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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
VIENNA

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# THE CEMENT INDUSTRY

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PROSPECTIVE ENGINEERING SECTION (PES)
71, avenue Louis-Casaï
1216 - Geneva

February 1971

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# THE CEMENT INDUSTRY

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# SUMMARY



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# G L O S S A R Y

## OF TECHNICAL TERMS

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## A B B R E V I A T I O N S

# GLOSSARY

## OF TECHNICAL TERMS

AIR CLASSIFIER : An apparatus which is used for the separation of raw material and cement into different particle ranges during the grinding process.

AIR QUENCHING : Rapid cooling of clinker by means of large quantities of air.

AUTOGENOUS GRINDING : A grinding process in which material is ground against material, without the help of grinding balls.

BENEFICIATION : Improvement of the chemical or physical properties of a raw material or intermediate product by the removal of undesirable components or impurities.

CALORIE : A unit of heat : (1) the amount of heat required to raise the temperature of one gram of water 1 deg. C. in food and fuel values (heat consumption in kiln) : (2) the amount of heat required to raise the temperature of one kilogram of water 1 deg. C. (called a "large" calorie, being 1000 times the "small" calorie).

CAPACITY : (1) Rated or garantied—The production capacity of equipment predicted or garantied by the supplier, based on its dimensions and the characteristics of materials to be processed. Annual rated capacity of kilns and entire plants usually determined as total production during three continuous months, of uninterupted operation divided by the number of days, multiplied by 330. (2) Actual—The annual production attainable under normal operating conditions.

CHAIN SYSTEM : Metallic or ceramic chains suspended in the upper section (feed end) of a rotary kiln, serving for the heat exchange from the gases to the material.

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CLINKER : Fused product of a raw material of calculated chemical composition.

COMMINUTE : To reduce to fine powder, pulverize, triturate with the help of crushers and/or grinding mills.

CONCRETE : Mixture of cement with aggregates such as sand, and gravel, crushed stone and water.

COUNTER STREAM SYSTEM : Vertical arrangement of successive cyclones serving for the heat exchange between the raw meal and the gases flowing in opposite directions.

CRUSHER : Machine used fore reduction of raw materials from quarry to millfeed size.

CYCLONE : Conical vessel for separation of dust from gases or materials from grinding circuits by centrifugal action.

EXPANSIVE CEMENT : Special type of cement exhibiting expanding properties, contrary to the shrinking characteristics of standard cements.

FINISH ADDITIVES : Materials added to the clinker and cement during grinding such as gypsum, slag, fly ash.

FLAKING (OF CEMENT) : The result of concentrated adhesion between individual cement particles.

FLUO-SOLID REACTOR : Burning of materials in fluidized beds.

FLY ASH : Volatile non combustible parts of coal (and other fuels).

GRATE COOLER : A horizontal type of clinker cooling apparatus equiped with oscillating grates, provided with holes through which the cooling air is blown into and through the clinker bed.

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GRINDING AID : A material added to the slurry, raw materials or cement either during or after grinding, such as sulphates or other deflocculants.

HEAT EXCHANGER : See "Counter Stream System".

HOMOGENIZER (dry system) : Bin in which ground raw materials or cement raw meal are mixed and blended with the help of compressed air.

INTEGRATED PLANT : An integrated plant is a plant where the process machinery and equipments are grouped in such a way as to form a more or less continuous production chain, with the intermediate material storage facilities either kept to an absolute minimum or eliminated altogether.

KILN (Rotary) : Rotating equipment heated by various fuels and serving for drying, calcining and burning of raw materials into clinker.

KILN (Shaft) : Stationary vertical piece of equipment used for the same purpose as the rotary kiln.

MILL : Piece of rotating equipment serving for the grinding of raw materials.

MILL DRIVE : Equipment consisting of a combination of electrical motors and mechanical gear reduction units serving for the rotating of grinding mills.

MILL-LINERS : Steel plates of various forms and sizes mounted inside grinding mills; to protect mill shell against abrasion from cascading material loads and ball charges.

MIXER (wet system) : Tank in which ground raw material slurries are mixed and blended with compressed air paddles or rakes.

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<u>OIL WELL CEMENT</u> : Cement introduced under high pressure into shafts for sealing of water and gas pockets during the drilling of oil wells.

<u>PELLETIZATION (for clinkerization)</u> : The operation of forming raw meal into pellets (small balls) for feading into grate kilns.

<u>PELLETIZATION (for analyzing)</u> : The same operation for the purpose of chemical X-Ray analyzing.

<u>PLANETARY COOLER</u> : Cooler consisting of a number of refractory lined cylinders mounted around the shell at the discharge end of a rotary kiln.

<u>POZZOLANE</u> : Volcanic materials which react chemically with calcium hydroxide to form compounds having hydraulic properties.

<u>RAW ADDITIVES</u> : Materials added to the raw mix before or during grinding such as silica sand, slag, fly ash, bauxite.

<u>REFRACTORIES</u> : Thermal insulation for various equipments such as kilns, coolers and heat exchangers, consisting of refractory, high heat and abrasion resistant bricks or concrete.

<u>ROD MILL</u> : Grinding mill in which the grinding media consist of steel rods extending the full length of the mill.

<u>ROD PEB MILL</u> : Combination of Rod and Ball Mill. Material is preground in rod compartment with the finish grinding taking place in the second compartment filled with grinding balls.

<u>ROTARY PACKER</u> : Cement packing apparatus consisting of a system of filling spouts mounted onto a rotary device.

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SHALE : Mineral rock usually high in alumina, silica and iron oxide.

SIEVE (screen) : Oscillating or vibrating apparatus equiped with wire mesh for the purpose of classifying (screening) materials into various sizes or granulometric ranges.

SLAG : By-product from blast furnace iron and stell production-containing $SiO_2$, $Al_2O_3$, $Fe_2O_3$, CaO and used as raw or finish additive (see "Raw Additives" "Finish Additives").

SLURRY : Ground raw materials mixed with water.

SUSPENSION PREHEATER : See counter stream system.

WASH MILL : Rotating mill or tank equiped with rotating rakes serving for the purpose of mixing sticky and mostly clay type materials with water, separation of silica blocks (Silex) and other inert materials.

WRAP AROUND MOTOR : New type of variable speed synchronous mill drive motor whose rotor is mounted directyl onto the shell of a grinding mill.

# ABBREVIATIONS

| | |
|---|---|
| BTU | = British Thermal Unit |
| °C | = Degree Centigrade |
| CECA | = Communauté Européenne du Charbon et de l'Acier |
| CIF | = Cost, Insurance, Freight |
| cm | = Centimeters |
| DM | = German Mark (Federal Republic) |
| E.E.C. | = European Economic Community |
| EFTA | = European Free Trade Area |
| F. CFA | = Francs of the "Communauté Financière d'Afrique" |
| F.O.B. | = Free on Board |
| GNP | = Gross National Product |
| H.P. | = Horse Power (.736 Kw) |
| I.E.E.E. | = Institute of Electrical and Electronic Engineers |
| Kcal | = Kilocalorie |
| Kg | = Kilogram |
| Km | = Kilometer |
| Kw | = Kilowatt |
| Kwh | = Kilowatt/hour |
| Lbs | = Pounds (450 gr.) |
| m | = meter |
| m3 | = cubic meter |
| mm | = Millimeter |
| OEEC | = Organization for European Economic Co-operation |
| OECD | = Organization for Economic Co-operation and Development |
| t or T | = metric ton (1'000 kg) |
| Ton | = 1'000 kg |

# I N T R O D U C T I O N

# INTRODUCTION

The following report represents a study and surveys the techno-economic characteristics of the cement industry, specifically in relation to developing countries.

This study is based on practical experience in cement plants of various sizes, and engineering studies regarding the conception and installation of cement plants both in developed and in developing countries.

Pertinent information has also been gathered from data and statistical reports published by organizations such as the United Nations, the Organization for Economic Co-operation and Development and CEMBUREAU.

The purpose of the study is two-fold :

a) To analyse the state-of-the-art in cement technology, to recognize the trends which have emerged during the last decade and to determine the probable consequences, economic as well as financial, of the future of the cement industry for developing countries.

b) To present a concise picture of the present day cement industry on a world wide bases, with emphasis on the developing countries.

Part I describes the techno-economic characteristics of the industry in the light of recent developments and experiences.

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<u>Chapter I</u> deals with the general characteristics of the cement industry and briefly describes the wet and dry processes which are the systems mostly used throughout the world.

<u>Chapter II</u> deals with the determinants of cement consumption. It elaborates on volume and activity of the construction industry as well as the state of the technology which are paramount in determining the cement consumption. Further discribed are other factors influencing the current consumption in the developing countries such as :

- the cost and availability of cement
- the number of building contractors and qualified workmen
- the size and movement of the populations
- the state of the national economy.

Concluding from this chapter it is quite apparent that there exists a definite relationship between the GNP of a country and its cement consumption. Some of the methods applicable to forecast the cement consumption are also reviewed in this chapter.

<u>Chapter III</u> deals with the economics of the cement industry, it presents a brief review of the required capital investment, the inputs of the cement industry, the economies of scale and the breakeven point of cement plants under various conditions. It demonstrates that larger plants are less costly per ton of installed annual capacity and more efficient to operate than smaller ones.

<u>Chapter IV</u> deals with cement plants of different sizes for markets of various sizes.

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It analyses the existing possibilities for the manufacturing of clinker and cement in individual countries or on a multinational basis.

Part II describes in some detail the different aspects of recent development in the cement technology.

Chapter I deals briefly with the different types of cement and their chemistry, the methods of processing the raw materials and the finished products. It describes technical developments of process and handling methods. It also includes a general geological map indicating the limestone resources on a global basis.

It describes the consequences of automation and integration on the conception and operation of cement plants.

Chapter II deals with the impact of the recent industry developments on developing countries, the difficulties faced by these countries in term of manpower, transports and personnel training.

Chapter III describes the problems which might arise if the current trend in technological development is maintained. It contains some predictions as to how the cement plant of the future may look; its size, the type of process, etc.

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Part III describes cement production and consumption throughout the world and the trade among countries.

Chapter I contains estimations of the world industrial production since 1913. It points out that the growth rate of cement production does not follow the same pattern neither in the old industrialized countries, nor the newly developed countries, nor the developing countries. It presents some details regarding the major cement producing countries and describes the structure of their cement industry and the types of cement produced.

Chapter II concentrates on statistics concerning the cement production of the developing countries, for Africa, Asia, Latin America and South America. A brief review is made of the state of the cement industry in the various countries of these areas.

Chapter III deals with the cement consumption on a worldwide basis, its variation from one country to another and the expected future consumption. The consequences of this trend are analysed.

Chapter IV describes the trend of international trade, the share of the developed and the developing countries for clinker and cement. The movements of cement trade from the exporting to the importing countries are reviewed.

It contains conclusions as to the development of the future international cement market with regard to the predictable trends in cement production and consumption in the developed and in the developing countries.

# PART I

## CHARACTERISTICS OF THE CEMENT INDUSTRY

# CHAPTER I

## GENERAL CHARACTERISTICS

### SECTION 1 - GENERAL REMARKS

The cement industry can be characterized as a heavy industry, manufacturing a bulky and low priced product from raw materials available in most parts of the world. The production process is a relatively simple but highly mechanized one and depends upon large size machinery consuming considerable amounts of electrical energy and fuel.

Together with steel, aluminium, chemical products, plastics and paper, cement must be considered as one of the major industrial commodities of this age. Being universally used in all types of building and engineering works, cement plays an important role in every country's economy.

Demand for cement is constantly increasing; the following table shows the development of the world cement production since 1920 :

Table 1 : World cement production

| | |
|---|---|
| 1920 | 32'000'000 t |
| 1930 | 73'400'000 t |
| 1936 | 86'700'000 t |
| 1950 | 131'400'000 t |
| 1960 | 315'000'000 t |
| 1970 | 570'000'000 t (estimation) |
| Source : Cembureau* | |

* World Cement market in figures 1913-1966.

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On a "per capita" basis, the world consumption rose from 24 kg in 1920 to approximately 153 kg in 1970.

As a rule, cement is consumed within a rather small radius from the location where it is produced. This is mainly due to its relatively low market value compared with the cost of transportation; consequently the volume of international trade is relatively small and at present accounts for only 4% of the world production.

## SECTION 2 - TECHNOLOGICAL CHARACTERISTICS OF THE CEMENT INDUSTRY

### 1 - What is Portland Cement ?

Portland Cement is a grey powder primarily made of calculated proportions of lime, alumina, silica and iron. It cannot be utilized as such; in order to obtain what is generally known as "concrete", it has to be mixed with aggregates such as sand, gravel, crushed stone and water. During the hardening process, the cement acts as a binder between the aggregates and reinforcing structures such as iron bars, wire mesh, etc.

The most commonly manufactured type of cement is the multiple purpose Standard Grey Portland Cement, which represents about 90% of the world production.

Slight changes in the proportions of the cement composing elements or differences in fineness result in cements with special properties : sulfate resisting cement, low heat of hydration cement, white cement, high early strength cement, etc.

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In order to increase production capacity without expanding the kiln capacity of a plant, European manufacturers often grind cement clinker together with steel furnace slags, cinders, fly ash or pozzolanic materials. Due to their high sulphate resistance, these special types of cement are particularly suited for foundation and seaside works.

In order to satisfy the requirement of deep well conditions, the oil industry uses special, so called "oil well cements".

An aluminious cement (40% alumina) developed by an European manufacturer possesses some very special fast hardening and refractory properties.

In developed as well as in a growing number of developing countries, the chemical and physical properties of the various types of cement are subject to official or semi-official standards, which are recognized both by cement manufacturers and users.[1)]

2 - The process of manufacturing Portland Cement

The manufacturing of cement consists principally in mixing finely ground raw materials and additives (limestone, marls, clay, shales, slags, iron ore, bauxite, silica, sand) and in clinkerizing this dry or wet mixture in rotary kilns at temperatures of up to 1'450°C. After cooling,

1) Cembureau - The European Cement Association- has published in 1968 a booklet titled "Cement Standards of the World" which reviews the standards issued by 44 countries.

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the fused material, called clinker, is ground again together with a certain percentage of gypsum to a fineness of 85% to 90% passing a sieve with 100'000 openings per square inch. The resulting finished product is cement.

Two principal processes are presently used to make Portland Cement. They differ mainly in the way the raw materials are ground and mixed before being introduced into the kiln.

In the wet process, the raw materials are ground together with water resulting in a slurry with a moisture content of between 30 to 40%. Easy to blend and to homogenize, this slurry is introduced in a long slightly inclined rotary kiln. Advancing by the rotating action of the kiln, the raw material passes into the lower and hotter zones (burning zone) of the kiln, where it is clinkerized at temperatures of up to 1'450°C.

Until approximately 15 years ago, the wet process was almost universally used. Replacing the original shaft kiln operations, its introduction made it possible to produce, in a more continuous way, large quantities of cement of higher and more regular quality.

Because of the short supply of water and the high cost of fuel in many countries, it became necessary to develop more economical processes.

In the dry process, the raw materials are dried, ground and homogenized before being fed into the rotary kiln system, either in the form of raw meal or as a nodulized material (Lepol process).

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Rotary kilns serving for dry process clinkerization are either of the long and large diameter type as used in the wet process operation or of the heat exchanger type, which consists of a combination of a cyclone suspension preheater and a relatively short rotary kiln.

Not very long ago, the debate between dry process and wet process was still going strong.[1] While the dry process offers lower fuel costs, the wet process has the advantage of easier handling and blending of the ground raw mix.

Through the availability of better dry blending and handling techniques, the advantages attributed to the wet process have been minimized in favor of the dry system.[1]

The main disadvantage of the dry process suspension preheater operation is its sensitivity to raw materials with high alkali, chloride, sulphate and carbon content.

As indicated in the following Table 2, the dry process is getting more and more popular, especially in Europe.

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1) P.K. Melita "Trends in Technology of Cement Ma: acture" Rock Products, March, 1970.

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Table 2 : Types of kilns installed in the European countries members of the OECD (Organization for Economic Cooperation and Development)

| | Number of new rotary kilns installed in new and existing plants | | |
|---|---|---|---|
| | Wet process | Dry process | Total |
| 1959 | 11 | 16 | 27 |
| 1960 | 10 | 17 | 27 |
| 1968 | 4 | 23 | 27 |
| 1969 | 1 | 15 | 16 |

Source : The Cement Industry in Europe 1960
The Cement Industry 1969
(OECD - 2 rue André Pascal - Paris 16ème)

Mainly due to the lower fuel cost and the higher alkali content in the cement raw materials in many parts of the country, North American cement manufacturers have been reluctant to install dry process suspension preheater kilns. According to data from the OECD, out of 16 new kilns installed in the U.S.A. during 1968 and 1969, eleven of them were still of the wet process type.

3 - <u>Other cement making processes</u>

For the purpose of further improving product quality and in order to reduce capital investments, experiments with new types of clinkerization systems have been under way for many years.

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Materials with chemical compositions and properties similar to those of the classical cement raw materials, are available in the form of by-products from the chemical industry. This has lead to the construction of combined chemical and cement plants in the United Kingdom, in South America and in some Eastern European countries. Despite all these new developments, the basic principles of manufacturing cement are nevertheless the same as almost fifty years ago and no drastic changes are likely to be expected for a number of years.

# CHAPTER II

## THE DETERMINANTS OF CEMENT CONSUMPTION

Before investing in a new cement plant or expanding an existing one, it is important to analyze the size of the future market which it will serve.

It takes about three years between the time an investment decision has been taken and the time a cement plant is actually in operation. Therefore sales forecasts are to be established well in advance of the first delivery date of cement from the contemplated plant.

Cement requirements vary widely from one country to another; Table 3 indicates the per capita consumption of cement in a number of countries in 1969.

Past history and statistics should not be used as the only indicators of future trends in the market; cement consumptions are influenced by a number of reasons which, if known, may form the basis for a realistic approach towards a cement industry development program.

The most significant of the determinants of cement consumption are reviewed hereafter; indications are also given how to arrive at more or less accurate forecasts of cement consumption in a given market area.

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Table 3 : Cement consumption per capita in various countries in 1969 - in kilogrammes.

**EUROPE**

| | |
|---|---|
| Belgium | 455 |
| Denmark | 414 |
| Finland | 353 |
| France | 535 |
| W. Germany | 583 |
| E. Germany | 432 |
| Greece | 481 |
| Italy | 591 |
| Norway | 382 |
| Portugal | 209 |
| Spain | 490 |
| Switzerland | 726 |
| U.K. | 316 |
| Yugoslavia | 235 |
| Hungary | 278 |
| Rumania | 301 |

| | |
|---|---|
| **U.S.S.R.** | 364 |

**AFRICA**

| | |
|---|---|
| North Africa | 83 |
| Sudan | 10 |
| Ethiopia | 6 |
| Malagasy Rep. | 21 |
| Mozambique | 73 |
| Rep. of Sth. Africa | 259 |
| Nigeria | 11 |
| Senegal | 52 |
| Ivory Coast | 85 |
| Togo | 47 |
| Chad | 4 |
| Congo (People Rep) | 102 |
| Cameroun | 18 |
| Liberia | 87 |

**AMERICA**

| | |
|---|---|
| U.S.A. | 344 |
| Mexico | 140 |
| Nicaragua | 58 |
| Jamaica | 166 |
| Martinique | 299 |
| Cuba | 188 |
| Haiti | 13 |
| Venezuela | 229 |
| Brazil | 91 |
| Argentina | 194 |
| Chile | 142 |
| Peru | 75 |
| Colombia | 105 |

**A S I A**

| | |
|---|---|
| Syria | 161 |
| Lebanon | 353 |
| Yemen | 20 |
| Kuweit | 2.632 |
| Iraq | 114 |
| Iran | 58 |
| India | 25 |
| Pakistan | 31 |
| Thailand | 68 |
| Laos | 17 |
| Japan | 447 |
| Taiwan | 252 |

**OCEANIA**

| | |
|---|---|
| Australia | 356 |

Source : Cembureau - Statistical Review 1969/1968

## SECTION 1 - CAUSES AFFECTING CEMENT CONSUMPTION

### 1 - The volume and activity of the construction industry

Cement is almost exclusively consumed by the construction industry in the form of concrete or mortar. The activity of the industry, therefore, is very closely related to the volume of cement consumption.

