

(a) Clinker conveyors from the kilns, based upon two parallel lines with the possibility of flexible operation of one or the other line to transport the whole production during work on extensions;

(b) Facilities for manipulation of raw gypsum with a comprehensive system for crushing and conveying to the feeding devices of the cement mills and ample storage bins to provide against possible interruptions in the crushing process;

(c) Feeding devices for the raw and cement mills, provided in both cases with a supplementary hopper for additional material and with an installation for dosing the feed material. This represents a means of correcting the raw-mix composition in the first case and introducing mixed cements in the second case;

(d) The ground water reservoirs, pumping stations, industrial and sanitary water treatment plants and overhead portable water tank were all located in a central position so as to facilitate water connections, centralization of operational and maintenance activities and use of either untreated or drinking water as flexible alternative sources for fire fighting;

(e) An emergency power set was designed to maintain essential operations whenever the main electrical current is off. The emergency power was re-calculated so as to cover the requirements of lighting, water pumping, air compressors, clinker conveyors, slow drive for mills, and to serve one of the packing machines in case of exceptional need for urgent constructional repairs;

(f) The facilities for oil storage and transport were properly revised to include storage silos and a system of transport with tank lorries, taking into consideration various risks and possible bottlenecks.

Improvement of layout proposals

The adviser took part in planning work on the plant layout, which was well adapted to the chosen plant location. Among the points taken into consideration were the following:

(a) The designs for the raw material and clinker storage halls were carefully revised to meet operational requirements for continuity of production in emergency cases, especially during the rainy season;

(b) The fuel-filling station for the raw material trucks was shifted to the area adjacent to the service station, thus eliminating various traffic risks;

(c) Various stores for spare parts and implements were assembled in a central storage area for easier organization and administration. An exception was made for inflammable materials such as oils, greases, paints and the like, which were isolated from other activities for safety reasons;

(d) The position of the central control panel was scrutinized in respect of all relevant factors, especially cable connections to various sections, movement facilities to production units and the possibility of future extensions;

(e) The natural slopes and gradients of the contour lines were used to economize levelling work on the site. The natural slopes were used for easier flow of liquids and simpler drainage schemes were possible.

Technical support for official committee delegations

The project adviser was delegated to accompany the Libyan officials travelling to Warsaw and Cracow in Poland in the capacity of technical adviser in all discussions with the consultant or tenderers. He assisted the committee in reaching decisions, concluding agreements, drawing up protocols and technical reports, and in preparation of the documentation necessary at various stages of the proceedings.

Revision of tender documents

In collaboration with HMC, tender documents were revised in terms of project design, technical specifications and related drawings to put them in a final form for international bidding. The original proposal, submitted by the Polish group POLSERVICE, was thus amended as regards raw material studies, industrial project design, civil construction work, and general principles. The following were some of the revisions made:

(a) The main principles governing the general conditions of the contract were made clear and the procedure for acceptance tests included to avoid any future misunderstanding;

(b) Enlargement of production facilities: it was decided to increase the installed production capacity to 1,600 tons of clinker per day for each of the two rotary kilns, with consequent increases in production capacity for all other production units. The storage capacity was revised to ensure ample facilities for storing materials sufficient for the production of one million tons of cement per year. The amount of quarry equipment was recalculated on the basis of ten hours work a day;

(c) Type of machinery and equipment: it was decided to specify types of machinery and equipment in neutral terms and not to specify machines from any particular supplier. It was also decided to reconsider the location of the raw material storage hall so as to be able to reclaim materials in the most efficient way by a front scraper;

(d) Hoppers for raw materials: the design of the raw mill hoppers was revised to avoid complicated engineering work. The hoppers were to be provided with control devices for indicating the level of contents and with an effective means of preventing clay sticking to the sides;

(e) Homogenization and storage silos: the batch type was selected. The number of silos was increased to two homogenization and two storage silos for each of the two production lines;

(f) Rotary kilns: the feeding system was shifted to the ground level in the heat exchange tower for easier control, maintenance, and cleaning. It was decided to cool the clinker by planetary tube coolers for simpler operation and reduction of interruptions;

(g) Technical specifications: specifications were made for an automatic sampler for raw materials, electrostatic precipitators, cooling towers, mill gears, fans, and compressors. Agreement was reached about the magnitude of the ellipticity for the kiln circumference and axial movement of the kilns;

(h) Clinker storage: it was agreed to store the clinker in roofed storage with a flat bottom. Clinker was to be extracted through vibrators leading to two steel pan conveyors, to be installed in two underground channels equipped with a good ventilation system;

(i) Gypsum storage: this was adapted to the concrete hopper and was to have a storage capacity of at least four days requirements. It was provided with a special anti-sticking outlet opening and a laminated apron belt;

(j) Cement grinding and transport: the open circuit cement grinding system was selected for simpler operation and maintenance. Clear specifications were given for minimum drive load, efficiency of ventilation, and internal water cooling. It was decided to transport the grinding product to the cement silo through an inclined rubber belt conveyor;

(k) Heavy fuel oil: the fuel-oil storage capacity was fixed at two steel tanks of 10,000 tons total volume, this being sufficient for one month's consumption at the maximum production rate. Provision was made for delivery of fuel oil by boats or tank lorries and for the possibility of future pipeline installation. The fuel tanks were to be provided with special security precautions including an internal fire extinguisher (foam generator) and external cooling by water sprays;

(l) Water installation: it was decided to provide the water supply pumps with an automatic control system for co-ordinating the sequence of pumping operations with the static water levels and the contents of the reception reservoir. Sterilization of drinking water was to be carried out by ultra-viclet rays and a chlorine injection system provided as standby;

(m) Completion of information and specifications: basic principles were clarified concerning civil engineering information with special reference to soil mechanics, design criteria, concrete specifications, reinforcement of steel and minimum storage capacities;

(n) General layout: suggestions were made for the rearrangement of the general layout plan, aiming at the proximity of various units, economy in conveyor length, and taking the possibility of future extensions into consideration;

(o) Cement silo design: it was decided to reduce the amount of construction work by cutting the number of cement silos to four and making them less high but larger in diameter. They were to be provided with cement extraction systems constructed overground so as to avoid difficulties caused by water leakage and cement spillage.