In its report "The Cement Industry 1969", p. 10, the OECD presents a comparison between the increase in investments in construction and in the consumption of cement. This comparison is reproduced below (in a different form, but figures are unchanged) :

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Table 4 : Increase in investments in construction and in the estimated consumption of cement.

| % change | 1967/1966 | 1968/1967 | 1969/1968 |
|---|---|---|---|
| **Germany** | | | |
| 1. Estimated cost of construction started | - 10,0 | + 4,0 | - 10,0 |
| 2. Estimated consumption of cement | - 10,0 | + 6,0 | + 4,9 |
| **France** | | | |
| 1. Index of construction | + 3,2 | - 0,8 | + 5,4 |
| 2. Estimated consumption of cement | + 5,9 | + 3,8 | + 8,6 |
| **Italy** | | | |
| 1. Estimated cost of construction started | + 1,1 | + 44,4 | - 51,6 |
| 2. Estimated consumption of cement | + 17,5 | + 13,1 | (+ 6,0) |
| **United Kingdom** | | | |
| 1. Estimated cost of construction started | + 17,9 | - 5,1 | + 1,1 |
| 2. Estimated consumption of cement | + 5,4 | + 2,1 | - 3,6 |
| **Canada** | | | |
| 1. Estimated cost of construction started | + 9,4 | + 17,4 | + 2,5 |
| 2. Estimated consumption of cement | - 11,7 | + 7,8 | - 10,7 |
| **United States** | | | |
| 1. Estimated cost of construction started | + 6,5 | + 17,1 | + 8,4 |
| 2. Estimated consumption of cement | + 3,2 | + 7,0 | + 0,6 |
| **Japan** | | | |
| 1. Estimated cost of construction started | + 35,1 | + 28,9 | + 24,5 |
| 2. Estimated consumption of cement | + 11,9 | + 12,8 | (+ 8,0) |

Keeping in mind that the period during which the cost of construction is initiated does not exactly coincide with actual consumption of cement, the above set of figures show that the trend between the two is "generally similar".

Information regarding the consumption of cement by the main sectors of the construction industry is very scarce and hard to come by.

Most of the time, cement is not directly sold to the eventual users but to building supply dealers, concrete products or ready mixed concrete manufacturers. (See Table 5).

Table 5 : Distribution of cement sales.

| Percent of total | France[1] (1967) | Switzerland[2] (1969) | U.S.A.[3] (1968) |
|---|---|---|---|
| Building supplies dealers | 65 | 10,6 | 8,4 |
| Building contractors | 15 | 51,8 | 4,5 |
| Concrete product manufacturers | 13 | 9,6 | 13,0 |
| Ready mixed concrete manufacturers | 7 | 24,3 | 59,5 |
| Hydro-electric works | - | 3,7 | - |
| Highway contractors | - | - | 10,4 |
| Government agencies and miscellaneous | - | - | 4,2 |
| | 100 | 100,0 | 100,0 |

Source : 1. Ciments Lafarge - Paris - Annual report 1967
2. "Holderbank" - Glaris - Annual report 1969
3. Modern Concrete - March 1969

Surveys made by specialized firms, manufacturers' associations and governmental agencies in North America and in Europe present more or less accurate estimates of the distribution of cement consumption by the various end users in the developed countries.

Table 6 shows the results of some of these surveys.

It is interesting to note that the housing sector is the largest customer of the cement industry.

The pattern of cement consumption prevailing in the developing countries is very different from the one in North America or in Europe : the share of housing is less significant. This share, however, is due to increase as a result of the development of their respective economies and the wealth of their population.

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Table 6 : Cement industry end uses markets in various countries.

| Percentage of total use | France[1] | Sweden[2] | United Kingdom[3] | U.S.A.[4] | India[5] |
|---|---|---|---|---|---|
| Housing | 35 % | 52 % | 22 % | 20 % | 30 % |
| Industrial and commercial | 14 % | 15 % | 9 % | 19 % | 13 % |
| Agricultural | - | - | - | - | 10 % |
| Public buildings | 14 % | - | - | 15 % | 25 % |
| Other buildings | - | 10 % | 16 % | - | - |
| Public industrial | 7 % | - | - | - | - |
| Public works | - | - | - | 33 % | - |
| Municipal public works and transportation | 9 % | 15 % | - | - | - |
| Roads, highways, bridges | - | - | 7 % | - | - |
| Fuel and energy | - | - | 5 % | - | 6 % |
| Concrete products | - | - | 21 % | - | - |
| Maintenance and repairs | 21 % | - | - | - | - |
| Building supplies dealers | - | - | 12 % | - | - |
| Others | - | 8 % | 18 % | 13 % | 6 % |
| | 100 % | 100 % | 100 % | 100 % | 100 % |

Sources : 1. Ciments Lafarge - Paris - Annual report 1967

2. Ciments et Chaux - Syndicat National des Fabricants de chaux et ciment - Paris- June 1969

3. Survey of the British Cement Industry by Hoare & Co., London, quoted by Cembureau IG News Letter 14/1968. Réf. CDU 666.94 (410)

4. Rock Products - March 1969 - What lies in store for the cement industry in 1980, by Mr. Roy A. Grancher

5. Ciments et Chaux - op. cit. May 1969

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2 - The technology of the construction industry

Cement consumption is largely determined by the technology of the construction industry and the development of the application of concrete and concrete products. The state of the building technology and the local architectural traditions will greatly influence the use of certain building materials.

In the developed countries, there exists a strong competition among the many building materials which are offered on the market : cement and cement products, plaster, steel, wood, aluminium, glass, plastics.[1] According to areas and circumstances, the quantity of cement which is used for the same volume of construction, may vary considerably.

Technological developments are responsible for important advances in the cement consumption. They continuously open new fields to the application of concrete : large factory-built concrete elements (especially in Europe and in USSR), prestressed concrete elements, lightweight concrete, ready mixed concrete delivered by special trucks to the job sites, etc.

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1) See "Aspects of competition between steel and other materials" United Nations - ST/ECE/STEEL 17.

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As a whole, and this applies especially to developing countries, the more the construction industry advances technologically, the more cement will be consumed.

3 - The cost and availability of cement

The cost of cement sometimes reaches such levels as to discourage the prospective users. In some land-locked countries of Central Africa, cement is sold for as much as 60 to 80 dollars per ton. This cost increases considerably the cost of construction and the use of cement is consequently kept to a minimum; badly needed dwellings and social structures are often not built.

Furthermore, if a country has to depend upon imported cement, delays in transportation and difficulties in dock side rehandling often create periodic shortages, which may be further accentuated because of the lack of local means of transportation.

It must clearly be recognized that cost and availability are two major determinants for the consumption of cement in developing countries.

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4 - <u>The availability of well equipped building contractors and of skilled workmen</u>

This is normally not a problem in developed countries, although some of them depend on a large quota of foreign workers (Switzerland) in order to keep their construction industry going.

The proper use of cement requires the availability of building contractors who are equipped to handle the volume of construction at hand and of workers who are sufficiently skilled in the use and application of concrete and mortar.

The first problem may be solved in making it attractive to local or foreign firms (credit facilities, loans, reduced import duties on equipment) to engage in the contracting business; the establishment of state-owned building companies is another possibility which helps to animate the building construction industry.

The second problem must be resolved with the training of personnel. Because of the advantage it would bring to cement manufacturers and building contractors in developing countries, it should actually be their responsibility to train the people who will use their product.

5 - <u>The general state of the economy : the growth of the G.N.P. (Gross National Product) and of its components</u>

All the determinants of the cement consumption which have been examined above are more or less related to the general state of the economy. It can therefore be said that favorable or adverse conditions affecting the growth of the Gross National Product (GNP) of a country will similarly affect the consumption of cement.

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Experts and economists have tried to research the "elasticity" which exists between these two values[1] or between the Gross Formation of Fixed Capital and the cement consumption.

The O.E.C.D. publishes each year a graph showing the relation which exists in the O.E.C.D. countries between the Industrial Production Index and the Cement Production Index.

Most of the developing countries have elaborated social and economic development plans which fix the expected rate of growth of the G.N.P., the directions to be given to the agricultural production, the degree of industrialization to be reached, etc.

Followed, or not, these development plans are the main determinant of the potential cement consumption in these countries.

6 - <u>The population</u>

All other conditions being equal in two different countries, the one with the larger population will normally consume more cement. It seems obvious that the more populous country needs more houses, more schools, more industrial, social and administrative buildings and consequently more cement.

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1) See : OECD - The Cement Industry in Europe - 1960 - Annex : Forecasts of cement consumption in 1965 and also "Les investissements dans l'industrie des chaux et ciments" Université de Paris - 1965 - by J. Reynaud - p. 90 and following.

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It should be added that the movements and the age of the population have a great influence upon the consumption of cement.

This is particularly felt in these developing countries where the rate of urbanization is progressing at a faster and faster rate. In South America, in Africa, in Asia, millions of people are leaving their homes each year, to settle in cities located on the coast or in the capital city of their country. These people have to be housed and cared for.

Countries with a large number of young people (who today are getting married much sooner than in the past) can expect to see the demand for cement rise very fast as these young people get married and desire to build homes of their own.

## SECTION - ESTIMATING FUTURE CEMENT CONSUMPTION

This review of the determinants of the cement consumption gives an idea as to how the problem of cement market forecasting may be tackled.

Many methods can be used, but each one of them should only be considered as an approximate approach to the problem.

The estimations should be based on carefully selected data. The results should be compared carefully; all things being considered equally, it is suggested to retain the two most likely forecasts and to consider one of them as the "high" and the other one as the "low" estimate. It can be assumed that the future cement consumption will probably be found between the two figures.

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The most used forecasting methods in the cement industry are based on :

- projections from past trends
- international comparisons
- analysis of predictable evolution of the determinants of cement consumption
- analysis of the future needs of the end users.

1 - <u>Projections from past trends</u>

The simplest way to make an estimate of the cement consumption is to suppose that it will follow the same trend as in the past.

> "If the past growth has been steady and if the conditions that determine this growth may reasonably be expected to persist in the future, a trend curve may be projected over five to ten years into the future as a preliminary forecast". 1)

These curves should be interpreted with great prudence as they do not take into account changes which, especially in the developing countries, are able to result from actions taken by these countries to get out of their underdeveloped situation.

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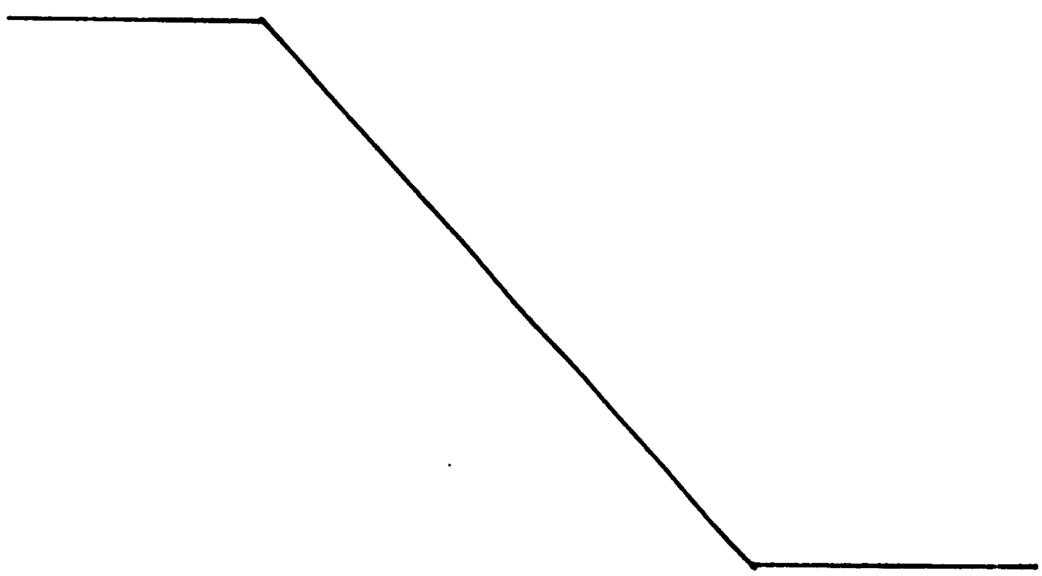
1) From "Business and economic statistics" by William A. Spurr, Lester S. Kellog, John H. Smith - 1961 - Richard D. Irwin, Inc., Homewood, Illinois - Chapter 18 - Secular trend - Graphic and mathematical methods of fitting a trend curve are also described and explained.

On the other hand, cement consumption in the developing countries is usually very small and is very sensitive to local variations of great magnitude.[1)]

2 - International comparisons

International or regional comparisons of cement consumption in areas of similar economical and geographical structures may give some interesting clues as to the direction the cement consumption will take in a given country.

This may take the form of a comparison of the cement consumption and of the GNP per inhabitant, as shown below for some African countries :



1) For instance, the building of a bridge or of a dam may represent half the normal cement consumption of a country during several years. When the job is completed, cement consumption will drop considerably.

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Table 7 : Comparison of cement consumption and GNP in African countries - per capita - in 1969.

| | Cement consumption in kgs per capita (1969) | GNP per capita in US $ 1) |
|---|---|---|
| Senegal | 52 | 170 |
| Gambia | 48 | 100 |
| Guinea | 10 | 90 |
| Sierra Leone | 20 | 150 |
| Liberia | 87 | 210 |
| Ivory Coast | 85 | 260 |
| Mali | 23 | 90 |
| Upper Volta | 7 | 50 |
| Chad | 4 | 60 |
| Togo | 47 | 100 |
| Dahomey | 30 | 80 |
| Ghana | 53 | 170 |
| Nigeria | 11 | 70 |
| Cameroun | 18 | 140 |
| Gabon | 89 | 310 |

A country in the US $ 60-100 range may not expect to exceed a cement consumption per capita of 10 to 50 kgs; its total cement consumption will only follow the increase of its population if its GNP per capita does not vary. Should an improvement in its economy become actual and bring its GNP per capita to the US $ 200.-- level or higher (following the discovery of mineral resources or a rise of the world prices of its produces), this country could expect to see its cement consumption per capita reach that of the countries (in the same area) with a similar GNP, i.e. more than 80 kilogs per inhabitant.

1) From "L'Express" - Weekly magazine - Paris - 1-7 February 1971 - p. 27.

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If on the other hand, the trend of the population growth is known, it is possible to obtain a reasonable forecast.

Cement consumption forecasts on the basis of international data have recently been made in comparing the "cumulated cement consumption" per capita of various countries. The idea behind this method is that cement should not be considered as a consumable good but as a durable good.[1)] This explains that in industrialized countries, having used large quantities of cement for long periods of time, the cement consumption per capita is relatively steady (as in the USA, Canada, United Kingdom). On the other hand, countries with no past history of large cement consumption may continue to hit high levels of consumption during many years to come as long as their "cumulated cement consumption" is not equal to that of the other countries.

The following examples are taken from a paper by Mr. Miguel Andia, Secretary of OFICEMEN (Association of the cement manufacturers of Spain) published by "Cemento-Hormigon" (see foot note) :

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1) See "Cemento - Hormigon" - Barcelona - May 1970 - No 434 "Cemento acumulado per capita" y "Cemento consumido por dolar de renta" en los paises europeos y en USA" by Mr. Miguel Andia - Secretary of OFICEMEN.

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Table 8 : Cumulated cement consumption per capita.

| | Cement consumption per capita in 1969 kgs | Cumulated cement consumption per capita - 1920-1969 - kgs |
|---|---|---|
| U S A | 342 | 7'900 |
| United Kingdom | 310 | 6'470 |
| Spain | 499 | 5'210 |
| E. and W. Germany | 532 | 8'710 |
| France | 534 | 7'590 |
| Italy | 584 | 7'270 |
| Greece | 484 | 4'610 |

These figures may lead to the conclusion that, in spite of their present high level of cement consumption, countries such as Greece and Spain may expect to see their cement market continue to grow while others like Germany, France, Italy, or the USA are likely to see their cement consumption level off.

3 - Determinants of cement consumption

If the future variations of the principal determinants of cement consumption may be forecast with some accuracy, it is possible to obtain reasonable estimates of the future cement consumption :

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a) In its report "The Cement Industry in Europe - 1960", the OEEC[1] made a study in order to "find a connection between the trend of the general economy and the demand for cement. It was found that such connections exist -although it may not be the same in all countries- and that, for the period 1950-1959, it can be expressed, for Member countries as a whole, as an almost constant ratio between the annual increase in the GNP and in cement consumption, this ratio corresponding to an elasticity rate of 1,81".

Working under this assumption the OEEC experts forecast, in 1960, a cement consumption of 84'500'000 tons in the Common market countries for 1965. The actual figure was 83'985'000 tons.[2]

This method which has proved to be very accurate in this specific case is however difficult to apply in the developing countries where statistical data and economic forecasts are not certain.

These difficulties appear when examining the results of the cement consumption forecasts made by the Economic Commission for Africa,[3] in 1965. According to

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1) OEEC = Organisation for European Economic Co-operation, now OECD (Organisation for Economic Co-operation and Development).

2) OECD - The Cement Industry 1965.

3) See "L'Industrie des Matériaux de Construction en Afrique : possibilités de développement à court terme". Réf. E/CN/14/AS/III/5 - 14 déc. 1963 - Commission économique pour l'Afrique - Colloque sur le développement industriel en Afrique - Le Caire - 27 Janv. - 10 Févr.1966.

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this source, the ratio between the cement consumption per capita and the GNP corresponds, in the various regions and sub-regions of Africa, to an elasticity rate of 1,80 to 2,60. Forecasts made following this method and compared with actual consumption figures (1969) in Africa show that this method is not always reliable.

b) If information is available, another method consists in correlating cement consumption with the volume of investments (Gross Formation of Fixed Capital) and with the share of construction expenditures which may be forecast.

c) Growth and movements of population are, if predictable, a basis for an estimate of future demands of cement.

Urbanization creates imperative needs for housing and municipal structures which must eventually be fulfilled. Calculations may be made of the volume of cement required to satisfy the basic needs of a family.

4 - Analysis of the future demand of end users

This method is based on surveys of the end users and on calculations of ratios determining the volume of cement required for the construction of the buildings, houses and structures which are contemplated.

This represents considerable work and is only possible in countries with very good statistical tools or in countries possessing complete and accurate development plans.

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These programs may assign very precise goals to the various sectors of the country's economy regarding housing, industrialization, highways, airports, ports, hospitals, schools, etc.

Valuable information may be gathered as far as future cement consumption is concerned, by adding, on the basis of estimates supplied by construction industry specialists, the volume of cement required by each of the sectors.

# CHAPTER III

## THE ECONOMICS OF THE CEMENT INDUSTRY

### SECTION 1 - THE CEMENT INDUSTRY REQUIRES HIGH CAPITAL INVESTMENTS

The average cement plant (especially in developed countries) is built for relatively high production rates. It handles large quantities of raw materials and finished products. Some of the largest and costliest machinery of the modern industry can be found in such plants.

In the most favorable case, the total investment cost for a single production line plant with an output of 3'000 to 3'500 tons of cement per day (1 to 1,2 millions of tons per year) amounts to between US $ 40 and US $ 45 per metric ton of installed yearly capacity. These prices apply to Europa as well as to North America.

The costs will likely increase to US $ 60 per ton for a 500'000 t/year capacity plant and up to US $ 85 for a 100'000 t/year capacity installation.

Some 30'000 and 50'000 t/year capacity plants which were built in developing countries are known to have cost in excess of US $ 200 per ton.

Table 9 indicates the actual investments which have been required for some recently built cement plants of various capacities in different parts of the world.

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The cost figures refer to published data or to estimates made by engineers on the basis of known elements.

All the costs are not exactly comparable as some investments include elaborate control systems, power plants, housing facilities, harbour installations, etc. and others not.

Table 9, however, is representative enough to give a general view of the present investment situation in the cement industry.

Costs which are more comparable and which are broken down by category, are presented in the next section.