Participation in finalization of tenders

The adviser participated in discussions on the evaluation of bids and in official negotiations with the successful tenderers. Due to the confidential nature of this stage, no information can be given at this time.

III. PERFORMANCE OF THE HAWARI CEMENT PLANT DURING 1978

The UNIDO technical assistance project has been directly linked to the activities of the Hawari cement plant. The team of specialists was first sent out at the time of commissioning and acceptance tests. The date of the provisional take-over (27 August 1978) was the starting point for full participation by the team of specialists and the transition point at which responsibility for running the factory was transferred from the suppliers' commissioning group to LCC personnel supported by the UNIDO team. The performance of the Hawari cement plant during the year 1978 gives an indication of the success of the UNIDO team.

The Hawari cement project was an extension to the Libyan Cement Company. The contract (1/75), signed with KHD Industrieanlagen AG on 18 January 1975, provided for the construction of a cement factory with a yearly production capacity of 1 million tons of normal Portland cement in a turnkey transaction worth DM 271,447,443 (= Libyan Dinars 32,619,839). The contractual period was 39 months from 21 March 1975 (the date of coming into force of the contract) to 20 March 1978 (scheduled date of readiness for acceptance tests).

In the end, 27 August 1978 was considered as the date of provisional take-over and the actual take-over operation was therefore confined to the last four months of the year from 1 September 1978. The preceding part of the year was considered as a breaking-in period subject to testing and adjustment of machinery and equipment. In the following sections, the performance of each production unit is analysed. Production data is given in statistical form in annex III. All these comments and production statistics were drawn up in Arabic by the adviser and were submitted to LCC.

A. Raw materials section

The raw materials section is the link connecting the Hawari cement works to the quarries supplying limestone and clay to the Benghazi and Hawari cement works and to the lime factory. The section consists of two crushers:

(a) The limestone crusher, hammer type, double rotor, capacity 450 tons per hour of limestone of 80 mm maximum size. With moisture not exceeding 7 per cent, power consumption 560 kilowatts;

(b) The clay crusher, double-teethed rollers, capacity 150 tons per hour of clay of 25 mm maximum size. With moisture not exceeding 12 per cent, power consumption 120 kilowatts.

This is a critical stage as there is only one crusher for limestone and one for clay. Consequently, long stoppages for either of the crushers would mean a stoppage for both production lines after the stock in the raw material storage hall, which is destined to cover only short stoppages, has been used up. Repeated long stoppages did occur due to breakage of the grate bars of the limestone crusher, which was attributed to the composition of the alloy being too stiff. A new set of bars was put in but they were again broken. The whole question is under further consideration. The performance of the clay crusher has been satisfactory, except for the central greasing device which was repaired during the correction of faults before the final take-over.

Both crushers were functioning throughout the year as they were the first units to be commissioned and the first to pass the acceptance tests. The limestone crusher produced 399,782 tons of crushed limestone during 1,203.1 hours operation with an average rate of 332.3 tons per hour, which is 26.2 per cent less than the designed capacity. This was due to the transport facilities having to be co-ordinated between the raw material requirements of the two factories.

The clay crusher produced 185,411 tons of crushed clay during 1,127.3 hours with an average production of 164.4 tons per hour, exceeding the installed capacity by 9.6 per cent due to the friable nature of the quarried clay. The lack of explosives was the most important obstacle to crushing activities. On some occasions, an insufficiency of explosives caused a complete standstill. However this situation was only temporary, being a natural consequence of the new arrangements foı :·orage in accordance with safety regulations.

B. Raw-mix grinding section

This section consists of two raw mills grinding limestone and clay in the proportions of 67 to 33%, designed in tandem system by KHD. The installed production capacity for each mill is 110 tons per hour of raw mix at a fineness of 7 per cent residue on a No. 170 B.S. (British Standard) sieve, with an energy consumption of 27.2 kilowatt hours per ton of production.

The raw-mix production for the section was 517,693 tons. The commissioning period started in January 1978, when the grinding commenced with a partial load which was gradually increased to 90 per cent of the designed grinding capacity, at which stage the acceptance tests were performed (August 1978). The last four months of the year (September-December 1978), the mills were under independent operation and the production of the raw-mix grinding section amounted to 208,132 tons, with an average capacity of 127.7 tons per hour and an average energy consumption of 14 kilowatt hours per ton.

Raw Mill I was first commissioned during January and February 1978 but it was stopped during March and April and most of May 1978 for corrections and adjustments by the suppliers. The acceptance tests ended in the provisional take-over in August 1978. The maximum production was attained during September 1978 right after take-over, when the mill produced 48,696 tons of raw mix during 365 working hours in this month. During the 4 operational months to the end of 1978, a total of 122,519 tons was produced during 901.3 hours, with an average production rate of 135.9 tons per hour, which was 23.5 per cent in excess of the guarantee figures.

Raw Mill II was first commissioned during February 1978. The maximum production was achieved during June 1978 during the acceptance tests when it produced 61,960 tons of raw mix in 459 working hours. The raw mix produced during the last 4 months of the year amounted to 85,613 tons in 727.6 hours with an average capacity of 117.6 tons per hour which exceeded the installed capacity by 16 per cent.

The raw-mix grinding section encountered some difficulties due to faults emerging during the provisional take-over. These are supposed to be corrected during the year of guarantee up to 27 August 1979. The most important faults were:

(a) The echo-lot in the raw material storage hall was not functioning, thus complicating the operation of depositing or withdrawing materials and necessitating closer supervision, which added to the problem of shortage of personnel;

(b) The automatic function of the clay scraper was out of order with the same consequence as above;

(c) The electronic cards for the raw mill weigh-feeders were burnt. The adjustment of raw material feed thus became quite complicated;

(d) There was an incorrect suspension of electrodes in the electrostatic dust precipitators. Electrodes therefore often dropped and disconnected the electrofilter functions;

(e) Damage occured to sensitive parts in the high-pressure water pumps of the conditioning towers, which were therefore out of order.

Natural factors also contributed to our difficulties in the form of moisture either as rain or existing naturally in the clay quarries. Consequently, the clay hoppers were often blocked. In addition, the clay hoppers were provided with openings which did not make access to the sticking clay easy. All the above-mentioned inconveniences represent faults that will be removed by the suppliers before the final take-over.

C. Clinker-burning section

This stage is considered as the most crucial step in cement production. All other processes and units are dependent on its productivity, and storage is planned to secure regular clinker burning and avoid interruptions through repairs or marketing difficulties. This section is composed of two rotary kilns with a production capacity of 1,500 tons per day (i.e. 62.5 tons per hour) of Portland cement clinker. They have a heat-energy consumption of 840 calories per kilogramme of clinker (using fuel oil of 9,800 calories per kilogramme specific heat) while bypassing up to 10 per cent of flue gasses.

Clinker production during the year 1978

The commissioning of the kilns started during February 1978. This was followed by several stoppages for both kilns to make contractual modifications and repairs. The total clinker production during the year 1978 amounted to 304,081 tons of which 138,749 tons were produced during the period of effective operation after the provisional take-over, at a rate of 63.5 tons per hour, which exceeded the guaranteed production capacity by 1.6 per cent.

Kiln No. I was commissioned during February 1978. It was then stopped during March, April, and the major part of May. It resumed production in June but was again stopped during July for further improvements by the suppliers. Finally it came into regular operation and acceptance tests were made during August 1978. The production of Kiln No. I over the year amounted to 122,937 tons, of which 82,911 tons were produced during the period of effective operation in the last four months (September-December 1978), with an average capacity of 63.7 tons per hour, which exceeds the guaranteed figures by 1.9 per cent. Kiln No. 1 attained its maximum production of 30,813 tons in 488.2 working hours during September 1978, rignt after the provisional take-over.

Kiln No. II started its commissioning procedure in March 1978. It attained its maximum clinker production of 38,591 tons in 531 hours during April 1978. After the provisional take-over, it produced 55,838 tons during the last 4 months of the year. The average output amounted to 63.1 tons per hour, which exceeds the installed production capacity by 1 per cent. Kiln No. II produced a total of 181, 144 tons during the year.

The production figures involved a fuel-oil consumption of 44,203,646 litres, indicating an average consumption of 131 kilogrammes of fuel oil per ton of clinker, equivalent to a heat energy consumption of 1,256 calories per kilogramme of clinker. The apparent consumption of fuel oil exceeds the actual consumption because it was worked out on the basis of issues of fuel oil of which the accuracy is diminished by the following facts:

(a) Weighing procedures were not adopted and the suppliers relied upon volumetric methods using counters subject to thermal expansion errors;

(b) The supplies for the Benghazi and Hawari works were not clearly differentiated. Consequently, the consumption figures were not always fairly distributed between the two projects.

The following examples demonstrate the most important defects which have to be corrected within the contractual year of guarantee:

(a) In the heat exchangers, the exhaust ventilator was out of order due to defective fan, motor and resistance;

(b) Overflowing took place from the daily fuel service tank, which necessitated several adjustments by the sub-contractor's specialist;

(c) Instrumentation for the heat-carrying oil caused a series of difficulties until the necessary interlocking and control implements were introduced;

(d) The flaps for the clinker-dust outlets showed faults in their automatic function and excessive dust in the plant hindered maintenance and cleaning work;

(e) The clinker storage hall still had a considerable portion of dead stock which required additional manipulation, and additional doors had to be opened for easier handling.

In general, there was considerable damage indirectly caused by the frequent stoppages. These numerous stops and starts caused the spalling (splintering) of refractory bricks and led to further lengthy stoppages for relining because of the premature wear of refractory materials.

D. Cement-grinding section

This consists of two cement mills, each producing 90 tons per hour of normal Portland cement with a specific surface area of 3,000 square centimetres per gramme and a power consumption of 46 kilowatt hours per ton. Total cement production amounted to 267,208 tons of cement for the year 1978 within a total of 2,871.5 working hours. The average capacity was 93 tons per hour, a surplus of 3.3 per cent over the installed capacity. The two cement mills were commissioned during March 1978 with a partial load of grinding media that was gradually increased to 90 per cent of the total load, at which stage the mills attained the guaranteed capacity. After take-over, the production amounted to 97,589 tons for cement mill I and 60,962 tons for cement mill II.

Cement Mill I produced 144,555 tons over the year, with an average of 93 tons per hour which exceeded the installed capacity by 3.3 per cent. The cement ground by this mill represents 54 per cent of the total cement production. It attained its maximum production of 39,111 tons during December 1978.

Cement Mill II produced 122,663 tons over the year representing 46 per cent of the total cement production. The maximum production was 30,162 tons ground during 258.5 working hours in August 1978 during the period of acceptance tests.

Among the obstacles which hindered cement grinding during the year 1978 were the following:

(a) Weight-feeders suffered from damage to the rubber belts of the feeders as a result of clinker and gypsum pressure. This necessitated the introduction of needle valves for the regulation of material flow;

(b) Electrodes in the electrostatic precipitators were poorly fixed, leading to their falling out and consequent disconnection of the electrofilter.

Moreover, a series of difficulties occurred in gypsum storage and its transport to the hoppers of the cement mills. The sticky gypsum did not flow from the limited gypsum storage except with continuous manipulation by a loader over all three shifts. Cement mills were often stopped due to shortage of gypsum. A new system has been proposed for solving the problem in the long run.

E. Packing section

Figures for these statements have been compiled on the basis of daily production reports which were adjusted according to the findings of the inventory committee's stock-taking checks at the end of every month.