Table 9 : Examples of investment costs.

| Country | Start-up year | Capacity/ year | Investment costs(US$) | COST PER TON INSTALLED (US $) |
|---|---|---|---|---|
| 1. Cameroun | 1970 | 26'000 T | 4'750'000 | 183 |
| 2. Niger | 1966 | 30'000 T | 6'800'000 | 226 |
| 3. Mali | 1970 | 50'000 T | 11'500'000 | 230 |
| 4. Qatar | 1970 | 100'000 T | 8'000'000 | 80 |
| 5. Congo Brazzaville | 1971 | 120'000 T | 8'900'000 | 74 |
| 6. Western Canada | 1970 | 200'000 T | 12'000'000 | 60 |
| 7. India | 1973 | 200'000 T | 11'050'000 | 55 |
| 8. Libya | 1970 | 200'000 T | 10'000'000 | 50 |
| 9. Algeria | 1972 | 500'000 T | 30'500'000 | 61 |
| 10. France | 1970 | 1'000'000 T | 42'000'000 | 42 |
| 11. Western Europe | 1971 | 1'400'000 T | 49'000'000 | 43 |

<u>Sources</u> : (The numbers correspond to the list of countries)

1. Industries et Travaux d'Outre Mer - Nov. 1967.
2. Readers' Digest - French Edition - "Usines clés en mains pour le Tiers Monde" after a paper of D. Deutschmann in the Winnipeg Free Press - (Investment cost includes power plant, housing facilities and numerous auxiliary services structures).
3. Office Suisse d'Expansion Commerciale -Fichier Industriel International- Lausanne (File 223-D0-001-Mali). A figure of Francs Mali 6'400'000'000 is indicated as investment for this plant - it includes a power plant of 2'500 kw/h (100 FM = US $ 0,18).
4. Cement lime and Gravel - January 1970/Office Suisse d'Expansion Commerciale. Fichier Industrie internationale (file 323-D0-001).
5. Industries et Travaux d'Outre Mer - Nov. 1967.
6. Cement Lime and Gravel - June 1970.
7. Office Suisse d'Expansion Commerciale. Fichier Industriel International. Lausanne (File 339-D0-003). Investment is estimated to be 85'000'000 Roupees).
8. Cement Lime and Gravel - June 1970 - Investment is announced to be Lib. L 3'200'000 (US $ 9 millions). This estimate has to be increased by at least 10% to reflect the final capital expenditure.
9. El Moudjahid - Algiers - 2 october 1969/Cement Lime and Gravel - February 1970.
10. Investment costs estimated by e gineers.
11. Investment costs estimated by engineers.

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A note of caution should be addressed to the potential investors regarding investment costs as published or predicted in the financial and technical press.

Such data are mostly furnished by equipment suppliers and often include only the costs of the mechanical and electrical equipements without any provisions for civil and environmental work, equipment erection, roads, rail and harbor facilities, material and equipment transportation costs and auxiliary service and administration buildings.

According to the figures listed in Table 2, a country planning to launch a cement industry of one million tons/year capacity will be required to invest (basis 1969/70)[1) ]:

- US $ 42 millions for a single plant of 1'000'000 t/y capacity
- US $ 61 millions for two plants of 500'000 t/y cap. each
- US $ 75 millions for five plants of 200'000 t/y cap. each

The criteria of choice between these solutions will be discussed at a later stage in this report.

Although the above figures might be considered high, the cement industry, as far as investments are concerned, figures favorably in comparison to other heavy industries such as steel.

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1) These figures are to be adjusted in taking into account the continuous devaluation of the money.

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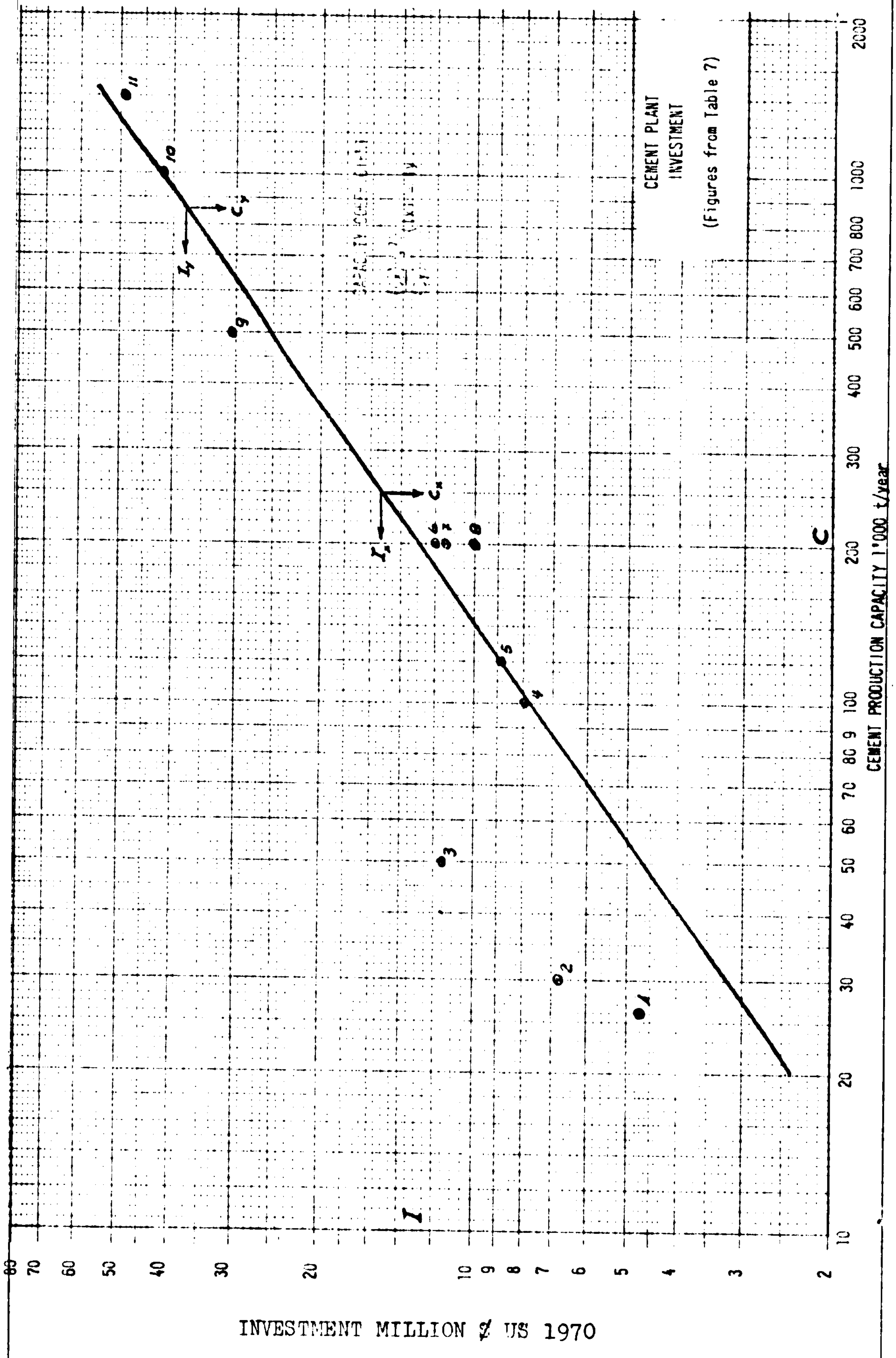
CEMENT PLANT
INVESTMENT
(Figures from Table 7)
CEMENT PRODUCTION CAPACITY 1'000 t/year
C
I
INVESTMENT MILLION $ US 1970

In the steel industry, "as a rule of thumb", it is generally assumed that an investment of US $ 300 per annual ton of crude steel capacity is required for an integrated plant of 1 million tons of annual output".[1)]

For a one million tons capacity plant, the ratio of investment cost per annual ton of production to the selling price, is 2/1 in the cement industry and 3/1 in the steel industry.

In the developed countries a ton of cement is sold for around US $ 20 FOB plant; the basic home price in the CECA countries of a ton of merchant bars (of steel) was US $ 100 [2)] at the beginning of 1969.

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1) Source : Aspects of competition between steel and other materials - United Nations, New-York - 1966 - ST/ECE/STEEL/17 - page 6.

See also : UNIDO Monograph on Industrial Development - ID/40/5 - Iron and Steel Industry - Table 2 - page 17.

2) Source : report on the Iron and Steel Industry in 1968 Table 38 - OECD - Paris.

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SECTION 2 - THE COMPONENTS OF THE FIXED INVESTMENT COST IN A CEMENT PLANT

If plant capacity is an important factor in the total investment required for a cement plant, it is, by far, not the only one.

Cement plants of the same size built at the same location and during the same period can vary considerably as to investment cost. This is often due to important differences in the raw materials to be processed, in the quality of the equipment chosen, the degree of process control automation and the general lay-out conception of the installations.

It also happens that the owner, in order to save foreign currency, may require extensive use of equipments and services of local manufacturers and contractors, even at the risk of higher investment costs.

In this section, the costs of the different items of cement plants of various capacities are reviewed. These costs are reflecting the price situation as it existed at the end of 1970.

Although the figures are drawn from offers made by equipment suppliers or by building contractors, they do not apply to any particular plant in actual operation or presently under construction.

In order to present a realistic picture of the relative importance of each category of capital expenditures, the cost for the various items have been averaged out.

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1 - Cement plants of 100'000 t/year capacity

Table 10 presents a cost distribution for a 300 t/day capacity (100'000 t/year), semi-automatic dry process plant built in a developing country. The figures for mechanical and electrical equipments were obtained from three different suppliers' proposals (averaged out).

The figures for the other items were obtained through engineering estimates.

Table 10 : Distribution of cost - 300 t/day cement plant

| | US $ (000 $) | % of total |
|---|---|---|
| a) Mechanical equipment | 2'600 | 30,5 |
| b) Electrical equipment | 450 | 5,3 |
| c) Spare parts | 300 | 3,5 |
| d) Insurance and transportation | 400 | 4,7 |
| e) Erection and start-up | 1'000 | 11,8 |
| f) Civil works | 3'000 | 35,3 |
| g) Others (including unforeseen) | 750 | 8,9 |
| | 8'500 | 100 |

Note 1 : According to actual experience, the cost of the mechanical and electrical equipment may vary as much as 10% from the figures quoted in Table 10.

The price of the mechanical items is closely related to their weight. For a 300 t/day capacity plant presently under study, the total weight of the equipment has been estimated at 2'400 tons.

Note 2 : In developing countries, the cost of civil works is generally high. However, the largest part of these expenditures is payable in local currency.

Note 3 : The costs for engineering studies amounting to approximately 10% of the total cost are included in the various items.

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2 - Large capacity, automated cement plants

Table 11 presents a cost distribution for two large and fully automated dry process plants. The figures are engineering estimates based on actual experiences in the construction of similar size (500'000 t and 1'000'000 t/year capacity) installations.

Table 11 : Distribution of cost for large capacity automated cement plants

| | 1.500 t/day | | 3.000 t/day | |
|---|---|---|---|---|
| | US$ (000) | % of total cost | US$ (000) | % of total cost |
| a) Mechanical equipment | 9.500 | 31,1 | 14.000 | 33,3 |
| b) Electrical equipment | 1.800 | 5,9 | 3.000 | 7,1 |
| c) Spare parts | 1.000 | 3,3 | 1.500 | 3,5 |
| d) Insurance and transportation | 900 | 2,9 | 1.000 | 2,4 |
| e) Erection and start-up | 2.600 | 8,5 | 3.400 | 8,1 |
| f) Civil works | 9.000 | 29,5 | 13.000 | 31,0 |
| g) Automation and instrumentation | 3.600 | 11,9 | 4.000 | 9,6 |
| h) Others incl. unfor. | 2.100 | 6,9 | 2.100 | 5,0 |
| | 30.500 | 100 | 42.000 | 100 |

Note 1 : The figures for the 3'000 tons/day plant (one million tons/year) apply to cement plants located in Europe. Due to higher cost for transportation, erection, civil construction and start-up, the cost for a similar plant would be higher in developing countries.

Note 2 : Costs for engineering studies amounting to between 6% and 8% of total costs, are included in the various items.

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3 - General remarks on the distribution of investment cost

Table 12 presents a grouping of the various cost items for the three plants analyzed in Tables 10 and 11.

Table 12 : Percentage of total cost

| Cost item | Annual capacity of the plant | | |
|---|---|---|---|
| | 100'000 t | 500'000 t | 1'000'000 t |
| Mechanical, electrical equipment and spare parts | 39,3 | 40,3 | 43,9 |
| Erection and start-up | 11,8 | 8,5 | 8,1 |
| Civil construction | 35,3 | 29,5 | 31,0 |
| Automation and instrumentation | - | 11,9 | 9,6 |
| Others | 13,6 | 9,8 | 7,4 |
| | 100 | 100 | 100 |

The figures in Table 12 clearly indicate that in all cases the costs for mechanical and electrical equipments do not exceed 45% of the total investment. However investors should not be misled by the relative low cost of this item. In order to obtain the true investment cost required for a plant, the equipment cost figures are to be multiplied with a factor of approximately 2,2 to 2,5.

Cost of automation is relatively high; automation of a cement plant generally does not result in a reduction of capital cost. The numerous benefits obtained from automation are of a different nature and are discussed in Part II of this report.

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SECTION 3 - THE INPUTS OF THE CEMENT INDUSTRY (COST OF MANUFACTURING)

The principal cost price elements of cement manufacturing are the following :

- Fuel : coal, oil, and natural gas are the principal fuels which are used in rotary kilns;
- Electricity : electricity is either purchased or generated in company owned power plants;
- Water : mixed with the raw materials in wet process plants; used for cooling of production machinery;
- Labor : engineers, technicians, workmen and laborers;
- Supplies : spare parts, grinding balls, crusher hammers, refractories, lubricants, bags;
- Raw materials : limestone, chalk, shale, clay; mostly deriving from company owned quarries;
- Additives : gypsum, bauxite, iron ore, silica, sand, slags, fly ash;
- Financial charges : depreciation, interest, insurances, general overhead and administration expenses.

Some of these costs fluctuate in accordance with the quantity of cement produced (fuel, energy, supplies,

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water, raw materials, direct labor); others are fix for whatever the output of the plant (indirect labor, financial charges, overhead expenses).

Under these conditions, the cost of cement manufacturing depends upon :

- the type of process which is used and which determines the fuel and energy rates;
- the degree of automation and integration of the process;
- the rate of utilization of the installed capacity;
- the installed capacity of the cement plant.

In order to arrive at the "technical cost" of cement manufacturing, the characteristics of the various cost components (variable and fixed expenses) will be reviewed.

Relations between the used rate of plant capacity, the size of the installations and the total cost of cement will be discussed in the Section 4 "Economies of scale in the cement industry".

1 - Fuel

The clinkerization of a kilo of clinker requires between 1'200 and 1'600 Kcal (Btu/Lbs)[1] in the wet process and between 750 and 1'000 Kcal (Btu/Lbs)[2] in the dry process.

The criteria of choice between the different types of fuel is their availability and their cost.

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1) = 1'200 and 1'600 Kcal/kg = 2'160 and 2'880 Btu/Lbs
2) = 750 and 1'000 Kcal/kg = 1'350 and 1'800 Btu/Lbs

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In India, for instance, "natural gas is not available and oil, approximately 10'000 Kcal/kg obtained from refineries which process largely imported oil, is 2½ to 3 times as expensive as coal. With only a few exceptions, therefore, the fuel is coal. India, incidentally, possesses the world's second largest coal reserve".[1)]

In Algeria, on the contrary, both oil and natural gas are available from local sources. Mainly, because it is easy to handle and does not require large storage installations, gas is used in all Algerian cement plants.

Countries with no local sources of fuels have to choose between imported oil or coal. In order to be suitable for burning in rotary kilns, coal is first to be ground and dried.

With proper precaution against internal combustion, coal may be stored on open stock piles. Despite the requirement for large storage facilities and relatively complex heating systems, fuel oil is easier to handle than coal. Many cement operators also maintain that oil firing results in higher kiln outputs. At present, the trend is toward oil and most of the new cement plants being built in the developing countries with no fuel resources of their own, are burning oil instead of coal.

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1) Rock Products - Feb. 1969 - Cement in a developing country by C.F. Clausen (page 76).

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As a defense against the unpredictable market and the frequent price fluctuations of the fuels, many cement manufacturers, when designing new plants or modifying their existing ones, provide equipments which allow the burning of different types of fuel.

2 - Electricity

The introduction of electricity more than 50 years ago, due to the flexibility of its distribution and its easy conversion into mechanical energy, did revolutionize the operational concept of industrial plants.

As a consequence of this electrification, the consumption of electrical energy in cement plant operation has increased considerably.

The typical modern cement plant of practically any size and under condition that clinkerization is done in rotary kilns will consume between 100 to 120 kWh per ton of cement produced.

Since there is no legitimate substitute for electrical energy in the operation of a cement plant such energy is either to be purchased from outside electric power sources or it is to be generated in power stations situated at the plant site.

The cost of power depends largely on the distance of transmission and in the case of non hydraulic generating stations also on the cost of fuel serving for the firing of the steam generators.

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It is generally demonstrated that in industrially developed and many developing countries, it is more economical for a cement plant to purchase electrical power rather than generate its own.

However, in the case of Venezuela where comparatively low cost natural gas and fuel oil are available, some cement plants are able to generate their own power at lower cost than they can purchase it from outside sources.

3 - Water

Water is required for raw mix preparation (wet process), cooling of equipment and for general cleaning and washing purposes.

The requirements depend on the type of production process employed in a particular plant :

- in a wet process operation, 0,7 to 1,0 m3 of water per ton of cement are necessary for raw mix preparation;

- in a semi-dry operation (Lepol or Shaft kilns), the raw material pelletizing process requires between 0,15 and 0,30 m3 of water per ton of cement.

For the cooling of equipments such as kiln roller bearings, grinding mill bearings, compressors, cement coolers, clinker cooler chutes, etc... only part of the water is wasted. In case of kiln shell spraying, the totality of the spraying water is wasted.

The water requirements for equipment cooling vary between 0,8 and 1,0 m3 per ton of cement (kiln shell spraying with 0,3 m3/t included).

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Through cooling and recirculation, these requirements can be reduced to between 0,1 and 0,35 m3 per ton of cement.

Water requirements for the cleaning of buildings and yards and for washing of the rolling stock (trucks, etc.) do not exceed 0,15 m3 per ton of cement.

Based on these figures, it is easily understandable why in areas with an accute water shortage, the application of the wet process must often be ruled out.

For raw material grinding only fresh water should be used. For the cooling of equipments, however, it is under certain conditions possible to use sea water.

4 - Labour

The introduction and the progress of mechanization has lead to the replacement of the muscular effort by a mechanical force. Mechanization did to a great extent eliminate work necessitating important physical efforts with all its limitations and did permit a considerable increase in production capacity.

The cement industry has traditionally measured its labour requirements in men hours per ton of cement produced (labour factor).

Less than 25 years ago, the average labour factor in the industry was approximately 2½ to 3 hours per ton.

Today, even medium size plants have reduced this factor to less than one hour per ton and some of the most

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recently completed installations of one million tons per year capacity operate with labour factors of less than ½ hour per ton of cement produced.

5 - Supplies and parts

This category groups production materials such as refractories, grinding balls, crusher hammers, mill-liners, kiln chains, etc...; maintenance materials such as spare parts, lubricants and other expendable materials; bags and pallets.

In order to assure the efficient and continuous operation of a plant, it is necessary to maintain right from the begining a sufficient stock of supplies and parts.

The importance of this stock of supplies and parts depends almost entirely on the delivery time of the materials and the frequency of their utilization.

Based on experience, it is established that the average plant located in an industrially developed country needs to keep a supply reserve of 12 to 18 months of operation for production and maintenance materials.

A six months reserve for lubricants and other expendable materials should be sufficient to cover all eventualities.

For plants located in developing countries, especially where long transportation by sea is involved, the reserves of supplies and parts are probably to be the double of the ones required for plants located in developed countries.

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It might be added that in recently completed projects, the initial cost for the production and maintenance material stock amounts to approximately 10% of the total investment for mechanical and electrical equipments.

6 - Raw materials

The principal raw materials used in the cement manufacturing process are limestone, chalk, oyster shell, shale and clay.

With the exception of oyster shell, which derives from offshore deposits, these raw materials are normally obtained from company owned quarries and deposits.

In most parts of the world, these materials are available in one form or another.

The quality of the cement is essentially determined by the proportions of its principal constituents which are lime, silica, alumina and iron.

In order to satisfy the specific composition requirements,the raw materials serving for the establishment of the raw mix must contain between 75 to 80% calcium carbonate ($CaCO_3$), 15% silica ($SiO_2$), 3 to 4% alumina ($Al_2O_3$), and approximately 1 to 2% iron oxyde ($Fe_2O_3$).