The cement-packing section was first commissioned during April 1978. Cement packing and despatch was then continued up to the performance of the acceptance tests and provisional take-over during August 1978. Cement despatch during the year amounted to 259,907.9 tons, of which 36,617.9 tons were despatched in bulk, equivalent to 14 per cent of the total cement despatch. During the last 4 months of effective operation, 151,590.5 tons of cement were despatched with an average of 30,318 tons per month. This amount includes 135,510 tons packed in paper bags, representing 89.4 per cent, plus 16,080.5 tons in bulk, representing 10.6 per cent of the total cement despatch during the period (see annex III - Cement packing and despatch).

The commissioning started with varying rates due to adjustments and training of personnel.

After the provisional take-over, the packing and despatch of cement proceeded well until reaching its maximum of 46,838.7 tons during December 1978, despite the drop in cement transport facilities during the last quarter of the year.

The most serious defects in this section were:

(a) A serious breakdown took place in the main gearboxes which transfer horizontal motive force to the vertical plane, as a result of which some packing machines were out of order during considerable periods of time until the electrical design of the starting mechanism was modified;

(b) The cement stock was air-set in the cement silos. Its extraction was therefore difficult and the packing and despatch processes were hampered. Several explanations for this were posited: (i) that moisture had developed from the newly-cast concrete; (ii) that water crystals were liberated from the raw gypsum as a result of excessive cement temperature; or (iii) that there was an abundance of tricalcium aluminate (C_3A) in the cement composition. In any case, the cement silos were successively out of order for manual emptying and cleaning, after which the finished cement was stored only up to a limited height in the cement silos, pending a solution of the problem by the contractor;

(c) The chutes for directing the cement bags needed a lot of correction and readjustment. A considerable percentage of bags were torn until the chutes were put into good order.

F. Marketing problems

Cement production depends on the size of local demand for it. The capacity of the works to store unmarketed cement has been reduced by the factors described in the last section. Cement storage has to be kept down to reduce problems of extraction, and clinker storage is also limited. At the same time, the demand for cement dropped all over the area and specially in the west of the country, apparently due to the following factors:

(a) Great quantities of cement were imported, using import permits issued for procurement of special cements. The local market was therefore inundated with imported cement, especially in the western areas;

(b) There was a shortage of some essential building materials naturally used in conjunction with cement, such as reinforcement steel, on which all reinforced concrete construction depends;

(c) Transport costs were too high which upset the economics of cement sales to distant areas.

In the later part of the year, there was a specially noticeable drop in demand for bulk cement which was probably due to the fact that major construction projects had reached an advanced stage at which they no longer had any appreciable cement requirements.

G. Main bottlenecks

In addition to the problems described so far, which hampered the activities of the various production sections, the production process in general met with other difficulties, the most appreciable of which were the following:

Loss of trained personnel and recruitment problems

As the project is a new one, the bulk of the labour force is also new and mainly drawn from local resources. Considerable effort goes into their training to familiarize them with the special working techniques. Many of these technical personnel then leave the works after full training. New people are brought in and trained with the same result and this is very disruptive to the production process and raises costs.

Proper planning is made very difficult by the insecure labour situation which is mainly due to:

(a) The acute demand for technical personnel;

(b) The limited choice in personnel because of the obvious shortage in available labour;

(c) The different wages offered by various firms;

(d) The ineffectiveness of positive and negative incentives. The threat of dismissal is no longer effective as there are many other available employment opportunities;

(e) Military service has national priority. It is difficult to find replacements for experienced technical personnel who are called to the armed forces;

(f) Sick leave and injury leave have been progressively increasing until they have reached a proportion exceeding normal levels, despite great efforts to provide hygienic care and industrial security;

(g) There is a shortage of technical graduates. The industry's requirements for university graduates and the specializations needed are made public every year, but the available number of graduates does not meet the growing requirements of the rapidly developing industrial projects;

(h) There is also difficulty in employing foreign technical personnel. The best people are not normally released from their existing employment. Language barriers and accomodation difficulties are also obstacles to recruitment from abroad.

LCC is using every possible means to train local personnel, either in on-the-job training, or through scholarships in European suppliers' works, so as to create sufficient national expertise to compensate for present shortages and to fill vacant posts.

Defects

During the commissioning and acceptance tests, various defects were noted in machinery and equipment in all production sections. During the procedures for take-over, the defects were evaluated. Adequate guarantees were sought to cover the completion of necessary repairs and corrections within the contractual year of guarantee up to the date for final take-over. It goes without saying that the production process has been hampered by these defects and by the stoppages necessary for adjustments and repairs.

Shortage of spare parts

The supply contract stipulates that the suppliers are responsible for providing the works with the spare parts needed for two years production at full operating capacity. However, there were great difficulties in the choice of appropriate spares for the initial stock. Furthermore, there was a considerable delay in supplying and delivering the required spares to their appropriate storage bins. More complications were caused by delayed replacement of missing spare parts, either because they were in short supply, or because some parts were required at short notice during the commissioning and acceptance tests. The question of spare parts has been the main obstacle to production and maintenance work.

Incomplete technical documentation

The scheduled procedure for technical documentation was not carried out either in terms of completeness or of timing. There has always been a lack of instruction manuals and technical drawings, especially on the electrical side. This was especially serious in instrumentation and control, where the sophistication of interlocking devices undoubtedly requires quite comprehensive technical references. The lack of documentation added to the other difficulties.

Shortage in some materials and equipment

The purchasing section has been having difficulty in procuring some local materials. An example was oxy-acetylene gas which was insufficient for the needs of the workshop. During the last few months, the gas was brought in from Tripoli but this involved transport delays and extra expense.

Other examples were simple spare parts, tools, bolts, steel sections and implements for the workshop machines. As a consequence, some operations were delayed and others were modified to suit the local circumstances.

Failure of electrical current

On several occasions, the electrical current failed, either through an unannounced cut, or through a drop in voltage. These failures caused partial or total stoppage of production units. In addition to the production loss during the electricity cut, an interval of time is normally needed to overcome any disruptions and restore the original levels of productivity. Moreover, the frequent interruptions in kiln operation reduce the lifetime of the refractory lining due to excessive spalling of firebricks as a results of consecutive cooling and heating.

Interruption of the operation of electrofilters

Whenever there are irregularities in kiln operation resulting in the production of carbon monoxide gas, the respective electrostatic dust precipitator is automatically disconnected to avoid explosions which might occur from the oxidation of carbon monoxide across electrical discharge. As soon as an electrostatic dust precipitator is out of action, the affected production unit is stopped for reasons of environmental protection. This entails a consequent loss of production.

IV. EXPANSION OF THE TECHNICAL ASSISTANCE PROJECT

As the Libyan authorities were entirely satisfied with the performance of the technical assistance personnel and had complete confidence in the project, they submitted a new request for the expansion of project personnel to 100 experts, to be financed under a trust fund arrangement. As the project personnel involved in this expansion were to be assigned to the project through a reimbursible loan agreement with the Polish consulting firm POLSERVICE, a tripartite meeting was held on 6 July 1979 at UNIDO headquarters in Vienna at which representatives of UNIDO, LCC and POLSERVICE agreed on the principles of the expansion and drew up a schedule for the recruitment programme. A protocol was drawn up in which it was agreed to bring the present team up to 40 experts and to recruit an additional group to form an integrated team of 100 experts. It was further agreed to extend the technical assistance project for one year, starting from the date on which the new and extended personnel took up their assignments.

New man/month rates were agreed for the one year extension. It was emphasized that the provision for housing and local transportation already made by LCC will be extended to the new group of specialists attached to the project.

The recruitment was accomplished in accordance with the proposed schedule. The project extension is being effected in compliance with the stipulations of the trust fund agreement between the concerned authorities of the Libyan Arab Jamahiriya and UNIDO, and according to the job descriptions prepared by the adviser.

V. RECOMMENDATIONS

Based upon experience gained during the project activities, a series of recommendations was made in the progress reports submitted by the adviser. A considerable proportion of these recommendations have already been implemented, but the following recommendations should still be considered:

1. In view of the magnitude of the industrial development, it is essential to ensure sufficient national technical personnel by promotion of training facilities. A team of UNIDO experts is recommended as trainers to support the work of the training and managerial development centre. It would be preferable to begin with Arabic-speaking experts to overcome the problem of language until some linguistic progress is achieved. Meanwhile LCC might make use of technical training aids, industrial information services, research and documentary facilities arranged by UNIDO.

2. The available gypsum reserves are sufficient for only 10 years cement production, whereas at least 25 years' reserves should be assured. Detailed investigations of additional gypsum sources are necessary. Ample supplies of gypsum should be ensured to meet the requirements of the existing cement works and the planned Derna cement project. It is recommended that complementary geological research into additional gypsum reserves in the area should be continued, and that the latest investigations in the Sedra area should be studied.

3. The quarrying of gypsum should be co-ordinated between the Hawa-El-Barag and Ragma deposits. The former should be quarried during the dry season, whereas the latter is also accessible during the rainy season. The two quarries combined will give a convenient supply until further gypsum resources are available.

4. Gypsum should be transported on an experimental scale from any western gypsum deposits which may emerge from recent investigations. Providing the costs of extraction and transport are economic, it would be advantageous to depend mainly upon the western gypsum resources and keep the nearby gypsum deposits as safeguards against emergencies when the flow of gypsum supply from the west is interrupted for any reason.

5. The principles of preventive maintenance, drawn up by the UNIDO mechanical engineering experts, should be implemented. Preventive maintenance particulars should be tabulated in a simplified comprehensive schedule. A group of maintenance personnel with well-defined responsibilities should be selected for

every group of machinery. These personnel would be responsible for the timing of periodic inspections, revision, checking, routine maintenance and general overhauling, and would keep special records for man hours per operation and average lifetime of wearing parts.

6. Systematic ordering of spare parts should be adopted for all the industrial projects of the complex. Ordering and maintenance of minimum stocks should be based initially on an experienced engineering evaluation. Revisions should be made every year according to practical needs and statistical data from the maintenance registers.

7. Special care should be given to the daily production figures. The tabulation of information in long sheets should be complemented by statistical measures of productivity and rates of electrical and heat consumption. Results should be carefully analysed and the daily reports regularly submitted to the responsible departments, with irregularities distinctly underlined. Copies of the daily data should also be sent to the cost-accounting section in which the figures should be compared with projected targets. Discrepancies are thus analysed and prompt information sent back to the responsible technical personnel so that problems can be dealt with.

8. In view of the surplus cement-grinding capacity, it is recommended that masonry cement be produced after a detailed investigation has been made to determine the suitability of local raw materials for the purpose. Before the product is incorporated into the local code of practice, a comprehensive study should be made on standards of quality, which must also be negotiated with national research centres and approved by the authorities concerned.

9. It is strongly recommended that periodic meetings should be kept up as these are essential for organization of production and maintenance procedures among different sections, and for co-ordination of duties and responsibilities between personnel of various kinds, national staff, contractual technical assistants, and UNIDO project personnel.

Annex I

NAMES AND FUNCTIONS OF PROJECT COUNTERPARTS

Libyan Cement Company

Ali El-Gheriani	Secretary of People's Committee and General Director, LCC
Ali Fathi	Manager for cement and lime plants
Mohamed Berruin	Commercial Manager
Mohamed El-Neihoum	Financial Manager
Ali Mukraz	Manager for organization and training
Fadil Musrati	Manager for public relations
Rostom Lofti	Organization and training adviser
Abdelhakam Gamal El-Din	Legal adviser
Muftah Ben Zablah	Chief of raw materials department
Saad Haikal	Chief of mechanical department
Abdel Latif Goma	Chief of electrical department
Hussein Feitouri	Chief of transport department
Mustapha Tueima	Chief of mechanical maintenance
Ezz El-Din Abdul Rahman	Chief of electrical maintenance
Sobhi Moh. Saleh	Chief of shift laboratory and physical tests
Idris Digawi	Chief of stores
Belgasem Azouz	Chief of purchases
Mustafa Ben Hemeid	Chief of accounts
Mohamed Zayed	Chief of costing
Ismail Azouz	Chief of auditors
Ahmed El-Drisi	Chief of personnel
Fathi El-Dalah	Chief of transport
Abubaker Saltani	Chief of process department, Benghazi
Ahmed Abu Setta	Chief of mills, Benghazi
Malek Eleyan	Chief of instrumentation, Benghazi
Saad El-Sherif	Chief of instrumentation, Hawari
Amin Abu-El-Rish	Chief of mechanical maintenance, Hawari
Saleh Shaker	Chief of mills and kilns, Hawari
Wahbi Abd El-Samad	Manager of lime plant
Khalifa El-Ubeidi	Manager of ceramic and cement-blocks works
El-Mabrouk El-Turki	Manager of paper-bags factory
Abd El Razeg El-Ghazali	Resident engineer of Derna project
Gad Alla El-Shelwi	Resident engineer of Derna project