Cement geologists are constantly searching for the ideal raw materials which do not contain excessive amounts of noxious materials such as alkali, chloride, phosphates, etc., which are difficult to separate from the raw materials; this often prevents or makes it difficult to use large and strategically located deposits.

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However, in recent years, the cement industry has made considerable progress in raw material preparation and beneficiation.

In the case of the Le Havre plant of Ciments Lambert-Lafarge, the Tororo plant of Uganda Cement and the Aveta plant (Togo) of Cimao, where the raw materials contain a relatively high percentages of pure silica or phosphates, the realization of these plants was made possible thanks to the application of newly developed beneficiation processes.

A more recently introduced system consists of a process in which the basic material for cement manufacturing is gypsum or anhydrite instead of limestone. In the chemical process to obtain sulfuric acid, cement clinker falls on as a by-product.

7 - Additives

Additives as used in the cement manufacturing process can be divided into two categories :

a) Raw additives

The most classical raw additives are silica sand ($SiO_2$), iron ore and pyrite ash ($F_2O_3$) and bauxite ($Al_2O_3$). These materials are seldom available from the cement companies own sources and therefore must be purchased.

Blast furnace slag, because of its origins (limestone), in most cases has a similar chemical composition as shale and clay. Especially in Europe, it is widely used as a raw additive replacing clay or shale.

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b) Finish additives

Finish additives are the ones which together with clinker are ground into certain types of cement.

Additives are used for two principal reasons :

1) either to give particular properties or characteristics to the cement or,

2) to influence the process of grinding as such.

The most commonly used additives in the first category are gypsum, anhydrite, blast furnace slag, fly ash and pozzolanic materials.

Gypsum and anhydrite added in quantities of 2 to 5% serve principally to control or regulate the setting time of the cement or concrete.

Blast furnace slags, fly ash and pozzolana are mainly used to improve the resistance of cement against the influence of sulphates, pure waters, etc.

The additives of the second categories such as lignin sulfonic acids serve to counteract the flaking[1] of the cement which is one of the basic causes of cement stickiness.

1) Flaking of Cement is the result of concentrated adhesion between individual cement particles.

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8 - Overhead and financial charges

These charges include the plant overhead and the general overhead expenses, depreciation and interest cost.

At the plant level, cost for supervision, clerical staff, office and laboratory supplies, laboratory personnel, etc., are to be considered as overhead charges which cannot be reduced whatever the volume of production.

At the head office, general expenditures, expenditures for sales, finance, technical management and staff, rents, insurances, supplies and taxes fall into the category of general overhead and miscellaneous expenses. These costs can be minimized through efficient management, but not completly eliminated.

Depreciation and interest on investment constitute a large share of the total production cost.

If a plant costing US $ 60,-- per ton of installed capacity, is depreciated at the average rate of 6% per annum, the depreciation expense will amount to US $ 3,60 per ton. Interest expenses at a similar rate of 6% per annum on half of the fixed capital, would represent US $ 1,80 per ton of cement during the first year. This amount, however, is due to decrease each year at the same rate than the reimbursement rate of the borrowed capital.

With fixed overhead and financial expenses the total cost of operation will be affected in two ways :

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a) the depreciation and interest expenses per ton are high in caseswhere the cost per ton of installed capacity is high. Investors should consequently look for the lowest possible cost per ton of installed capacity (large manufacturing units for instance);

b) the depreciation and interest expenses per ton increase in cases where the installed capacity is not fully used. The capacity of the plant should be comparable to the size or the short-time development of the market.

The above mentioned consequences of the fixed capital cost upon the operating cost are somewhat contradictory and require thorough studies of all the factors involved before the final decision as to the capacity of a cement plant is taken.

On the other hand, large differences between the various manufacturing cost elements occur when the size of the plant varies or if the plant is strategically not properly located in respect to its sources of fuel, electricity, raw materials and additives.

The following section 4 examines the influence of the "economy of scale" on the cement manufacturing costs.

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## SECTION 4 - ECONOMIES OF SCALE IN THE CEMENT INDUSTRY - CALCULATION OF THE BREAKEVEN POINT

### 1. Manufacturing cost of cement in relation with the plant size

Operating costs in cement plants of various capacities are passed under review hereafter.

For the purpose of this comparison, it is assumed that all these plants are using the dry process combined with suspension preheater kilns, that they are equiped with a single kiln unit, up to date machinery, modern control systems and that the larger plants (500'000 t/year and 1'000'000t/year) are fully integrated[1] and automated.

Figures regarding the prices of fuel, electricity, supplies and spare sparts, labor, etc. are <u>average industry figures</u> taking into account the fact that costs are somewhat higher in developing countries and that smaller plants are mostly located in developing countries.

### 1.1. The cost of combustible

The following table indicates the cost of fuel per ton of cement. The type of fuel taken into consideration is "Bunker C (9'500 Kcal/kg)".

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1) In an integrated plant, the process machinery and equipments are grouped in such a way as to form a more or less continuous production chain, with the intermediate material storage facilities either kept to an absolute minimum or eliminated altogether.

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Table 13 : Cost of fuel

| PLANT SIZE T/YEAR | Kcal used per kg clinker (1) | Fuel consumption per T of cl. | Estimated cost of a T fuel - FOB plant (2) | T clinker per T of cement | Fuel cost per Ton of cement |
|---|---|---|---|---|---|
| 30'000 | 1150 kcal | 121 kg | US$ 35 | 0,96 | US$ 4,07 |
| 50'000 | 1075 " | 113 " | " 33 | 0,96 | " 3,58 |
| 100'000 | 1000 " | 105 " | " 31 | 0,96 | " 3,13 |
| 250'000 | 920 " | 97 " | " 29 | 0,96 | " 2,70 |
| 500'000 | 860 " | 91 " | " 27 | 0,96 | " 2,36 |
| 1'000'000 | 840 " | 89 " | " 25 | 0,96 | " 2,14 |

1) Includes 100 Kcal/kg clinker for start up and raw materials drying and oil pre-heating (Source : Zement Kalk & Gyps - No 10/1967.

2) Fuel cost is smaller for large plants due to the negociating advantage of larger fuel supply contracts. In addition, large plants are usually located in areas where fuel transportation costs are lower.

## 1.2. Power cost

It is assumed that power is purchased from utility companies on the basis of long term contracts. As is customary in the case of such contracts, the power rates are composed of a fixed and a variable charge.

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It should be noted that the plant power consumption is not linear with production rates. This is due to the fact that certain pieces of equipment are to be kept in operation at all times : water pumps, air compressors, air conditioning, lighting, ventilation, etc.

Table 14 : Cost of power per ton of cement

| PLANT SIZE T/YEAR | FIXED COST (100% USED CAPACITY) | | | | VARIABLE COST | | | TOTAL PER TON | |
|---|---|---|---|---|---|---|---|---|---|
| | DEMAND CHARGE PER T OF CEMENT | KWH PER T | COST OF KWH | TOTAL FIXED COST PER T (1) | KWH PER T | COST OF KWH | TOTAL VAR-IABLE COST (1) | KWH PER T (2) | COST PER T |
| | US $ | -- | US $ | US $ | -- | US $ | US $ | -- | US $ |
| 30'000 | 0,47 | 17 | 0,015 | 0,72 | 98 | 0,015 | 1,45 | 115 | 2,17 |
| 50'000 | 0,44 | 16 | 0,015 | 0,69 | 94 | 0,015 | 1,41 | 110 | 2,10 |
| 100'000 | 0,41 | 16 | 0,014 | 0,64 | 91 | 0,014 | 1,27 | 107 | 1,91 |
| 250'000 | 0,37 | 16 | 0,013 | 0,58 | 89 | 0,013 | 1,16 | 105 | 1,74 |
| 500'000 | 0,34 | 16 | 0,012 | 0,53 | 87 | 0,012 | 1,04 | 103 | 1,57 |
| 1'000'000 | 0,32 | 15 | 0,011 | 0,49 | 85 | 0,011 | 0,94 | 100 | 1,43 |

1) Cost rounded up to nearest cent and to nearest kwh/t.

2) Raw materials are assumed to be of average hardness.

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1.3. Labor cost

The total labor force of a cement plant consists of a "direct" force, engaged in the actual manufacturing and shipping operations and an "indirect" force in charge of general supervision, administrative, engineering and laboratory activities.

Cost of labor varies widely from one country to another and is normaly much lower in the developing countries than in industrialized areas.

In the USA, "the average hourly wage paid by the cement industry during 1966, according to the U.S. Department of Labor, Bureau of Labor Statistics, was $ 3,18... Fringe benefits are estimated to represent an additional cost of 76 ¢ per hour for a total average per manhour of $ 3,94 in 1966".[1)]

In West Germany, according to Labahn/Kaminski[2)] the average hourly wage in the cement industry varies from DM 4,60 (US $ 1,25) to DM 5,10 (US $ 1,38) with fringe benefits amounting to an additional 20% of the salary.

On the Ivory Coast,[3)] in July 1968, the top salary of an industry worker, was F.CFA 77,81 per hour (US $ 0,31) plus

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1) Source : Rock Products - April 1968 - p. 60 "For the Cement Industry : a time of Crisis" by R. Sterling Harwell. (based on latest information, hourly wage in the USA (1970) cement industry have since increased by approximately 30%)

2) Source : Ratgeber für Zement-Ingenieure 4. Auflage - October 1969 - p. 87.

3) Source : Bulletin mensuel de statistique - Août 1968 - Ministère des Affaires économiques et financières de la République de la Côte d'Ivoire.

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fringe benefits amounting to an additional F.CFA 33,52 (US $ 0,14), for a total cost of US $ 0,45 per manhour. The same differences appear, although to a lesser extent, if we consider the wages of the supervisors, clerks and chemists.

Labor costs being of a much smaller significance in the developing countries than in the developed countries, a relatively large labor force may be contemplated to run a cement plant.

In order to facilitate cost comparison, a minimum number of workers has been taken into consideration in the following table. For the plants of upwards of 100'000 T, the hourly average cost for the total labor force is estimated at US $ 2,50 per hour including fringe benefits and social charges. This hourly rate has been reduced to US $ 1,25 for the 30'000 and 50'000 t/year plants because they are likely to be located in developing countries.

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Table 15 : Labor cost per ton of cement

| PLANT SIZE T/YEAR | Direct labor | | | Indirect labor | | Total cost of labor | |
|---|---|---|---|---|---|---|---|
| | Number of manual workers | Total man/ hours | Total annual cost of direct labor | Number of indirect labor | Total annual cost of indirect labor (3) | Per year | Per T of cement |
| | | | US $ | | US $ | US $ | US $ |
| 30'000 | 120 | 240'000 | 300'000 1 | 8 | 64'000 | 364'000 | 12,13 |
| 50'000 | 120 | 240'000 | 300'000 1 | 8 | 64'000 | 364'000 | 7,28 |
| 100'000 | 80 | 160'000 | 400'000 2 | 8 | 64'000 | 464'000 | 4,64 |
| 250'000 | 100 | 200'000 | 500'000 2 | 10 | 80'000 | 580'000 | 2,32 |
| 500'000 | 135 | 270'000 | 675'000 2 | 16 | 128'000 | 803'000 | 1,60 |
| 1'000'000 | 185 | 370'000 | 925'000 2 | 21 | 168'000 | 1'093'000 | 1,10 |

1) At a cost of US $ 1,25 per hour including fringe benefits and social charges

2) At a cost of US $ 2,50 per hour including fringe benefits and social charges

3) At a cost of US $ 8'000,-- per year including fringe benefits and social charges

N.B. See the UNO's publication, F.68.II. B.16, "Evaluation des besoins en personnel technique et de gestion dans certaines industries" - Chapter 1 - The Cement Industry.

1.4. Production supplies and maintenance materials cost

It is supposed that under normal conditions, this cost item amounts to approximately US $ 2,05 per ton of cement, whatever the plant capacity.

| This amount includes : | US $ per t cement |
|---|---|
| - Diesel fuel : 0,5 litre/ton of cement, at $ 0,10 per liter | 0,05 |
| - Grinding media, liners, hammers, etc. 0,250 kg per t. of cement, at $ 1,00 per kg | 0,25 |
| - Refractories for kiln, cooler, preheater : 1,00 kg per t. of cement at $ 0,25 per kg | 0,25 |
| - Other expendables (explosives, etc.) | 0,25 |
| - Gypsum : 45 kg per t. of cement at $ 10.- per t. | 0,45 |
| - Mechanical and electrical parts | 0,70 |
| - Lubricants, oil, grease : 0,2 liter per t. of cement at $ 0,50 per liter | 0,10 |
| Total : | 2,05 |

(These costs have to be adjusted to local conditions).

1.5. General plant expenses

This item includes all the sundry expenses related to the general plant operation : office and laboratory supplies, telephone, insurances, property taxes and miscellaneous.

Experience shows that these expenses are about equivalent to the indirect labor cost.

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## 1.6. Depreciation and interest

Depending on the length of time a plant has to be amortized and to the system of depreciation which is used the average annual depreciation rate which is considered as acceptable for a cement plant varies between 5 and 7% of the fixed capital.

Assuming a full depreciation of the plant over a period of 20 years, a depreciation rate of 5% is tabulated in the following Table 16.

For the purpose of this study an additional interest rate of 6% on the fixed capital will be charged against the cost of manufacturing.

Table 16 :
Depreciation and financial charges per ton of cement

| PLANT SIZE | Investment cost per T of installed capacity | Depreciation 5% per year | Interest 6% per year | TOTAL per ton of cement |
|---|---|---|---|---|
| | US $ | US $ | US $ | US $ |
| 30'000 T | 168 | 8,40 | 10,08 | 18,48 |
| 50'000 T | 116 | 5,80 | 6,96 | 12,76 |
| 100'000 T | 80 | 4,00 | 4,80 | 8,80 |
| 250'000 T | 60 | 3,00 | 3,60 | 6,60 |
| 500'000 T | 55 | 2,75 | 3,30 | 6,05 |
| 1'000'000 T | 42 | 2,10 | 2,52 | 4,62 |

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## 1.7. Total manufacturing cost calculation - Relation cost/capacity

In the following Table 17 all the above calculated costs are grouped together in order to present a comparison of total manufacturing cost of cement in modern plants of 30'000, 50'000, 100'000, 250'000, 500'000 and 1 million tons per year capacity.

These calculations are based on a 100% capacity utilization.

Although it is considered that these total manufacturing costs are more or less accurately reflecting the average situation in the cement industry in the early 1970's, large variations are to be expected from one country to another, as well as over certain periods for one particular country.

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| COST ITEM | Table 17 : Cement manufacturing costs - Plant capacity in t/year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30'000 | | 50'000 | | 100'000 | | 250'000 | | 500'000 | | 1'000'000 | |
| | $ / t | % | $/t | % | $/t | % | $/t | % | $/t | % | $/t | % |
| VARIABLE COSTS | | | | | | | | | | | | |
| Fuel | 4,07 | | 3,58 | | 3,13 | | 2,70 | 15,2 | 2,36 | | 2,14 | |
| Power | 1,45 | | 1,41 | | 1,27 | | 1,16 | 6,6 | 1,04 | | 0,94 | |
| Production supplies spare parts | 2,05 | | 2,05 | | 2,05 | | 2,05 | | 2,05 | | 2,05 | |
| Sub total | 7,57 | | 7,04 | | 6,45 | | 5,91 | | 5,45 | | 5,13 | |
| FIXED COSTS AT 100% PRODUCTION | | | | | | | | | | | | |
| Labour cost | 12,13 | 28,0 | 7,28 | 23,3 | 4,64 | 20,0 | 2,32 | 13,0 | 1,60 | 10,0 | 1,10 | 8,2 |
| Power fixed cost | 0,72 | | 0,69 | | 0,64 | | 0,58 | | 0,53 | | 0,49 | |
| General mill expenses | 2,13 | | 1,28 | | 0,64 | | 0,32 | | 0,26 | | 0,17 | |
| Interest and depreciation | 18,48 | 42,7 | 12,76 | 40,8 | 8,80 | 37,9 | 6,60 | 37,2 | 6,05 | 38,3 | 4,62 | 34,4 |
| Sub total | 33,46 | | 22,01 | | 14,72 | | 9,82 | | 8,44 | | 6,38 | |
| Total bulk cement | 41,03 | | 29,05 | | 21,17 | | 15,73 | | 13,89 | | 11,51 | |
| Addition for cement bags (bags 50 kg) | 2,20 | | 2,20 | | 2,00 | | 2,00 | | 1,90 | | 1,90 | |
| Total cement in bag | 43,23 | 100,-- | 31,25 | 100,-- | 23,17 | 100,-- | 17,73 | 100,-- | 15,79 | 100,-- | 13,41 | 100,-- |

Taking the manufacturing cost of a ton of cement in a 250'000 t/year plant as 100, the cost will very according to the plant capacity as follows :

| | |
|---|---|
| 30'000 T/year plant : | 221 |
| 50'000 T " " | 176 |
| 100'000 T " " | 130 |
| 250'000 T " " | 100 |
| ========= | === |
| 500'000 T " " | 89 |
| 1'000'000 T " " | 76 |

Large plants are more economical to operate than smaller ones because :

- depreciation, interest charges, and general fixed expenses are distributed over a greater number of tons of cement manufactured;
- advances in modern technology have mainly benefited large size plants; thus reducing labor force, maintenance and fuel drastically.

As matters stand now, cement manufacturers in the developed countries are up against very strong competition. In order to stay competitive, they have practically no choice but to build plants of larger and larger capacities.

The situation is somewhat different in developing countries and should therefore be examined case by case. Other factors have to be taken into consideration : price of imported cement, cost of transportation, necessity of saving hard currency, desire to create a local industry, etc. These questions are dealt with, in Chapter IV pertaining to the problem of "small cement plants".

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2. <u>Manufacturing cost of cement in relation with the utilization of plant capacity - Breakeven point analysis</u>

Should a prospective cement manufacturer build a large plant in view to reduce his manufacturing costs to a minimum, even if the plant is to be operated at reduced capacity? Or is he in a more favorable position in operating a smaller plant at 100% of its designed capacity?

The answer to this question can be found by determining the breakeven point of future plants.

This breakeven point is the level of operation at which "revenue from sales exactly equals expenses".[1)]

The breakeven point depends upon three factors :

- the selling price
- fixed costs, which are "those costs that are expected to remain relatively constant regardless of the level of output" (depreciation, general plant expenses, labor, etc.)
- variable costs which are "those costs that vary directly with changes in the level of output" (fuel, power, production supply, spare parts, etc.).

The breakeven point is given by the formula :

$$BK = \frac{Cf}{S - Cv} \times \frac{100}{P}$$

in which :

BK = Breakeven point : percentage of plant utilization, at which plant expenses equal revenue from sales

Cf = Total fixed costs

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1) From "Management in Industry "by Claude S. George Jr. Prentice-Hall-1959.

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S = Selling price of a ton of cement

Cv = Variable manufacturing cost per ton of cement

P = Designed plant capacity

The breakeven point of each of the cement plants reviewed in Table 17 has been calculated and the results are shown in Table 18.

Table 18 : Cement plants breakeven points

| Cement selling price | Plant capacity (T/year) | | | | | |
|---|---|---|---|---|---|---|
| | 30'000 | 50'000 | 100'000 | 250'000 | 500'000 | 1'000'000 |
| FOB plant in Bulk per T | %* | %* | %* | %* | %* | %* |
| 15 US $ | -- | -- | -- | -- | 96 | 65 |
| 20 | -- | -- | -- | 70 | 58 | 43 |
| 25 | -- | -- | 80 | 52 | 43 | 32 |
| 30 | -- | 96 | 63 | 43 | 35 | 27 |
| 35 | -- | 79 | 52 | 33 | 29 | 22 |
| 40 | 103 | 66 | 44 | 29 | 25 | 18 |
| 45 | 82 | 58 | 38 | 25 | 21 | 16 |

* Minimum percentage of utilization of plant capacity in order to breakeven.

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Comments on Table 18

a) Selling price

Selling prices, as indicated, are in the range of $ 15 to $ 45 per ton, in bulk, FOB plant, because this range reflects the present world pricing situation (plus or minus 10%);

- US $ 15,-- : price prevailing in most of the Western Europe countries
- US $ 20,-- : price prevailing in North America, Venezuela
- US $ 25,-- : price prevailing in India,[1] North Africa
- US $ 30,-- : price prevailing in the coastal cities of Western Africa [2]
- US $ 40/45 : price prevailing in land-locked countries (In Agades, Republic of Niger, cement is sold at US $ 80,-- per ton).