Annex II

DEVELOPMENT OF PROJECT PERSONNEL

Job No.	Post title and specialization	Initially requested	Actually recrui-ted	Contract extended	Resident at site	Present require-ment
		Number of persons				
11.06	Shift leader	4	4	4	3	4
11.07	Control-panel operator	6	4	4	2	4
11.08	Miller	4	4	4	3	4
11.09	Burner (cement)	4	4	3	1	6
11.10	Foreman (mech. maint.)	4	4	2	2	2
11.11	Fitter (maint.)	15	13	8	7	9
11.12	Compressor mechanic	1	1	1	-	-
11.13	Foreman (mech. w/shop)	1	1	-	-	-
11.14	Operator (w/shop machines)	1	1	1	1	1
11.15	Plumber	1	-	-	-	-
11.16	Shift electrician	8	8	6	5	15
11.17	Instrumentation specialist	3	3	4	3	13
11.18	Quality controller	1	-	-	-	-
11.19	X-ray specialist	1	1	-	-	1
	Raw materials engineer					1
	Mechanical engineer					5
	Sheet metal fitter					6
	Welder					4
	Workshop fitter					3
	Maint. electrical engineer					1
	Instrumentation engineer					1
	Foreman (electr. maint.)					2
	Foreman (instrumentation)					1
	Electrician (workshop and light)					5
	High tension electrician					2
	Diesel mechanic					2
	Benzine mechanic					1
	Electrician (quarry equip.)					1
	Mason (refractory lining)					2
	Burner (lime)					4
	Total	54	48	37	27	100

Annex III

PRODUCTION STATISTICS FOR HAWARI CEMENT PLANT 1973

3.4.1 Raw materials section

	L.S. CRUSHER				CLAY CRUSHER			
	Time H/min	Trips Nr.	Load t/l	Output tn	Time H/min	Trips Nr.	Load t/l	Output tn
I. COMMISSIONING :								
JANUARY	18.10	1514	23	34836	56.20	450	23	10337
FEBRUARY	16.40	180	23	4146	6.50	43	23	1003
MARCH	27.05	288	23	6624	23.15	240	23	5514
APRIL	114.50	1593	23	36653	93.45	748	23	17202
MAY	120.35	1514	23	34829	140.15	1066	23	24515
JUNE	166.30	2362	23	54328	247.45	1790	23	41162
JULY	118.30	1587	23	36509	60.30	437	23	10067
AUGUST	102.30	1048	23	24111	91.15	492	20	9847
SUBTOTAL :	684.50	10086	23	232036	719.55	5266	22.7	119647
II. OPERATION :								
SEPTEMBER	143.50	1997	23	45946	131.20	1205	20	24102
OCTOBER	158.45	2308	23	53100	55.30	411	20	8223
NOVEMBER	105.35	1435	23	32893	128.00	939	20	18702
DECEMBER	110.10	1556	23	35807	92.45	733	20	14657
SUBTOTAL :	518.20	7296	23	167746	407.35	3288	20	65764
T O T A L	1203.10	17382	23	399782	1127.30	8554	21.7	185411

8.4.2 RAW MILL Nr. 1.

	Time H/min	L.S. tn.	Clay tn.	R.Mix. tn.	Prod. t/h.	Power KwH	Economy. KwH/t	Power Kw.
I. COMM.:								
JANUARY	51.35	2835	1553	4388	85.1	52070	11.9	1009
FEBRUARY	98.25	6329	3560	9889	100.5	139790	14.1	1420
MARCH	-	-	-	-	-	-	-	-
APRIL	-	-	-	-	-	-	-	-
MAY	29.25	2084	1088	3172	107.8	52270	16.5	1777
JUNE	312.50	28667	15234	43901	140.3	516150	11.8	1650
JULY	57.20	4173	2027	6200	107.5	105490	17.0	1840
AUGUST	164.05	14886	6973	21859	133.2	306830	14.0	1870
SUBTOTAL :	713.40	58974	30435	89409	125.3	1172600	13.1	1643
II. OPERATION:								
SEPTEMBER	365.10	34087	14609	48696	133.3	682890	14.0	1870
OCTOBER	39.15	3710	1590	5300	135.0	68295	12.9	1740
NOVEMBER	280.25	27289	11751	39040	139.2	513220	13.1	1830
DECEMBER	216.40	20638	8845	29483	136.1	400820	13.6	1850
SUBTOTAL :	901.30	85724	36795	122519	135.9	1665225	13.6	1847
T O T A L :	1615	144698	67230	211928	131.2	2837825	13.4	1757

3.4.3 Raw Mill Nr. 2

	Time H/min	L.S. tn.	Clay tn.	R. Mix tn.	Prod. t/h.	Power KwH	Econo-my. KwH/t	Power Kw.
I. COMM.:								
JANUARY	-	-	-	-	-	-	-	-
FEBRUARY	19.50	744	401	1145	57.7	20130	17.6	1015
MARCH	311.35	19847	10876	30723	98.6	420590	13.7	1350
APRIL	395.10	31056	17319	48315	122.4	588820	12.2	1490
MAY	351.55	31288	17753	49041	139.3	545490	11.1	1550
JUNE	459.00	39964	21996	61960	135.0	720620	11.6	1570
JULY	74.25	7480	3837	11317	152.0	131030	11.6	1760
AUGUST	134.55	12243	5348	17591	130.4	236130	13.4	1750
SUBTOTAL :	1746.50	142622	77530	220152	126.0	2662810	12.1	1524
II. OPERATION:								
SEPTEMBER	199.00	16723	7167	23890	120.0	332340	13.9	1670
OCTOBER	260.00	22837	9787	32624	125.5	439400	13.7	1690
NOVEMBER	112.35	88565	3738	12625	112.1	200340	19.5	1779
DECEMBER	156.20	11565	4909	16474	105.4	282960	17.2	1810
SUBTOTAL :	727.55	59962	25651	85613	117.6	1255040	14.7	1724
T O T A L :	2474.45	202584	103181	305765	123.5	3917850	12.8	1583

8.4.4 Total Production for Raw Grinding Section.

	Time H/min	L.S. tn.	Clay tn.	R.Mix tn.	Prod. t/h	Power KwH	Economy KwH/t	Power Kw
I. COMM. :								
JANUARY	51.35	2825	1553	4388	85.1	52070	11.9	1009
FEBRUARY	118.15	7073	3961	11034	93.3	159920	14.5	1359
MARCH	311.35	19847	10876	30723	98.6	420590	13.7	1350
APRIL	395.10	31056	17319	48375	122.4	588820	12.2	1490
MAY	381.20	33372	18841	52213	137.1	597760	11.5	1567
JUNE	771.50	68631	37230	105861	137.2	1236770	11.7	1602
JULY	131.45	11653	5864	17517	133.0	236520	13.5	1795
AUGUST	299.00	27129	12321	38450	132.0	542960	13.8	1816
SUBTOTAL :	2460.30	201596	107965	309561	125.8	3835410	12.4	1559
II. OPERATION:								
SEPTEMBER	564.10	50810	21776	72586	128.6	1015230	14.0	1799
OCTOBER	299.15	26547	11377	37924	126.7	507695	13.4	1396
NOVEMBER	393.00	36126	15539	51665	131.5	713560	13.8	1815
DECEMBER	373.00	32203	13754	45937	123.2	683780	14.9	1833
SUBTOTAL :	1629.25	145636	62446	208132	127.7	2920265	14.0	1792
TOTAL :	4089.55	347232	170411	517693	126.7	6755675	13.0	1651

3.4.5. Kiln Nr. 1

	Time H/min	R. Mix tn.	Clinker tn.	Prod. t/h	Mazout lt.	Fuel cons. %	Ht.cons. Kal/Kg
I. COMM. :							
JANUARY	–	–	–	–	–	–	–
FEBRUARY	59.40	6184	3710	62.2	662.634	16.1	1543
MARCH	–	–	–	–	–	–	–
APRIL	–	–	–	–	–	–	–
MAY	53.25	5281	3169	59.3	588213	16.1	1604
JUNE	193.10	20469	12289	63.5	174529	12.5	1199
JULY	–	–	–	–	–	–	–
AUGUST	332.45	34777	20866	62.7	3015486	13.0	1248
SUBTOTAL :	639.00	66711	40026	62.6	5970812	13.4	1288
II. OPERATION :							
SEPTEMBER	488.15	51355	30813	63.1	4541118	12.2	1273
OCTOBER	79.10	8116	4870	61.5	682681	12.6	1211
NOVEMBER	439.55	47140	28284	64.3	3965786	12.6	1211
DECEMBER	293.35	31547	18944	64.5	2710645	12.8	1236
SUBTOTAL :	1300.55	138185	82911	63.7	11900230	12.9	1240
T O T A L :	1939.55	204896	122937	64.9	17871092	13.1	1256

8.4.6. Kiln Nr. 2

	Time H/min	R.Mix tn	Clinker tn	Prod. t/h	Mazout lt	Fuel cons. %	Ht. cons. Kal/Kg
I. COMM. :							
JANUARY	-	-	-	-	-	-	-
FEBRUARY	-	-	-	-	-	-	-
MARCH	318.25	28327	16996	53.4	3020055	15.9	1535
APRIL	531.00	64319	38591	52.7	6173497	14.4	1383
MAY	403.20	57153	34291	85.0	5117543	14.4	1383
JUNE	101.20	13336	8001	79.0	1139644	12.8	1228
JULY	232.45	38470	17083	73.4	2248083	11.8	1133
AUGUST	164.30	17240	10344	62.9	1431338	12.7	1190
SUBTOTAL :	1751.20	208845	125306	71.5	19135160	13.7	1315
II. OPERATION:							
SEPTEMBER	175.00	18418	11052	63.2	1424555	11.6	1114
OCTOBER	322.00	35696	21419	66.5	2760923	11.6	1114
NOVEMBER	177.50	18651	11188	63.0	1442192	11.6	1104
DECEMBER	209.10	20297	12179	58.2	1569724	11.5	1104
SUBTOTAL :	884.20	93032	55838	63.1	7197394	11.6	1113
T O T A L :	2635.20	301907	181144	68.7	26332554	13.1	1256

8.4.7. Total Production for kilns section.

	Time H/min	R. Mix tn	Clinker tn	Prod. t/h	Mazout lt.	Fuel cons. %	Ht.cons Kal/Kg
I. COMM.:							
JANUARY	-	-	-	-	-	-	-
FEBRUARY	59.40	6184	3710	62.2	662634	16.1	1543
MARCH	318.25	28327	16996	53.4	3020055	15.9	1535
APRIL	531.00	64319	38591	72.7	6178497	14.4	1383
MAY	456.45	62434	37460	82.0	5705756	13.7	1316
JUNE	294.30	33805	20282	68.9	2844173	12.6	1211
JULY	232.45	28470	17083	73.4	2248083	11.8	1137
AUGUST	497.15	52017	31210	62.8	4446824	12.8	1231
SUBTOTAL :	2390.20	275556	165332	69.2	25106022	13.7	1315
II. OPERATION:							
SEPTEMBER	663.15	69773	41865	63.1	5965673	12.8	1231
OCTOBER	401.10	43812	26289	65.5	3443604	11.8	1131
NOVEMBER	617.45	65791	39472	63.9	5407978	12.3	1184
DECEMBER	502.45	51871	31123	61.9	4280369	12.4	1188
SUBTOTAL :	2184.55	231247	138749	63.5	19097624	12.4	1189
TOTAL :	4575.15	506803	304081	66.5	44203646	13.1	1256