The selling price of cement in a given location consists of the manufacturing cost plus the cost of handling and transportation. Cement prices are the highest in remote locations. They are reduced when good highways or railroads are available.

b) Indicative value of the table

Figures given in the table have to be interpreted : the differences between fixed and variable costs are often difficult to ascertain.

1) Source : Rock products - February 1969 - Cement in a developing country - page 76.

2) Source : Bulletin mensuel de Statistique - Ministère des Affaires économiques et financières - République de côte d'Ivoire.

It would be unrealistic to build oversized plants in small markets only because the selling price seems to be profitable at a low level of utilization.

At a very low level of capacity utilization, there is a lot of waste and, in reality, the variable costs are often considerably higher than they appear to be, based on a purely theoretical basis.

c) Relation between the selling price and the breakeven point

The breakeven point may be expressed in two ways :

- the level of volume of sales, at constant price, at which revenue from sales equals expense

or

- the level of price in dollars, at constant volume of sales, at which revenue from sales equals expense.

Expressed in the second way, the breakeven point is the indication of the price at which the product should be sold in order to make a profit.

The following Table 19 shows, as an example, the profit and loss variations occuring in a 100'000 T plant, at various levels of sales and selling prices.

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| Table 19 | | | | |
|---|---|---|---|---|
| Profit (+) or loss (-) per Ton in US $ in a 100'000 T/year capacity cement plant | | | | |
| Selling price Bulk cement per ton FOB plant | Volume of sales in tons | | | |
| | 100'000 T | 80'000 T | 70'000 T | 50'000 T |
| | MANUFACTURING COST = $ 21,17 | MANUFACTURING COST = $ 24,80 | MANUFACTURING COST = $ 27,50 | MANUFACTURING COST = $ 35,90 |
| US $ | | | | |
| 27 | + 5,83 | + 2,20 | - 0,50 | - 8,90 |
| 25 | + 3,83 | + 0,20 | - 2,50 | - 10,90 |
| 23 | + 1,83 | - 1,80 | - 4,50 | - 12,90 |
| 21 | - 0,17 | - 3,80 | - 6,50 | - 14,90 |
| 20 | - 1,17 | - 4,80 | - 7,50 | - 15,90 |
| 19 | - 2,17 | - 5,80 | - 8,50 | - 16,90 |
| 17 | - 4,17 | - 7,80 | - 10,50 | - 18,90 |
| 15 | - 6,17 | - 9,80 | - 12,50 | - 20,90 |

3. <u>The size of the market and its influence upon manufacturing cost</u>.

Plant size and rate of utilization of the installed capacity are major factors determining the manufacturing cost of cement. This makes it essential not to start new ventures in the cement industry before having acquired a most accurate knowledge of its future market.

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Plants which are too small will have soon to be expanded by installing additional units; as a consequence the cost savings which would have accrued from manufacturing cement in large one-line plants are likely to be lost. On the other hand, plants conceived on too large a scale may never, or only after a long period of time, use their full capacity. For instance, it costs US $ 9,-- (nine) dollars more per ton to manufacture 100'000 T of cement in a 250'000 T/year capacity plant (40% capacity utilization) than in a 100'000 T plant working at full capacity.[1)]

Market surveys shall not only serve to estimate the future volume of sales but the average net FOB plant price left, after deduction of handling, transportation and other sales charges.

1) See Table 17 : the manufacturing cost of 100'000 T in a 250'000 T plant may be computed as follows :

| | | |
|---|---|---|
| Fixed cost | $ 9,82 per T x 250'000 T = | 2'455'000 $ |
| Variable cost | $ 5,91 per T x 100'000 T = | 591'000 $ |
| Total manufacturing cost for 100'000 T | | 3'046'000 $ |

Manufacturing cost of 1 ton : $ 30,46 instead $ 21,17 in a 100'000 T/cement plant (bulk cement).

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# CHAPTER IV

## CEMENT PLANTS ADAPTED TO LARGE AND SMALL MARKETS IN DEVELOPING COUNTRIES

### SECTION 1 - DEVELOPING COUNTRIES ENJOYING A LARGE CEMENT MARKET

Developing countries are generally very anxious to get a cement industry of their own or to expand their existing capacity.

The imported cement they need for their housing, social and industrialization programs is generally paid at a very high price in hard currency, which results in a heavy burden for their economy.

With few exceptions,[1] the raw materials necessary to manufacture cement are practically available everywhere and insurmountable difficulties of technical nature which may prevent a developing country from materializing its projects do normally not exist.

However, the analysis of the cement manufacturing cost and of the breakeven point indicates that low cost cement can only be produced in large capacity plants.

Developing countries with a large cement market or with large and predictable future demands for cement are in a position to take full advantage of the economies of scale prevailing in the cement industry.

1) For instance in Western Africa

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They can contemplate the creation of a few large, very modern and economical manufacturing units instead of a series of small plants.

Even if their market is spread over vast territories, economies of scale and full capacity utilization generate sufficient profits to absorb a large part of the excessive transportation costs and, at the same time, keep the selling price in remote areas at reasonable levels.

Furthermore, equalization of prices throughout the country, or a region, is made possible. The cost of transportation to distant areas may be subsidized both by somewhat adjusting the delivered prices paid by the cement consumers who are closest to the plants and by passing to the clientele the manufacturing cost margins resulting from the large plants.

Some developing countries, as for instance Algeria, have already followed this policy. Two very modern, automated, one-million tons/year capacity plants are presently being built; one near Algiers, the other near Annaba.

## SECTION 2 - DEVELOPING COUNTRIES WITH SMALL CEMENT MARKETS

It should be kept in mind that there exists some developing and landlocked countries whose cement consumption (present and future) does not justify the installation of cement plants with annual capacities exceeding 30'000 to 100'000 tons.

Despite this, such countries driven by the extremely high prices of imported cement, mainly due to high transportation cost, nevertheless promote the idea of creating their own cement industry in order :

- to have their own source of supply
- to reduce the cement selling price in their country.

If the first objective is generally not too difficult to achieve as long as capital is available or may be borrowed, the second one is more difficult to realize.

Some of the possible solutions which developing countries may retain are briefly reviewed hereafter :

a) To install a small cement plant equipped with a rotary kiln, using either dry or wet process. In the preceding chapter, manufacturing costs of such types of plants have been discussed. These costs are high. Result : the cement user who had been paying 40 to 45 dollars a ton for imported cement, will not get much relief by purchasing cement from a local plant.

Before any investment decision is taken, the availability and the quality of the raw materials and fuels have to be thoroughly scrutinized.

The plant should be simple to operate and in order to minimize the problems of personnel training and of plant maintenance, the equipment should be of the sturdy type.

Many small plants in developing countries have got more than their share of trouble because these prerequisites were not respected.

During the past years, with the size of cement plants becoming larger and larger, equipment suppliers have somewhat lost interest in small cement plants which, thirty years ago, were commonplace in the cement industry.

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No real technological advance has recently taken place in this field. In general, it is rather difficult today to find suppliers who are willing to tender on cement plants for less than 100'000 tons yearly capacity. As a result of a recent enquiry for small plants, made by an engineering firm, a well known cement machinery supplier answered as follows :

> "We thank you for your letter dated 1970... and would inform you that we do not consider cement plant of less than 60'000 tons per annum economical propositions under present conditions, and have indeed, in the past, refused to tender for plants of less than 100'000 tons per annum for this reason".

Nevertheless, in spite of these difficulties, the small classical plant of 30'000 to 50'000 tons per year capacity may be, under certain circumstances, the only choice which is left to prospective investors who desire to create a cement industry in a developing country.

b) To install a shaft kiln plant

An excellent description of this type of cement plant may be found in the United Nations publication "Studies in Economics of Industry-Cement/Nitrogenous fertilizers" published in 1963 (reference ST/ECA/75).

Lower investment costs are certainly possible with this type of kiln, but even in a small plant, the kiln is only a minor part of the installation.

The kiln itself is a vertical steel or concrete cylinder, 4 to 10 meters high and of a diametre of 1,25 to

4 meters. It is feed from the top with pelletized cement raw materials and coal (which serves as fuel). After completion of the combustion, the clinker is discharged at the bottom of the kiln by a rotary grate.

The advantages of shaft kiln plants are the following :

- vertical kilns are cheaper than rotary kilns
- very small units are possible (15'000 t/year capacity)
- no clinker cooler is needed
- low fuel consumption
- short construction time
- capacity easy to expand.

On the other hand, this type of plant has some serious drawbacks :

- special low volatile coal is required
- dry raw materials, with good pelletizing characteristics must be available
- well trained and skilled operators are required
- quality of cement manufactured is rather irregular.

Experiments are underway to improve the efficiency of shaft kiln operation and the quality of the product.

It is still too soon to draw definitive conclusions as to the future of modernized shaft kiln plants. For the time being the realization of this type of installation should be preceded by a thorough analysis of all the aspects

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and problems, including the availability of proper fuel, raw materials and manpower.[1)]

c) <u>To install a clinker grinding station</u>

An intermediary solution between importing foreign cement and the construction of a complete cement plant of small capacity consists in the installation of a clinker grinding station.

This solution distributes the manufacturing cost between the firms (or countries) exporting and importing clinker.

Clinker is the semi-finished product which results from burning cement raw materials in the kiln. Cement is obtained in grinding clinker together with a small percentage of gypsum into cement.

This final operation, including storage and bagging of cement takes place in a grinding station whose owners purchase the clinker from clinker and cement manufacturers.

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1) - See Rock Products - Jan. 1966 - The Modern vertical kiln, by Dr Steven Gottlieb

Rock Products - Dec. 1970 - Vertical Shaft Kilns - Present and future, by Walter Gribbin.

Rock Products - May 1967 - World's smallest cement plant by N. Ramachandrau, describing an experimental vertical kiln plant of 50 t/day capacity in an Indian village

A French cement manufacturer, Ciments Chiron at Chambery, claims to have brought new developments in the vertical kiln operation.

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The investment cost for a 100'000 t/year capacity clinker grinding station amounts to $ 1 million to 1'400'000. This includes the mechanical and electrical equipments, laboratories, workshop, storage silos and other miscellaneous constructions and installations.

Not included in the above indicated amounts are the cost for land, access roads, etc.

The following table summarizes the main investment and operating cost data of two hypothetical 100'000 t/year capacity grinding stations located on the West Coast of Africa (1970 figures) :

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Table 20 : Cement clinker grinding station

I - Technical Data

- capacity of the plant — 100'000 t/year
- materials used : clinker — 95'000 t/year
  gypsum — 5'000 t/year
- personnel : technical and administrative : 8 to 10
  production and maintenance : 25 to 35
- electricity : 45 kwh/per Ton

II - Financial data

Average investment cost : US $ 1'300'000

| Operating cost per Ton of cement | Plant A* | Plant B* |
|---|---|---|
| a) Raw materials and supplies | | |
| - clinker at US $ 14.- per T CIF | 13,30 | 13,30 |
| - gypsum at US $ 14.- per T CIF | 0,70 | 0,70 |
| - handling and transportation | 0,80 | 1,20 |
| - paper bags (20 per T) | 0,70 | 1,00 |
| - spare parts, maintenance supplies | 0,50 | 0,50 |
| b) Electricity | | |
| - fix charge | 0,17 | 0,20 |
| - variable charge (45 kwh per T) | 1,20 | 1,40 |
| c) Personnel | 1,00 | 1,25 |
| d) Miscellaneous | | |
| - general overhead (taxes, insurances, rent, administrative expenses) | 0,25 | 0,50 |
| - others | 0,10 | 0,10 |
| Sub-total : | 18,72 | 20,15 |
| e) Depreciation and interest (10%) | 1,30 | 1,30 |
| Total : | 20,02 | 21,45 |

*Plants A and B are considered to operate under slightly different conditions.

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Taking into account the raw materials, products and services which are directly or indirectly paid with foreign exchange, the value which is added in the country where the station is located, amounts to $ 3 to $ 4,-- per ton.

Additional $ 1,-- per ton may result from manufacturing paper bags by using wood pulp from local sources.

A clinker grinding station should only be set up if clinker is available at low cost and the price of electricity is not prohibitive. These two conditions make it almost compulsory to locate clinker grinding stations near the water and in the vicinity of well equiped harbors.

However if the plant site is served by rail and if reasonable transportation rates can be obtained, it is possible to contemplate the installation of clinker grinding stations in inland locations. These inland plants would be supplied :

- either with clinker originating from overseas cement plants and reloaded into rail cars at the nearest harbor
- or from other cement plants located on the connecting railway line.

The main advantages of clinker grinding stations are the following :

- existence of large stocks of clinker assures the regularity of supply for the country and the stability of price;
- additional employment for local labor
- some savings in foreign exchange;
- lowering of the cement selling price because the cost of transportation and handling of clinker is lower than that of cement.

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In spite of these advantages, clinker grinding stations remain too much dependent on foreign resources to be considered the best solution to the problem of cement supply for developing countries.

d) <u>To build a multinational cement plant</u>

UNIDO Monograph on Industrial Development No 18 "Regional co-operation in Industry"[1] identifies "appropriate opportunities for fostering regional co-operation among developing countries as an essential step towards achieving rational industrial promotion and expansion". (Introduction, P. 2).

Although the authors of this Monograph did not specifically refer to the cement industry, their reasonning do really apply to it especially when they state that (p.6) "For a great number of developing countries, economies of scale do not become possible until they join a wider regional market...... In the absence of a sufficient market and because of the unavailability of capital equipment designed to meet the exact requirement of the size of the market, investors in many developing countries are faced with a choice between plants that are either too small or too large and (p. 9) "Regional integration would appear to favor capital-intensive technologies".

1) Ref. ID/40/18 - United Nations Publication - Sales No : E.69.11.B.39, Vol. 18.

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Already in 1966, a document issued by the Economic Commission for Africa[1], was strongly suggesting that a co-operation be established among the Western Africa countries in order that the countries with large resources in raw materials supply cement clinker to the others. This would be mutually profitable : the first ones would be in a position to take advantage of the economies of scale while the other could rely on regular and low cost supply of clinker.

Such co-operation is presently considered among the African countries who are members of the "Conseil de l'Entente"[2].

The solution put forward is that of a multinational cement company, in which all the interested Nations would participate.

The proposed plant would exploit Aveta (Togo)[3] limestone deposits which are situated appr. 30 kms from the port of Lomé.

The plant would have a capacity of approximately one million tons of cement clinker per year. It would export its production by water -through the port of Lomé- to the coastal Nations of the "Conseil de l'Entente" and it could possibly look forward to supply clinker to neighbouring Nations such as Ghana.

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1) Un programme de Développement pour l'Industrie du ciment en Afrique de l'Ouest - 10 août 1966 - E/CN.14/INR/117 - (see pages 65 and 66).

2) Ivory Coast, Upper Volta, Republic of Niger. Togo and Dahomey.

3) See for details : Industries et Travaux d'Outre-Mer, June 1970.

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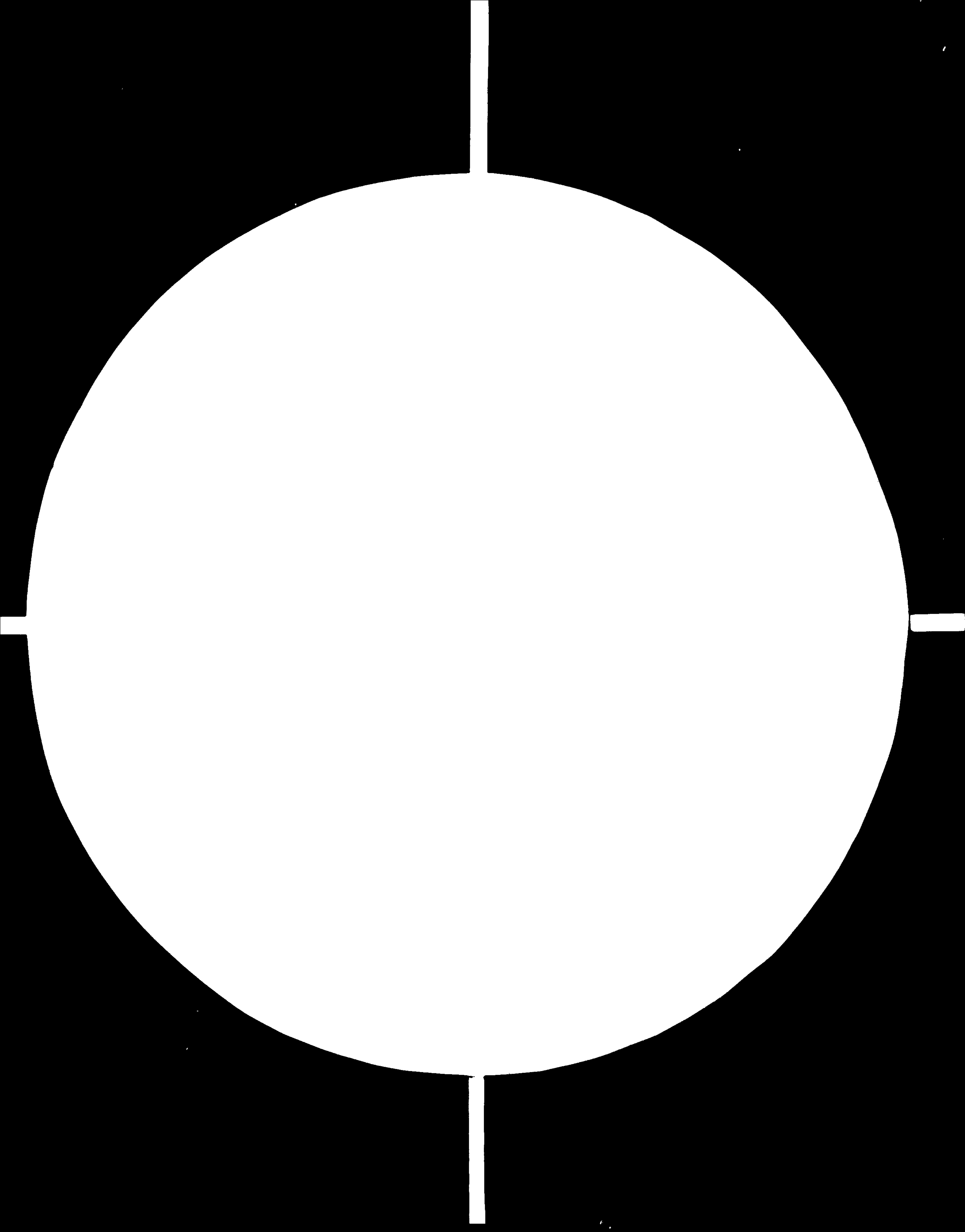

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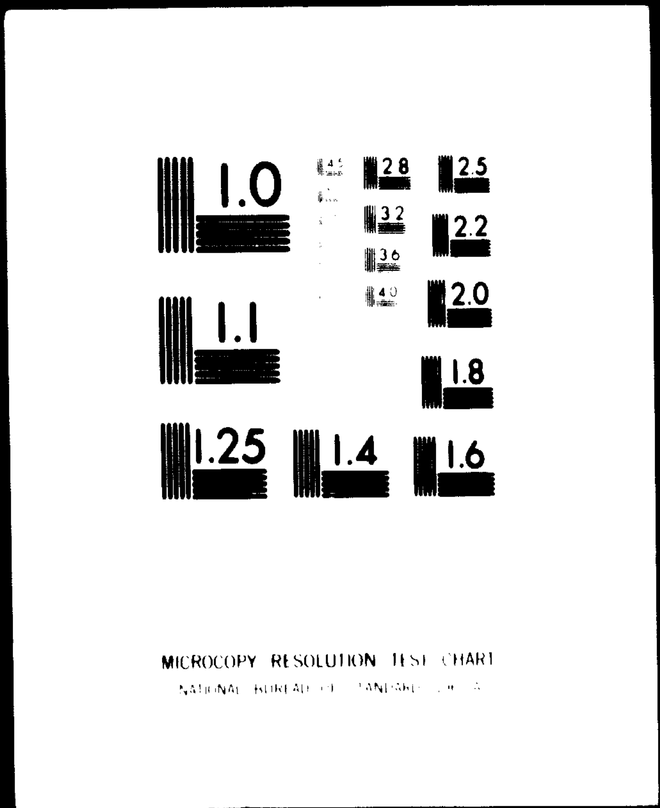


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The plant would only manufacture clinker and therefore not compete with existing or planned clinker grinding stations; it would complement them as a supplier of clinker.

# P A R T  II

## DEVELOPMENT OF CEMENT TECHNOLOGY

## GENERAL REMARKS

With practically no revolutionary changes having taken place in the basic technology of cement during several decades, important developments and improvements of evolutionary nature have.[1)]

This is especially apparent in plants built after 1965 and is demonstrated in the form of better designed equipment, higher operational efficiency, lower labor factors, lower fuel consumption and to a certain extent lower electrical energy requirements.

Some changes which have occured lately and which have been inspired by a new generation of cement people, ...e lead to improvements such as, higher equipment availability, larger production units, process automation, more intimate knowledge of the production process through systems engineering, better qualified operating personnel, reduction of airpollution rates, higher and more regular cement qualities, etc.

The application of advanced operations research methods and electronic computers has resulted in a more analytical approach to many problems and has lead to plant conceptions which take full advantage of the most modern equipments and operating techniques.

1) P.K. MELITA "Trends in Technology of Cement Manufacture" Rock Products March, 1970.

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The cement industry was always known for its high labor requirements. However in the past few years it has progressed to a point where, as far as labor requirements are concerned, it can be considered as one of the most efficient operations in the domaine of heavy industries.

The application to the cement manufacturing of some concepts partly used in the mining and the petrochemical industry is seriously considered. Such designs can lead to more integrated plants.

It is interesting to note that developing countries have a tendency to reject the idea of passing through the different stages of technological evolution.

They are mostly free of many of the restrictive considerations which, in developed nations or traditionalized industries, such as cement, hinder the acceptance of progressive methods and techniques.

It is not at all improbable that as a consequence of this, developing countries will progress relatively fast and in some cases may possibly compete with the leaders in modern cement manufacturing.

The cement industry is known for its relatively high ratio of investment cost to annual output. Despite the anticipated technological improvements, this situation is not likely to change very noticeably in the near future.

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# CHAPTER I

## RECENT TECHNOLOGICAL INNOVATIONS IN THE CEMENT INDUSTRY

### 1. CHEMISTRY AND CEMENT TYPES

The theories on the formation and the constitution of Portland Cement clinker and on the hydration and hardening of Portland Cement have become common knowledge.[1] Recent studies on these subjects have clarified some points but it is not very likely that the results of these studies will lead to fundamental changes.

Basic research may lead to the development of cement with the best characteristics for their specific applications.[2]

The manufacture and use of expansive cement is now well known and is the subjects of numerous and important studies.[3]

The substitution of baryum or strontium to the calcium in the silicates and aluminates is another example of the industries search for improved products.[4]

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1) W. EITEL, Silica Science, Vol. V. Academic Press, New-York & London, 1966.

2) Proc. of the 5th Intern. Symposium on the Chemistry of Cement, Tokyo 1968.

3) Proc. of the 5th Intern. Symposium on the Chemistry of Cement, Tokyo 1968.

4) A. BRANICKI, Calcium, Strontium and Barium Cement, Z.K.G. November 1969.

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More recently, concentrated studies and investigations have lead to a reappraisal of the influence of phosphates ($P_2O_5$) on the quality of cement.

Generally speaking there have been few developments in the line of new cement types.

It must however be recognized that some of the existing types of cement have been greatly improved and the user has a better assurance to purchase products which lend themselves better to general and to specific applications.

## 2. RAW MATERIALS

Not too many years ago cement geologists and chemists would only accept so called "pure materials" as suitable for the manufacture of cement.

This has often lead to the rejection of economically and commercially desirable plant locations.

In today's strive to optimize the economics of industrial projects, commercial considerations are heavily weighed against possible shortcomings of raw materials and plant locations.

This, together with a steadily growing shortage of so called "ideal raw materials", has forced cement producers to consider limestones of inferior quality as a raw material for cement manufacturing.

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The attached map titled "World Limestone Resources" shows the repartition of limestone, throughout the world.

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The recent advance in material beneficiation, such as silex separation from chalk in France and phosphate removal from limestone in Uganda and Togo has opened up new possibilities to realize cement plants in some previously rejected areas.

The introduction of computer simulation methods in the calculation and optimization of raw mix designs has resulted in a new approach to raw mix chemistry and has made it possible to overcome some of the traditional and restrictive tendencies in the industry.

The introduction and refinement of the prehomogenization method has created the possibility to pre-blend (before grinding) raw materials of inferior quality with the necessary corrective additives.

## 3. RAW MATERIAL QUARRYING

The choice of method depends almost entirely on the type of raw materials available.

In most plants, raw materials are quarried in so-called open pit operations.

The classical method, still widely applied, is the combination of drilling-blasting with reclaiming by power shovels or by bucket-wheels.

Within the last decade and for materials of lesser hardness, the industry has developed a new method : the ripping operation.

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WORLD LIMESTONE RESOURCES

The purpose of the map is to give a general review of limestone resources. Off - shore deposit of recent sediments are not indicated.

Regions with large deposits over wide areas and ranges. It indicates continental margins and miogo deposits.Little prospecting is required to locate and evaluate the limestone deposits in these ar

Regions with medium or unknown possibilities.

Regions with small or no possibilities. This includes zones without limestone : Wide Volcanic area Deccan's basaltic plateau ), main alluvial plains ( Mesopotamia, Gange ) and ancient metamorphic s of the Canadian shield, West - Australia ). Areas with few limestone deposits are also included: mentary basins and metamorphic series with scarce lenses of marble,( Finland ,indian shield ). In these regions limestone prospection may be difficult.

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SECTION 2

Derived from a technique developed mainly in road construction the equipment consists of a heavy bulldozer with large teeth attached to the rear of it. The ripping action of these teeth permits the loosening and to a certain extent breaking up of the materials to a deepth of approximately 30 to 60 cm.

After ripping, the material is pushed by the same bulldozer to the quarry bottom where it is reclaimed by powershovels or bucket wheels.

Besides eliminating the disadvantages of drilling and blasting, this method results in considerable quarrying cost reductions.

The feasibility of ripping has been demonstrated in materials and rockformation where previously no other method than drilling and blasting was considered possible.

THE TREND ?

The trend develops definitely in the direction of ripping. With heavy bulldozers being available in most parts of the world, ripping has also become possible in developing countries.

4. RAW MATERIAL CRUSHING

During the last decades, the methods of crushing have not changed much.

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In a cement plant the "quarry run raw material" normally passes through primary and secondary crushers for size reductions down to approximately 30 mm. In the case of wet and sticky materials the primary-secondary combination is often replaced by a circuit consisting of washmills and crushers.

Despite the fact that the efficiency of machines such as the jaw-crusher, the roll crusher, the single and double rotor hammer-crushers, the gyratory and the impact crusher, has been improved considerably, especially through the use of more abrasive resistant materials for liners and hammers, they have not quite reached the desired efficiency and availability.

A new method which in certain cases can replace the classical crushing equipment, is the autogenous mill (Hydrofall, Aerofall).

Known in the mining industry for many years, it has lately found its way into cement plants. Autogenous mills are built up to 35 feet in dia. permitting feed-sizes exceeding 1 m3. With this type of machine it is possible to crush and pregrind quarry run material down to less than 10 mm size, on a single pass.

Several of these autogenous mills are already in operation in the cement industry and one of them is presently being installed in Algeria.

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THE TREND ?

Despite the advantages of autogenous comminution, the industry will continue to employ the classical crushing system especially for dry materials.

The autogenous system might become increasingly popular, in cases where materials of medium and high moisture contents are to be crushed and dried before being fed into a dry process raw grinding circuit.

5. RAW GRINDING

In the cement industry grinding of raw material is mostly done in ball and tube mills.

Introduced before the turn of the century, the tube mill has not changed much in its conception over the years.

Improvements in operating efficiency were obtained mainly through the use of more abrasive resistant materials for liners and grinding balls and to a certain extent through a better understanding of the effect of increased mill speeds.

The replacement of the steel liners by rubber liners in wet mills has resulted in reducing wear, maintenance costs and noise.

A more interesting development in the domain of grinding has been the rod mill or rodpeb mill. In this type of mill the first compartment is filled with steel rods of up to 10 feet lenght and the second one with ordinary grinding balls. It can be fed with larger sized material

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than the standard tube mill and many cement people claim better efficiency in the grinding of hard raw materials.

As a counterpart to the tube mill for dry grinding, the roller mill was introduced a few years ago. Rather efficient, it has up to now been limited to the grinding of relatively soft and rather non abrasive materials.

THE TREND ?

Especially for finish grind the tube mill will maintain its place for many years to come. However some cement companies, especially in Germany, England, Canada, France and Algeria, have installed autogenous equipment for preliminary grinding and a number of cement manufacturers are considering the much improved roller mill.

## 6. CLINKER BURNING

The rotary kiln was introduced in the industry at the beginning of the century.

For almost 50 years the wet process was considered to be the most efficient method to burn clinker.

Approximately 25 years ago the first dry process suspension preheater kilns appeared on the market. Debates between the wet process operators and the proponants of the preheater kiln have been going on ever since.[1)]

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1) P.K. Melita "Trends in Technology of cement Manufacture" Rock Products, March, 1970.

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The wet process has some advantages such as easier handling and blending of the raw materials, reported gains in clinker quality, etc. However with improved dry blending and homogenization techniques, the dry process has lately been overtaking the classical "wet" operation.

It now seems that only in cases where the raw materials are of relatively high moisture content or contain important percentages of alkali and chlorides does the wet kiln still has its justified application.

THE TREND ?

There is no doubt that the suspension preheater kiln is replacing the long kiln (wet and dry process) and has become the most efficient equipment for clinker burning presently known in the industry.

The heat consumption, as low as 750 Kcal per kg. of clinker, obtained with this system is so close to the theoretical limit of 475 Kcal, that it will probably take many years before the suspension preheater type kiln is confronted with a more efficient system. (Fluo-solid reactor ?)[1)]

## 7. CLINKER COOLING

With the introduction of the grate -type air-quenching clinker cooler around 1930, the planetary and rotary coolers started to disappear from the market.

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1) E. Van Dernik "Will Fluo-solid reactors replace rotary kilns" Rock Products, September, 1969.

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However lately certain equipment manufacturers have made considerable efforts to reintroduce the planetary cooler. Such a cooler has been installed approximately 2 years ago on a 2'000 tons per day capacity rotary kiln in Holland.

There seems to be little doubt that the planetary cooler is mechanically more reliable and less prone to breakdowns than the rather complex grate cooler. However, size, cost, high clinker discharge temperatures and a reduced airquenching effect, might be serious drawbacks against its sucessfull reintroduction in the industry.

The latest development on the cooler market is the counter stream system.[1)]

Developed in Germany, very few of them have so far been installed. It will probably take many years of industrial experience until cement manufacturers will accept it more widely.

THE TREND ?

The cement industry will continue to install mainly grate coolers. However with more competition developing in the field of cooler manufacturing the cement industry might find a better response to its desire for more reliable and less costly installations.

1) Klinker Gegenstromkühler für die Zementindustrie Walther - Beraterm mitteilungen 1 - 1968.

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8. CLINKER STORAGE

Beside the rotary kilns, large clinker-storage halls have been the land-mark of practically every cement plant. However dust emission and high maintenance costs for their overhead travelling cranes have created more and more problems for cement operators.

In the past few years, the industry has changed some of its traditional principles and some companies have started to consider storage of clinker in large concrete silos.

Actual experience with such installations in Germany and France has been positive and many new plants are now adopting this new method of clinker storage.

The latest techniques in pre-stressed silo construction have permitted considerable construction cost reductions. Construction cost comparisons between clinker storage halls and clinker storage silos (handling equipment included) for plants presently under construction in Italy, France, Venezuela and Algeria, definitely indicate that silos can be built for the same, or in certain cases, for a somewhat lower price per ton of storage capacity than storage halls.

THE TREND ?

The industry seems to move definitely in the direction of clinker storage in silos. Why not? Silos for cement storage have been built for decades. In addition the surface area required for a silogroup is only approximately one third of that required for a storage hall.

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## 9. CEMENT GRINDING AND CEMENT STORAGE

Approximately 25 years ago, the industry was engaged in a debate about open circuit against closed circuit grinding. Today the closed circuit, with continuous separation by air classifier is accepted as the most efficient cement grinding method.

The development of closed circuit grinding has resulted in more regular fineness of the cement. It is also claimed that compared to open circuit grinding an increase of approximately 10% in mill capacity has been obtained.

With the exception of some improvements in equipment technology, the use of more wear resistant materials for mill liners and grinding balls and an increase in mill speed, no revolutionary changes have been introduced lately.

### THE TREND ?

The industry will continue to operate with the closed circuit-system which consists of a combination of tube mills and airclassifiers.

Several new plants are starting to replace the dynamic airclassifier with the less complex and mechanically more reliable cyclone type.

## 10. MILL DRIVES

First there was the bullgear-pinion drive, it was followed by the central drive consisting of a mechanical gear reduction unit driven by a single or by two electric motors

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Today raw and finish grinding mills are built for capacities exceeding 220 tons/hour with power requirements of up to 7'000 kW.

This increase in mill size and capacity has created the necessity for a less complex and more reliable drive systems, such as the recently developed "Wrap Around Motor".[1)]

This mill drive consists of a variable speed synchronous motor, whose rotor is mounted directly onto the shell (tube) of the mill, with the stator mounted on the mill foundations.

The first such unit of 6'500 kW has been in operation in Le Havre, France, since November 1969. Three more of these gearless type machines of 6'000 kW are presently being installed in a new 4'000 tons per day capacity cement plant in Italy; another one of 5'000 kW has been ordered by a German cement manufacturer.

## THE TREND ?

The bullgear-pinion combination and the mechanical gear reduction type central drives will prevail for units of up to 4'000 kW.

For higher capacities and despite higher investment cost, the gearless variable speed "wrap-around" motor will become the choice of many cement plant owners and operators.

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1) 1970 I.E.E.E. Cement Industry conference "Worlds First Gearless Milldrive" by H.U. Wuergler.

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## 11. BAGGING AND LOADING OF CEMENT

### 11.1. Bagging machines

In a relatively short period the mechanization of cement plants has progressed rapidly and has resulted in important labour reductions in the quarry, the raw and cement grinding, the clinker burning and the maintenance operation.

This is however not the case as far as the packhouse operations are concerned. It is a fact that the number of workmen required in the packhouse depends largely on the ratio of bags as against bulk. Even in some of the most modern plants (Le Havre for instance) the number of workmen employed in the packhouse still accounts for approximately 25% of the total plant workforce.

Over the years some important changes in the technique of filling cement into bags have taken place. Over a period of approximately 30 years equipment manufacturers have developed machines which have permitted to increase bagging capacities considerably (semi automatic single and multi spout packers).

Aroung 1950, the first rotary packer was introduced in the industry. This system has resulted in the elimination of many, previously necessary, hand-operations and now limits the activity of the operator to the application of the empty bags onto one of the several spouts of the packer. This machine is built for a capacity of up to 2'000 bags per hour.

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Despite this increase in the bagging rates, the labor force in the baghouse has not decreased appreciably. This is due to the fact that the bagging machine operators, who became free through the introduction of the rotary packer, are now needed to handle the additional flow of bags for stacking them into trucks, railroad cars, river barges and boats.

Efforts to develop a device for the automatic bag application onto the packer in order to replace the operator have so far met with little success.

One of the most labor consuming packhouse operation is the loading of bags onto trucks and into railcars. An automatic stacker has been developed and the results of the first industrial tests in France and Italy are promising.

## 11.2. Bags

### a) Jute

Less than 30 years ago the jute bag was still the standard container for shipping cement; the empty bags where returned to the cement plant.

After thorough cleaning they where inspected for damages, if necessary repaired and then re-used. This procedure permitted to keep them in circulation for extended periods of time.

Even today the jute bag can still be found and for instance in India it is widely used.

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Despite of its re-usability the jute bags have many disadvantages (dust, high labor requirements, etc.) which have forced the industry to search for improved means of cement bagging.

b) Paper

With the development of the kraft paper, cement manufacturers did not hesitate to switch their interest to the paper bag.

With the introduction of the multi-ply bag combined with the selfclosing valve it became even more popular.

The development of the expandable (elastic) kraft papers and the introduction of the polyethylene waterproof lining have been major features in creating a paperbag which can satisfy most of the requirements of cement manufacturers and users.

## 11.3. Palletizing

For many years the industry has made considerable efforts to develop the idea of palletized shipments of bag cement. Efficient palletizing machines have been in operation for more than a decade. Mostly due to the high investment cost of the equipment, the high cost of the pallets,[1] the increase in bulkshipments and the reluctance of the customers to absorb the additional cost for pallets, palletizing has not had much success outside the U.S.A.

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1) Research for cheaper and disposable pallets made of paper, plastics and wood have not yet been crowned with much success.

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THE TREND ?

Beside the possible introduction of a mechanical stacker for loading of bags into trucks and into railroad cars and the development of a low price expendable pallet, nothing revolutionary seems to appear on the market.

11.4. Bulk

With the construction of larger plants, improved means of transportation, the development of the ready-mix concrete, the cement industry has seen its bulk shipments increase at a steady accelerating rate.

Today there exist plants which ship up to 95% of their production in bulk. The average in most of the developed countries does however already exceed the 50% mark.[1] In most of the developing countries this rate is much lower.

1) See report on the Cement Industry Statistics 1969-OECD-Paris.

The percentage of bulk in the OECD countries in 1969 was the following :

| | | | | | |
|---|---|---|---|---|---|
| Germany | : 64% | Austria | : 45% | Greece | : 10% |
| Belgium | : 61% | Denmark | : 68% | Turkey | : 2% |
| Netherlands | : 77% | Sweden | : 85% | USA | : 90% |
| France | : 56% | Switzerland | : 76% | | |
| Italy | : 48% | Spain | : 35% | | |

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From modest beginnings approximately 25 years ago, the industry has made considerable progress as to the techniques of loading bulk cement into trucks, railway containers, river barges and ocean going ships.

Problems with transportation of cement to the loading spouts, heavy dust emission in the plant areas and spilling of cement by the transportation equipment, have been the most serious drawbacks of the bulk-loading operations. With the development of better means of cement conveying, telescopic loading spouts and more efficient dust collection systems, the situation has improved. Today it is possible to load bulk-cement absolutely dustfree into trucks and railroad cars at rates exceeding 200 tons per hour and into barges and boats at rates exceeding 1'000 tons per hour.

THE TREND ?

More and more shipments of cement by bulk and development of more efficient bulk loading installations. Further development of bulk transportation by whole train loads between plants and major distribution or consumption centers.

## 12. PLANT CONCEPTION AND PROCESS CONTROL

In the past, plants were small, or, if large, processes were divided into major segments, each of them operated from a separate control room.

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Technological restrictions did limit the size of the operating units. Communications between plant and control room operators used to depend on personal or voice contacts. Therefore the distances between operating equipment and control centers could not be too long.[1)]

In the cement industry, the change to centralized controls with a single control room for the entire plant started approximately 15 to 20 years ago.

With the development of larger production units and the introduction of the digital computer, cement engineers are adopting the more integrated system of plant layout and automatic process control. Today a considerable number of plants are built according to the "one-line straight through flow" layout method. Consisting of single production units for each operation, a large number of them are equipped with Analog or DDC computers.

## 13. AUTOMATION

Automation is a new way of life. It requires a different thinking; it is in many ways in direct contradiction with the conventional accepted methods. It breaks down the barriers between plant departments; it leads to the principle of integration, and more direct management control of the operation.

1) Jay MATLEY "Where Operations & Maintenance are going" Chemical Engineering, January, 1969.

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Automation does not normally result in large manpower reductions. However if properly applied it should have a positive effect on equipment availability, fuel consumption, production capacity, refractories life and cement quality.

Today there are approximately 5 or 6 fully automated plants in operation in the U.S.A., two in France and one in Canada. Fully integrated and automated plants are presently under construction in Italy, Venezuela, Algeria and Sweden.

What does automation cost? It is easy to prove that a computer control system with all its special instruments, sensors, shieldings, etc., costs considerably more than a conventional or semi-automatic installation. But if a plant is designed to take advantage from the beginning of all the possibilities automation and modern equipment technology present, the higher investment cost for a computer system is returned many times over. These reductions are mostly the result of fewer and smaller material storage facilities, smaller equipments for the same production capacity, a reduced number of production units, etc.

THE TREND ?