8.4.8 Cement Mill Nr. 1

	Time H/min	Clinker tn	Gyps. tn	Cement tn	Power KwH	Output t/h	Economy. KwH/t	Power Kw
I. COMM.:								
JANUARY	–	–	–	–	–	–	–	–
FEBRUARY	–	–	–	–	–	–	–	–
MARCH	31.20	1702	146	1848	18150	59.0	36.9	2175
APRIL	187.45	13820	1176	15016	437680	80.0	29.1	2331
MAY	191.20	18036	1547	19583	443500	102.3	22.6	2318
JUNE	5.20	691	59	750	14250	140.6	19.0	2672
JULY	27.30	2299	197	2496	72040	90.8	28.9	2620
AUGUST	72.30	6688	574	7262	200310	100.4	27.6	2771
SUBTOTAL	515.45	43246	3699	46955	1235930	91.0	26.3	2396
II. OPERATION:								
SEPTEMBER	169.30	13078	1122	14200	491220	83.7	34.6	2898
OCTOBER	247.15	24245	1986	26231	817840	106.1	31.2	2308
NOVEMBER	196.35	16621	1426	18047	563110	91.8	31.2	2865
DECEMBER	425.25	35934	3177	39111	1214770	91.9	31.1	2856
SUBTOTAL :	1038.45	89878	7711	97589	3086940	93.9	31.6	2972
TOTAL :	1554.30	133135	11420	144555	4322870	93.0	29.9	2780

3.4.9. Cement Mill Nr. 2

	Time H/min	Clinker tn	Gyps. tn	Cement tn	Power KwH	Output t/h	Economy. KwH/t	Power Kw
I. COMM. :								
JANUARY	-	-	-	-	-	-	-	-
FEBRUARY	-	-	-	-	-	-	-	-
MARCH	18.10	1085	93	1178	37750	63.0	32.0	2030
APRIL	44.25	2804	240	3044	125200	69.0	41.1	2819
MAY	247.30	22649	1943	24592	757900	99.3	30.8	3063
JUNE	4.55	546	47	593	11390	122.2	19.2	2348
JULY	21.20	2212	190	2402	53980	122.6	22.4	3530
AUGUST	258.45	27779	2383	30162	736320	116.6	24.4	2846
SUBTOTAL :	595.05	57075	4896	61971	1722540	103.5	27.8	2891
II. OPERATION:								
SEPTEMBER	245.25	18906	1622	20528	724470	83.6	35.3	2952
OCTOBER	106.45	9085	744	9829	215490	72.1	21.9	2019
NOVEMBER	161.35	14941	1282	16223	481590	100.4	29.7	2981
DECEMBER	208.25	12966	1146	14112	619270	67.7	43.8	2971
SUBTOTAL :	722.10	55898	4794	60692	2040820	84.0	33.6	2826
TOTAL :	1317.15	112962	9690	122653	3763360	93.1	30.7	2858

8.4.10 Total production of cement grinding section

	Time H/min	Clinker tn	Gyps. tn	Cement tn	Power KwH	Output t/h	Economy. KwH/t	Power Kw
I. COMM.:								
JANUARY	-	-	-	-	-	-	-	-
FEBRUARY	-	-	-	-	-	-	-	-
MARCH	49.30	2787	239	3026	105900	61.1	35.0	2139
APRIL	232.10	16634	1426	18060	562880	77.6	31.2	5420
MAY	438.50	40685	3490	44175	1201400	100.6	27.2	2738
JUNE	10.15	1237	106	1343	25640	131.0	19.1	2501
JULY	48.50	4511	387	4898	126020	100.3	25.7	2581
AUGUST	331.15	34467	2957	37424	936630	112.9	25.0	2828
SUBTOTAL :	1110.50	100321	8605	108926	2958470	98.1	27.1	2663
II. OPERATION:								
SEPTEMBER	414.55	31984	2744	34728	1215690	83.7	35.0	2930
OCTOBER	354.00	33330	2730	36060	103330	101.9	28.7	2919
NOVEMBER	358.10	31562	2708	34270	1044700	95.7	30.5	2917
DECEMBER	633.50	48901	4323	53224	1834040	84.0	34.5	2895
SUBTOTAL :	1760.55	145777	12505	158282	5127760	89.8	32.4	2912
TOTAL :	2871.45	246098	21110	267208	8086230	93.0	30.3	2816

8.4.11 Cement Packing & Despatch section.

	DESPATCHED CEMENT			PAPER BAGS		
	Packed tn	Bulk tn	Total tn	Packed Nr.	Torn Nr.	Total Nr.
I. COMM. :						
JANUARY	–	–	–	–	–	–
FEBRUARY	–	–	–	–	–	–
MARCH	–	–	–	–	–	–
APRIL	6070.0	–	6070.000	121400		
MAY	19535.0	2133.740	21668.740	397 800	5 100	392 900
JUNE	128305.0	3877.600	32182600	568 800	18 200	587 000
JULY	13170.0	6223.460	19393.460	227 730	17 000	244 730
AUGUST	20700.0	8302.600	29002.600	414 000		
SUBTOTAL :	87780.0	20537.400	108317.400	1755600		
II. OPER.:						
SEPTEMBER	26507.5	5470.900	31978.400	530150		
OCTOBER	34502.5	4432.880	38935.380	690050		
NOVEMBER	30882.5	2955.600	33838.100	617650		
DECEMBER	43617.5	3221.160	46838.660	872350		
SUBTOTAL :	135510.0	16080.540	151590.540	2710200		
TOTAL :	223290.0	36617.940	259907.940	4465800	344450	4810250