Cement people are now willing to consider the possibilities and advantages automation might bring. For many plants, including some of them being built in developing countries, process automation is specified by the owner right from the begining. In most cases automation is applied as the basis for plant conception and operating philosophy.

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Automation is feasible even for smaller units (possibly to a reduced degree). Within a few years it will become standard practice for cement plants in developed as well as developing countries (see Algeria, Togo).

## 14. PERSONNEL TRAINING

Complete mechanization, combined with modern automation have contributed to a reduction of the number of operating personnel. This number, although production capacities have risen considerably, is now approximately one third of the total strength needed not very long ago.

The development of large plants, equiped with process automation has had a considerable effect on the qualification requirements of the managerial and technical operating staff. Cement plant operation was formerly an art based on imponderable criteria and the experience acquired in long years of operation. Today however, systems engineering has developed methods which make it possible to learn plant operating procedures and techniques in classrooms.

Personnel recruitment and interchangeability are greatly facilited by this type of education and practical training possibilities. The required skill for computer use and standard maintenance can easily be acquired in training courses organized by equipment suppliers.

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The relatively high operational availability of industrial computers and of their peripherals require few specialized interventions. Routine tasks being executed by the computer, operational personnel have more time for analytical and previsional activities.

Except for a limited number of operators, the training of the future personnel for an automated plant is not essentially different from that of a conventional one. The difference affects mostly key people.

# CHAPTER II

## IMPACT OF RECENT TECHNOLOGICAL DEVELOPMENTS ON THE CEMENT INDUSTRY IN DEVELOPING COUNTRIES

It is a fact that engineers and equipment suppliers have applied, and to a certain extent still are different standards for cement plants to be realized in developed and in developing countries. Such a policy was, among other reasons, justified because of a lack of sufficiently skilled and reliable workmen.

Many developing countries were happy to see industrial plants being built within their boundaries and did not care very much if the plant could be considered as modern or not.

The situation has changed and today many developing countries and their young generation of better trained and more business minded functionaries, industrialists, economists and engineers have established industrial and technical standards which compare favorably with the ones applied in developed nations.

The developing countries and their more selfassured technical elite are mostly free of many of the restrictive considerations which not so very long ago were imposed upon them.

On the other hand, 2'000 to 4'000 tons per day capacity superplants cannot be built just anywhere and many developing countries have markets which hardly justify the installation of a 300 tons per day plant.

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In many of these areas, lacking proper means of transportation, the need of cement, especially at the beginning of the economical evolution, might require the installation of cement manufacturing facilities of even lesser capacities than that.

But looking at it from an equipment and operational point of view, there is no reason why the cement equipment industry could not provide technologically well developed plants of practically any size and which do not require more operational skills than the more ancient installations.

The best installation will not work satisfactorily if it is built at the wrong location, if the wrong process has been chosen, or if for lack of proper geological prospecting, raw materials are insufficient as to reserves and quality.

The notion that developing countries should be provided with plants of inferior conception as compared to those built in developed countries is definitely to be rejected. Modern machinery and industrial installations are of high operational availability and relatively easy to operate and maintain.

It often happens that in their promoting efforts for new industries, developing countries receive unqualified advise. Many examples of plants, which have been built with the best of intentions, but have never goten of the ground to produce cement economically by any standard, do regretfully still exist.

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An important consequence of recent technological developments in the cement industry on developing countries is the necessity to train administrators, engineers and operators who, under the guidance of qualified organizations, will be capable to evaluate and specify their countrie's needs.

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# CHAPTER III

## PROBLEMS WHICH MIGHT ARISE IF THE TREND IN TECHNOLOGICAL DEVELOPMENT IS MAINTAINED

### SECTION 1 - THE CEMENT PLANT OF THE FUTURE

In order to answer this question, one must try to anticipate what the future will look like in cement plant design and operation.

#### 1 - Capacities of plants will increase more and more

A few years ago, it was maintained that for Europe the ideal plant size was 400'000 tons per year capacity. The same authority recently upgraded this estimate to 500'000 tons per year.[1)]

The size of a cement plant does not any longer depend upon technological possibilities. "It is generally accepted that the limiting factors on desirable cement plant size are the size and location of acceptable markets and the costs of physical distribution for adequate services of these markets".[2)]

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1) See "Entreprise" - Paris - Ciments Lafarge : "Réflexion sur une politique d'investissements". Sept. 1966 - P. 19 to 25.

See also "Entreprise" - Paris - Interview Marcel Demonque (Chairman of Ciments Lafarge France) - 31 oct. 1970-

2) "The effect of distribution costs on plant size" by R. Sterling Harwell Jr. - Rock Products - May and June 1969.

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Larger plants will be built close to very dense markets (industrialized and populated areas) or at locations where these markets are easily and economically accessible (waterways, sea transportation, special rail freight rates).

The plant sizes of the future will be largely influenced by economic rather than technological possibilities.

2 - Capacities of individual production units will also continue to increase.

Up to approximately 10 years ago, kilns of 1'000 tons/day capacity (330'000 tons annually) were considered very large. Today, kilns of 3'500 tons/day capacity (1'150'000 tons annually) are accepted as standard and some cement companies are already planning kilns of up to 6'000 tons/day capacity.

Mills which 10 years ago were limited to 1'000 or 1'500 HP have sky-rocketed into the 10'000 HP range.

An interesting example of this trend is the Amöneburg plant (Germany) of the Dyckerhoff Company.

The company has proceeded to replace ten wet kilns of 3,2-3,8 m. in diameter with a total production of 4'000 tons per day by two kilns of 2'500 tons/day capacity each. The gain is 1'000 tons/day of production plus enormous savings in maintenance, personnel, fuel, etc.

3 - The technological trends of the late sixties will be consolidated

Conventional long wet and dry process kilns will slowly disappear from the scene. Less complex clinker cooling

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equipments are in the development stage and some operators are again attracted by the simplicity of the planetary cooler.

Autogenous grinding, as already used in the mining industry, as a replacement for the conventional crushing operations, will be given more and more consideration.

More refined systems of spare parts service will replace most present forms of maintenance repair.

Production materials with higher degrees of abrasion and heat resistance will be widely used.

Equipment availability considerations will outrank certain outdated and overvalued efficiency requirements. The availability of reliable on-line analyzers, combined with careful geological evaluation of raw materials deposits, new process methods, mathematical simulation of raw mix design possibilities, etc. will allow utilization of raw materials of a more marginal quality.

Due to customers' demand, cement will be more and more delivered in bulk form.

4 - Cement plants will become more automated

The totally integrated plant appears on the horizon and process automation by computer program will be more widely accepted. Automation will eventually become an integral part of practically every operation.

The feasibility of automating the main production lines (raw grinding, homogenization, clinkerization, clinker cooling, cement grinding) has been proven in actual operation

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since the beginning of the sixties. As a result of this, the conventional labour force will be largely replaced by chemists and skilled specialists in mechanics, electricity and automation.

5 - Old and obsolete plant will be scrapped or totally modernized

It has been stated that by modern standards approximately 70% of the cement installations in North America were obsolete as late as 1966.[1)] This was probably not only true then and for North America but still is the case today and applies to many other countries.

Approximately five years ago, the industry all over the world started a drive toward modernization; the trend seems to be set for many years to come.

As a conclusion, the cement plant of the future will be large (by today's standards), equiped with big production units, automated, integrated and will employ very few people. It will exploit raw material deposits which would presently be considered as unsuitable. Dry process will be the most usual way of manufacturing cement.

1) See Rock Products - April 1968 - "For the Cement Industry : a time of crisis", by R. Stirling Harwell.

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## SECTION 2 - THE PROBLEMS OF THE FUTURE

The planning and construction of the cement plant described in the preceding Section 1 will not encounter technological problems that cannot be solved.

Some of the problems which may arise will be of operational nature. Special care will have to be given to the training of the cement plant operating force.

Application of systems engineering principles and an analytical approach to the various problems, will enable the cement industry to solve most difficulties of operational nature.

However from a financing point of view, the investment burden for cement companies increases as plants become larger. Mergers and regional co-operation in the developing countries may be the answer to this particular problem.

# PART III

## CEMENT PRODUCTION, CONSUMPTION AND TRADE IN THE WORLD

# CHAPTER I

## PRODUCTION OF CEMENT IN THE WORLD

### SECTION 1 - THE GENERAL TRENDS IN CEMENT PRODUCTION

It is estimated that the world cement production in 1913 amounted to 39'500'000 tons. Twenty five years later, in 1938, it totalled 86'700'000 tons, thus growing at a rather moderate average compound rate of 3,1% per year.[1)]

During the following twenty five years, 1938-1963, and in spite of World War II, cement production increased at a rate of about 5,8% per year, reaching 374 millions tons in 1963.

From 1963 to 1969, cement production did progress at a faster pace than during the preceding period; the average annual rate of growth rose to 6,3%.

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1) Statistical information in this chapter are generally drawn from Cembureau sources :

- World Cement market in Figures - Production - Trade - Consumption - 1913/1956
- Annual Cembureau Statistical Review.

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Table 21 : World cement production

| | | |
|---|---|---|
| 1913 : | 39'500'000 | Tons |
| 1938 : | 86'700'000 | " |
| 1948 : | 102'100'000 | " |
| 1949 : | 117'200'000 | " |
| 1950 : | 133'000'000 | " |
| 1960 : | 314'200'000 | " |
| 1961 : | 330'000'000 | " |
| 1962 : | 355'000'000 | " |
| 1963 : | 374'000'000 | " |
| 1964 : | 411'000'000 | " |
| 1965 : | 430'500'000 | " |
| 1966 : | 457'500'000 | " |
| 1967 : | 482'000'000 | " |
| 1968 : | 513'000'000 | " |
| 1969 : | 540'000'000 | " |

One of the principal trends of the world cement production for the past twenty years is the decrease of the share of the more industrialized countries and the disparity of the rate of growth among the producing countries.

In 1969, 114 countries or territories were producing cement.

On a worldwide basis, it is possible to select three large groups of cement manufacturing areas :

a) the old industrialized countries of Western Europe and North America, which commanded 69% of the world production in 1949. Their share has reduced to 45% in 1969;

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b) the newly developed countries of Eastern Europe, Australia, Israël, Republic of S. Africa, the USSR and Japan, whose share of the world production rose from 18% in 1949 to 36% in 1969;

c) the developing countries of Latin America, Africa, Asia and Oceania, which represented less than 12% of the world production in 1949, have increased their share to 16% in 1969.

Table 22 : Percentage of world cement production

| | 1969 | 1960 | 1949 |
|---|---|---|---|
| 1. Old industrialized countries | | | |
| - Western Europe and Turkey | 31,6 | 33,0 | 37,1 |
| - North America | 14,1 | 19,0 | 32,4 |
| | 45,7 | 52,0 | 69,5 |
| 2. Newly developed countries | | | |
| - Eastern Europe | 8,1 | 7,5 | 6,1 |
| - USSR | 16,6 | 14,7 | 6,9 |
| - Japan, Australia, N. Zealand. S. Africa, Israël | 11,6 | 9,5 | 5,2 |
| | 36,3 | 31,7 | 18,2 |
| 3. Developing countries | | | |
| - Africa | 2,1 | 1,9 | 1,6 |
| - Asia | 8,0 | 5,8 | 4,3 |
| - Latin America | 6,1 | 5,5 | 5,7 |
| | 16,2 | 13,2 | 11,6 |
| 4. China (Mainland) | (1,8) | (3,1) | (0,7) |
| 5. World Total | 100,0 | 100,0 | 100,0 |

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The rates of production growth for these three groups of countries for the period 1949-1969 were the following (Table 23) :

Table 23 : Production and annual rates of growth - 1949 - 1960 - 1969

| | Production (million tons) | | | Annual rate of growth (%) | |
|---|---|---|---|---|---|
| | 1969 | 1960 | 1949 | 1960-1969 | 1949-1960 |
| 1. Old industrialized countries | | | | | |
| - Western Europe and Turkey | 171 | 102 | 43 | 5,8 | 7,9 |
| - North America | 76 | 59 | 38 | 3,0 | 3,9 |
| | 247 | 161 | 81 | 4,8 | 6,4 |
| 2. Newly developed countries | | | | | |
| - USSR | 90 | 46 | 8 | 7,7 | 16 |
| - Eastern Europe | 44 | 23 | 7 | 7,5 | 11 |
| - Japan | 51 | 22 | 3 | 9,8 | 19,6 |
| - Others 1) | 12 | 7 | 3 | 6,2 | 8 |
| | 197 | 98 | 21 | 8,0 | 15,0 |
| 3. Developing countries | | | | | |
| - Africa | 11 | 6 | 2 | 6,9 | 10,5 |
| - Asia | 43 | 16 | 5 | 10,3 | 12,3 |
| - Latin America | 33 | 17 | 7 | 7,7 | 8,4 |
| | 87 | 39 | 13 | 9,3 | 10,7 |
| 4. China (Mainland) 2) | 10 | (--) | (--) | (--) | (--) |
| 5. World Total | 541 | 314 | 116 | 6,3 | 9,7 |
| | | | | 1949 - 1969: 8,0 | |

1) Australia, New Zealand, Israël, Rep. of S. Africa
2) Estimates

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## SECTION 2 - THE MAJOR PRODUCING COUNTRIES, STRUCTURE OF THEIR CEMENT INDUSTRY

### 1 - Major producing countries - Statistical information

Table 24 indicates the 25 major cement producing countries in the world in 1969 and in 1960.

Total production of the 25 major cement producing countries in 1969 amounted to 455 millions tons, representing 84% of the world production. In 1960, it totalled 270 millions tons, representing 86% of the world production.

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Table 24 : Major cement producing countries
(Figures in thousand tons)

| | 1969 | | | 1960 | |
|---|---|---|---|---|---|
| 1 | USSR | 89'800 | 1 | USA | 53'480 |
| 2 | USA | 68'450 | 2 | USSR | 45'500 |
| 3 | Japan | 50'780 | 3 | W. Germany | 25'845 |
| 4 | W. Germany | 34'420 | 4 | Japan | 22'425 |
| 5 | Italy | 31'360 | 5 | Italy | 15'825 |
| 6 | France | 27'880 | 6 | France | 14'175 |
| 7 | United Kgdom | 17'470 | 7 | United Kgdom | 13'500 |
| 8 | Spain | 16'015 | 8 | China (Mainland) | (12'000) |
| 9 | India | 13'625 | 9 | India | 7'830 |
| 10 | Poland | 11'590 | 10 | Poland | 6'600 |
| 11 | China (Mainland) | (10'000) | 11 | Canada | 5'340 |
| 12 | Brazil | 7'825 | 12 | Spain | 5'145 |
| 13 | East Germany | 7'800 | 13 | Czechoslovakia | 5'050 |
| 14 | Rumania | 7'515 | 14 | E. Germany | 5'035 |
| 15 | Canada | 7'275 | 15 | Belgium | 4'600 |
| 16 | Czechoslovakia | 7'040 | 16 | Brazil | 4'445 |
| 17 | Mexico | 6'970 | 17 | Mexico | 3'090 |
| 18 | Belgium | 6'270 | 18 | Rumania | 3'055 |
| 19 | Turkey | 5'795 | 19 | Switzerland | 3'040 |
| 20 | South Africa | 5'114 | 20 | Austria | 2'830 |
| 21 | Greece | 4'940 | 21 | Sweden | 2'810 |
| 22 | South Korea | 4'870 | 22 | Australia | 2'795 |
| 23 | Austria | 4'580 | 23 | South Africa | 2'700 |
| 24 | Switzerland | 4'550 | 24 | Argentina | 2'615 |
| 25 | Argentina | 4'350 | 25 | Yugoslavia | 2'390 |

Sources : Cembureau - World Cement Market in Figures - 1913-1966
Statistical Review-Survey 1969.

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Most of the major cement producing countries are developed countries of Europe, America, Asia and Africa.

Some changes have occured in the classification of these major producers between 1960 and 1969.

Since 1962, the USSR is the largest world cement producer. According to recent information,[1] this country is expanding its capacity considerably. A new manufacturing unit with an annual capacity of 3'600'000 tons is projected for construction at Staryl Osky, in the area of Belgorod. When completed, this plant will be the largest ever built. In 1970, a total of 8 million tons of new capacity is to be made available. The trend towards larger plants is very noticeable in the USSR, where only 0,8% of the total production is manufactured in cement plants with an annual production inferior to 200'000 tons.

The rate of growth of cement production in the USA has followed the rather slowly increasing rate of cement consumption. During the second part of the 1960's the US cement industry has experienced a severe crisis.

Better selling prices in 1969/1970 have encouraged the modernization and automatization of existing facilities and their extension in order to increase the production capacity.

1) Cemento Hormigon - Revista Tecnica - Barcelona - Numero 440 - November 1970 - Panorama de la industria del cemento europea en el año 1969 by P.P. Llovet.

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"About 3,6 million tons of new capacity will be installed in the United States in 1970-71, compared with 2,2 million tons in 1969-70, while nearly 2 million tons are expected to be withdrawn during these two years owing to plant closures".[1]

Japan is now the third largest cement producing country in the world. With an estimated annual production capacity of 69 million tons in 1969[2] and with a corresponding utilization rate of 73,7% the country is presently suffering from a considerable over capacity.

West Germany which in 1969 was number 4 in the world, is the largest European cement producer. At the end of 1969, this country had 95 cement plants, equiped with 197 kilns, in operation. The average plant capacity was 360'000 tons, and the average kiln production capacity 175'000 tons. As a matter of comparison, in 1954, the West German cement industry was operating 361 kilns with an average capacity of 45'000 tons per kiln, for a total annual production of 16 million tons.[3]

Italy is the worlds number 5 producer of cement. Cement production in 1969 amounted to an average of 265'000 tons for 118 plants.[4] Important concentration, integration and mergers are presently taking place in the Italian cement industry.

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1) The Cement Industry - 1969 - OECD - Paris.

2) OEDC report on Cement Industry in 1969 - op. cit. Table 6.

3) Information from "Panorama de la industria del cemento europea en el año 1969" by P.P. Llovet - Cemento - Hormigon - No 438 - Sept. 1970.

4) Same source as for 3.

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The cement industry of these five countries accounts for 50% of the world production.

Europe is by far the largest cement producing continent. Production is distributed among the main economic groups as indicated in the following table 25.

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Table 25 : European production of cement

| (thousand of tons) | | 1969 |
|---|---|---|
| 1. European Economic Community | | |
| W. Germany | | 36.422 |
| Belgium-Luxembourg | | 6.209 |
| Nethorlands | | 3.296 |
| France | | 27.543 |
| Italy | | 31.347 |
| | Total E.E.C. countries | 102.817 |
| 2. European Free Trade Area | | |
| Austria | | 4.383 |
| Denmark | | 2.432 |
| Finland | | 1.759 |
| Norway | | 1.794 |
| Portugal | | 2.035 |
| United Kingdom | | 17.455 |
| Sweden | | 4.072 |
| Switzerland | | 4.495 |
| | Total EFTA countries | 38.425 |
| 3. Other OECD member countries | | |
| Spain | | 16.013 |
| Greece | | 4.832 |
| Ireland | | 1.237 |
| Iceland | | 93 |
| Turkey | | 5.795 |
| | | 27.970 |
| 4. Total European OECD countries | | 169.212 |
| 5. Eastern Europe | | |
| Yugoslavia | | 3.870 |
| Albania | | (220) |
| Bulgaria | | 3.551 |
| Czechoslovakia | | 7.044 |
| East Germany | | (7.800) |
| Hungary | | 2.564 |
| Poland | | 11.592 |
| Rumania | | 7.514 |
| | Total Eastern Europe | 44.155 |
| | Total Europe (without USSR) | 213.367 |
| 6. USSR | | 89.800 |
| | Total Europe (with USSR) | 303.167 |
| 7. Total World | | 540.000 |

Sources : OECD - The Cement Industry 1969 - Cembureau - Statistical Review - Survey 1969.

2 - Major producing countries - Structure of the industry

Identical general trends have been observed in the major producing countries of Europe and in the rest of the world :

- the capacity and the productivity of the cement plants have increased considerably;
- the size of installations and equipments have become larger;
- the number of cement companies has decreased;
- cement manufacturers tend to control their market through the integration of the physical distribution of cement and of concrete manufacturing;
- old and obsolete cement plants are being scrapped.

Some of the above points are emphasized in the 1969 Report on the Cement Industry published by the Organisation for Economic Co-operation and Development (p. 16 and 19) :

> "Output of cement in the OECD area as a whole rose by 4,3% whereas the industry's labour force was virtually stable (in 1969) compared with the previous year...... Kiln capacity reached about 415'000 tons annually in 1969 compared with 340'000 tons in 1968.... Except for Japan... ... more capacity appears to have been taken out of production in 1969 than in the previous year. Among the European countries, the scrapping of 600'000 tons of capacity in Germany should be noted. The capacity of plantsclosed in the United States exceeded one million tons".

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3 - Types of cement produced in the Western European countries

Several types of cements are manufactured in Europe but not everywhere in the same proportions.

There is a general trend (as for instance in North America) towards high early strength cements. "Pure" Portland cements are given more and more preference over products containing additions such as slag and pozzolanic materials.

Cement of this last type is, nevertheless, still manufactured in large quantities in some countries.

Table 26 shows the distribution of cement production by types in some European countries, in 1967.

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Table 26 : Types of cement produced
1967 - in some European countries

| | In % of total cement production | | | |
|---|---|---|---|---|
| | Ordinary Portland Cement | Other (1) Portland Cements | Cement (2) with additives | Others (3) |
| Belgium | 53,0 | 28,0 | 19,0 | -- |
| France | ----- 82,8 ------ | | 12,9 | 4,3 |
| Germany | ----- 70,1 ------ | | 28,0 | 1,9 |
| Netherlands | 46,1 | 1,5 | 52,4 | -- |
| Norway | 88,0 | 10,0 | -- | 2,0 |
| Switzerland | 93,8 | 6,2 | -- | -- |
| United Kingdom | ----- 98,0 ------ | | ----- 2,0 ------ | |

1) Lowheat, rapid hardening, high strength, sulfate resisting Portland, white, etc.

2) Mixtures of Portland clinker and slag, fly ash, pozzolan, etc.

3) Pure pozzolan, aluminious, etc.

Source : Cembureau - Paris - Bulletin No 50 - The cement market in 1967.

# CHAPTER II

## CEMENT PRODUCTION IN DEVELOPING COUNTRIES

### SECTION 1 - GENERAL STATISTICAL INFORMATION

In passing from 39 million tons to 87 million tons, cement production in the developing countries has more than doubled during the period 1960-1969.

Table 27 indicates the breakdown of cement production by geographical areas in Africa, Asia and Latin America as well as the rate of increase for each area between 1960 and 1969. Figures include cement produced both in cement plants and in clinker grinding stations.

If the average annual rate of growth for the developing countries was 9,3% during the past decade, Table 27 shows the discrepancies which have occured among the continents and among each of the producing areas.

Some areas do not follow the world rate of growth of 6,3% per year : South Africa, East coast of South America. The most remarkable production increases have taken place in Asia.

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Table 27 : Cement production in developing countries

| (in thousand tons) | 1969 | 1960 | Annual rate of growth 1960-1969 |
|---|---|---|---|
| **AFRICA** | | | |
| North Africa | 6'190 | 4'090 | 4,5% |
| East Africa | 1'630 | 800 | 8,2% |
| South Africa (1) | 680 | 425 | 5,3% |
| West and Central Africa | 2'620 | 700 | 15,7% |
| Total Africa | 11'120 | 6'015 | 7,0% |
| **ASIA** | | | |
| Middle East (2) | 6'350 | 3'070 | 8,4% |
| South West Asia | 16'960 | 9'130 | 7,1% |
| South East Asia | 5'250 | 1'510 | 15,0% |
| East Asia (3) | 14'590 | 2'405 | 21,5% |
| Total Asia | 43'150 | 16'115 | 10,3% |
| **LATIN AMERICA** | | | |
| Mexico | 6'970 | 3'090 | 8,5% |
| Central America | 920 | 390 | 10,0% |
| West Indies | 4'660 | 1'450 | 13,5% |
| S. Am. East Coast | 15'170 | 8'975 | 6,0% |
| S. Am. West Coast | 5'420 | 3'030 | 6,6% |
| Total L. America | 33'140 | 16'935 | 7,7% |
| Total Developing countries | 87'140 | 39'065 | 9,3% |
| World | 540'000 | 314'000 | 6,3% |

1) Rep. of South Africa not included

2) Turkey and Israël not included

3) China (Main land) and Japan not included

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## SECTION 2 - REVIEW OF THE STATE OF THE CEMENT INDUSTRY IN THE DEVELOPING COUNTRIES

### 1 - Africa

a) North Africa is on the threshold of a boom in cement production. Plant expansions and modernizations have recently taken place in Morocco. In Algeria, it is planned to increase cement production capacity from 950'000 tons in 1970 to 3'750'000 in 1974 (two new one million tons capacity plants are under construction near Algiers and near Annaba). Lybia, long a non producing country, is presently building its second cement plant, while in Tunisia several new projects are under considerations. Partly in order to supply the export market the already strong Egyptian industry is contemplating the addition of new capacity.

b) West Africa which, for a long time, has been one of the largest cement importers in the world is now on its way to self sufficiency.

By the end of 1969, the only cement plants of this region were located in Senegal, Nigeria, Republic of Niger, Angola and the two Republics of Congo. Their production amounted to approximately 1'500'000 tons. In addition, a series of clinker grinding stations, manufacturing cement with clinker imported from Europe, have been or are being installed in Sierra Leone (closed after a very short period of operation), Liberia, Ivory Coast, Togo, Dahomey, Ghana, Nigeria, Gabon, Cameroun. In 1971, these clinker grinding stations will manufacture around 1'400'000 tons of cement.

In addition, studies with a view to exploiting the scarce and low quality limestone deposits of this area are presently under way. Small cement plants have recently been

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built in Mali and Cameroun. The construction of a 300'000 t/year plant in Dahomey is under serious consideration. The most important cement project of Western Africa is the Aveta plant (Togo), with a production capacity of one million tons per year; the clinker from this plant will be shipped to clinker grinding stations located on the Ivory Coast, in Togo, Upper Volta (when realized) and Ghana.

Various expansion programs are under way in Nigeria and the Congo (Kinshasa).

At the end of 1970, the countries still without cement plants or clinker grinding stations (operating or under construction) within their boundaries were Guinea, Chad, Gambia, Mauretania, Upper Volta, Central African Republic, Equatorial Guinea. The 1969 cement consumption of these countries amounted to approximately 160'000 tons (less than 8 kilogs per capita).

c) In East and South Africa, almost all countries with the exception of the Indian Ocean Islands (Comoro Islands, Seychelles, Mauritius, Reunion), the Republic of Somali and the French territories of Afars and Issars, are cement producer. The non producing countries accounted for a cement consumption of 300'000 tons in 1969. New clinker grinding stations are contemplated at La Reunion and at Tamatave (Malagasy Republic).

2 - Asia

a) In West Asia[1)] (also called "Middle East), the producing countries during the 1960's have expanded their

1) Israël and Turkey not included

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production capacity at a growing rate. The three cement plants of Saudi Arabia are planned to double their present capacity. New expansions are expected in Syria (three plants of 300'000 T capacity each), Iran and Iraq.

A new cement plant of 100'000 T/capacity has recently been completed in Qatar. In the Arabia Peninsula there exist, however, large cement consuming areas which do not have a cement industry of their own (Yemen, South Yemen, Kuwait, Bahrain) and whose cement consumption amounted to approximately 1'800'000 tons in 1969. All the countries of the Arabic Peninsula, with the exception of Bahrain and South Yemen, have launched feasibility studies regarding cement plants or clinker grinding stations.

b) The India group (South West Asia) is led by India which manufactured 13'600'000 tons of cement in 1969. "There are now (1969) a total of 44 cement plants in India, operated by 25 companies, with 6 under expansion and 9 more under construction".[1] At the end of the 4th Plan, India's capacity is expected to reach 19'600'000 tons (1974). It is interesting to note that the Indian government organized the Cement Corp. of India "to survey the entire country for limestone deposits and build whatever plants necessary to supplement production". On the other hand, the Indian Associated Cement Companies (ACC) has erected its own factory

1) Information regarding India, in this paragraph, is from : "Cement in a developing country" by C.F. Clausen - Rock Products - February 1969.

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for the manufacture of cement plant equipment. The Indian Cement Industry is characterized by relatively small size kilns (new kilns are standardized at a capacity of 600 tons per day)and by a high labour consumption (varying between 4.4 and 20.12 man hours per ton, the average is 10.18 man hours per ton of finished cement). A new 500'000 t/year capacity cement plant has been put into operation in Ceylon in 1970,thus making this country self sufficient.

Pakistan's 4th Plan provides for the doubling of the 1970 cement production capacity of 4 million tons. Eastern Pakistan cement production is largely deficient.

c) In South East Asia, the only non producing countries are Laos and Brunei; their cement consumption is relatively small (120'000 T in 1969).

Production of cement in the others countries of this region has strongly increased during the 1960-1969 period.

Cambodia has installed a new cement plant; Thailand has multiplyed its 1960 production six fold, Malaysia and Indonesia 3 fold. Production in South East Asia is still not yet sufficient to meet the demand; expansions and new capacities are planned in most of these countries.

d) East Asia[1)] has experienced a very large production increase between 1960 and 1969 (see Table 27). This resulted mainly from the creation of a powerful cement industry in North and South Korea and in Taïwan.

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1) China (Mainland) and Japan not included.

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3 - Latin America

a) Mexico and Central America

Mexico, with a production of 7 million tons in 1969, is the second largest cement producer of Latin America (after Brazil). Its industry is expanding at a regular pace.

Each of the small countries of Central America have their own cement industry, consisting of one single cement plant. Modernizations and expansions are under way. Total production of cement for Guatemala, El Salvador, Nicaragua, Costa Rica, Honduras and Panama totalled 920'000 tons in 1969. Regional co-operation within the framework of the Central America Common Market could result in industry concentration and substancial savings for the consumers.

b) West Indies

Cement production in the West Indies is dominated by Puerto Rico and Grand Bahamas. Puerto Rico may be considered as being part of the USA economic zone of influence. Sales of the large cement plant located in Freeport (Bahamas) are mainly oriented towards the East Coast of the USA.

Cuba has doubled its production between 1960 and 1969. The Dominican Republic is presently considering a large expansion of its capacity. Haïti was still producing at only 60% of its installed capacity in 1969.

In the French territories of Martinique and Guadeloupe, two 100'000 tons/year capacity clinker grinding stations are under construction. The first one will allready be operating in 1971.

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c) South America

Brazil is the largest producer of South America and number 12 world producer (see Table 24). Production capacity was estimated to be 8'500'000 T in 1969 and should reach 15 million tons by 1975.[1] 31 cement plants are operating in Brazil, 9 of them having been built during the decade 1960-1970.[2]

Argentina has 15 cement plants, whose capacity amounts to approximately 5 million tons. This capacity is not sufficient to meet the demand. Expansion of existing installation and the construction of a new plant will bring Argentina's capacity to 7'500'000 tons by 1971.

Venezuela is also expanding and modernizing its capacity. Since 1968, four new plants have either been completed or are under construction. The new Pertigalete plant (3'000 t/day) will be fully automated.

The single small plant of Paraguay (34'000 t in 1969) is due to be expanded in the near future. In Uruguay, production has been stagnant for the past ten years.

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1) Cemento - Hormigon - Barcelona - February 1970 - p. 154. "Panorama de la industria del cemento americana en el año 1968" by P.P. Llovet - Dr. Ing.

2) Industries et Travaux d'Outre Mer - Nov. 1970 - Brésil - Les perspectives de l'Industrie du ciment.

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As a whole, production increases on the Atlantic ocean side of the South American continent have been relatively modest during the last decade and have not followed the general world trend (see Table 27). In order to meet the growing cement needs of the area since 1967, importing of cement has been necessary.

On the Pacific Ocean side of the continent Colombia is the largest cement producer with 14 cement plants and one clinker grinding station. Colombia is also the largest cement exporter of South America.

Cement production in Peru has doubled between 1960 and 1965 and seems to be stabilizing at the 1965 figure (one million tons). However a new 600'000 to 1'000'000 tons capacity plant is presently in the final construction stage.

Ecuador has doubled its production from 1960 to 1969; expansion of one of the plants is under study. Bolivia is also expanding its capacity in order to meet the increasing demand.

Chile, on the other hand, seems to suffer from over-capacity. Its 1968 production equalled the 1964 rate. Improvements have however been noticeable in 1969 (+ 15%).

# CHAPTER III

## CEMENT CONSUMPTION IN THE WORLD

### SECTION 1 - GENERAL TRENDS

#### 1 - Cement consumption per capita

World cement consumption per capita is generally increasing, but varies widely from one country to another.

Table 28 : Cement consumption per capita (in kilogrammes)

| | 1938 | 1949 | 1960 | 1969 |
|---|---|---|---|---|
| World | 40 | 50 | 104 | 152 |
| Africa | 18 | 27 | 40 | 49 |
| North America | 133 | 231 | 299 | 342 |
| Latin America | 32 | 54 | 85 | (125) 1) |
| Asia | 9 | 8 | 33 | 56 |
| West Europe | 127 | 131 | 289 | 487 |
| East Europe | 48 | 76 | 230 | (375) 1) |
| USSR | 33 | 42 | 211 | 364 |

Source : Cembureau : World cement market in figures 1913-1956 = Statistical Review 1969.

1) Estimates

The reasons for these variations have been given earlier in this report.

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In 1969, West Europe was leading the cement consumption per capita, the highest figures being reached by Switzerland (726 kg), Italy (591), Austria (587), Germany (583) and France (535), the lowest by Turkey (176) and Portugal (209).

In East Europe, the largest cement consumer is Czechoslovakia (515 kg in 1969), followed by East Germany (432); the lowest is Albania (129).

Compared with the other world areas, North America, after having lead world cement consumption for years, has been slowing down considerably.

In the vast land locked areas of Africa, cement consumption is only 10 kgs per capita; India, with a density[1] of 160 inhabitants per km2, consumed only 25 kg per inhabitant in 1969. Japan, on the other hand, is the largest cement consumer in Asia with 477 kg per inhabitant in 1969.

Extreme variations in consumption figures are found in the Latin American countries, from Puerto Rico with 592 kg to Paraguay with 15 kg and Haïti with 13 kg. Cuba and Argentina are medium cement consumers (188 and 194 kg). Brazil has not yet reached the 100 kg mark (91 kg in 1969).

Cement consumption in the developing countries, although increasing rapidly, is still very low, thus indicating the enormous potential demand which exists in these areas.

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1) Source United Nations statistics.

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SECTION 2 - FUTURE WORLD CEMENT CONSUMPTION - ITS CONSEQUENCES

If the world cement demand, during 1970-1980, continues to grow at the same rate as during 1960-1969, i.e. at 6,3% per year, it will reach around one billion tons in 1980, corresponding to a cement consumption of 250 kg per capita (which is still modest).

World production capacity being estimated to be about 600 million tons in 1969, 400 million tons of additional capacity will be necessary to meet the 1980 demand.

Almost traditionally the cement industry has never made a clear distinction between real and announced production capacity. Very often the capacity of old plants, after being kept off stream for many years and hardly in operating condition, is still figuring in the production capacity announcement of many companies. As a consequence it is quite possible that world cement capacity production accumulated on an announced capacity basis, would largely exceed the above figure of 600 million tons.

The above approximate estimate emphazizes the magnitude of the problems prospective and existing cement manufacturers will be faced with in the years to come.

An annual average of 40 million tons/year of new capacity will have to be added and about 10 million t/year of old and obsolete capacity (2% of world capacity) will have to be scrapped and replaced.

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Capital expenditures necessary to install 50 million tons/year capacity amounts to approximately two and half billion dollars (at $ 50,-- per ton of annual installed capacity).

Most of this capacity is to be installed in developing countries,which will have to exploit all possible sources to finance their growing cement industry.

On the other hand, manufacturers of cement plant machinery and equipment will have to expand their production facilities. In 1969 and 1970, all the major suppliers were already overloaded with orders. As a consequence delivery times for cement plant equipment have been increasing considerably. At the same time, prices have risen continuously. This sellers' market could possibly encourage the expansion of production machinery factories in the developed countries and the creation of new equipment industries in the developing countries,as has recently been the case in India.

Should such expansion not be realized, the growth of the world cement consumption, stimulated by the ever increasing demand,would be seriously impaired.

In 1960 it was possible to put a 500'000 tons/year capacity cement plant "on stream" within 18 months from the date the decision for its construction had been taken.

In 1969/1970 construction time for a similar plant had almost doubled.

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With the continuous increase in demand for cement manufacturing equipment and machinery, the qualified suppliers have a tendency of getting rather selective about the orders they like to accept.

It can also be noted that in comparison to cement prices, equipment, machinery and general construction costs have increased considerably.

Investment costs have grown to a point where the financing and depreciation part of the production cost price has become a very heavy burden.

# CHAPTER IV

## INTERNATIONAL CEMENT TRADE

### SECTION 1 - GENERAL TRENDS - THE SHARE OF THE DEVELOPED AND OF THE DEVELOPING COUNTRIES IN WORLD CEMENT TRADE

The volume of international trade in cement represents a small share of the world cement production (see Table 29).

Table 29 : World cement production and Trade 1938-1950 and 1960 to 1969 (thousand tons)

| Years | World production | World Trade | % |
|---|---|---|---|
| 1938 | 86'700 | 5'700 | 6,57 |
| 1950 | 133'000 | 8'100 | 6,09 |
| 1960 | 314'200 | 11'200 | 3,37 |
| 1961 | 330'000 | 12'000 | 3,63 |
| 1962 | 355'000 | 12'400 | 3,49 |
| 1963 | 374'000 | 13'600 | 3,63 |
| 1964 | 411'000 | 15'700 | 3,82 |
| 1965 | 430'500 | 19'100 | 4,44 |
| 1966 | 457'500 | 18'700 | 4,09 |
| 1967 | 482'000 | 20'350 | 4,22 |
| 1968 | 513'320 | 20'300 | 3,95 |
| 1969 | 540'000 | 22'450 | 4,16 |

Source : Cembureau : World Cement Market in Figures
Statistical Review

A large part of the world trade results from exchanges among the European countries (URSS included) and between Europe or Canada and the USA.

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The developed countries of Europe and North America have imported increasing tonnages of cement from other developed countries <u>of the same areas</u> (in 1960 and 1969) as shown hereafter[1]:

| | 1960 | 1969 |
|---|---|---|
| - Western Europe | 2'810'000 T | 4'140'000 T |
| - Eastern Europe | 95'000 T | 2'910'000 T |
| - USSR | 20'000 T | 380'000 T |
| - USA and Canada | 675'000 T | 1'620'000 T |
| | 3'600'000 T | 9'050'000 T |
| Percentage of world trade | 32% | 40% |

The total cement exports of the above countries amounted to 7 million tons in 1960 and 13'220'000 tons in 1969; it resulted that their net export trade towards the developing countries was 3'400'000 tons in 1960 and 4'170'000 tons in 1960, thus increasing only by 20% during the last decade.

Japan which is the second largest cement producer and exporter in the world also increased its exports to the developing countries by only 20% from 1960 to 1969.

The most striking feature of the international cement trade during the past ten years, is the predominant position taken by the developing countries.

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1) Approximates figures only; occasional imports from countries belonging to other areas may be included.

The situation is summarized in Table 30 which shows the sources of supply of imported cement in the developing countries.

Table 30 : International cement Trade (rounded figures)

| Exporting countries | Importing developing countries 1969 | 1960 |
|---|---|---|
| Europe and USSR | 4'170'000 T | 3'400'000 T |
| Japan | 2'055'000 T | 1'600'000 T |
| Developing countries | 7'175'000 T | 2'500'000 T |
| Total | 13'400'000 T | 7'500'000 T |

Source : from Cembureau statistics.

## SECTION 2 - THE CHANGE TO CLINKER AND BULK CEMENT IN INTERNATIONAL TRADE

The international cement trade is following an identical trend to that of domestic trade, with respect to the progressive substitution of clinker and of cement in bulk form to the traditional paper bags package.

Clinker exports from members of the OECD[1)] to non-member countries (mostly African countries) amounted to 280'000 tons in 1960 and to 945'000 tons in 1969. Japan is shipping clinker and bulk cement all over Asia (330'000 T of

1) Source : Organisation for Economic Co-operation and Development - Paris - Reports on the Cement Industry - 1960 - 1969.

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clinker in 1968). A Kenyan cement company[1] is shipping bulk cement to Mauritius Island and clinker to La Reunion. Venezuela is shipping bulk cement into the Caribbean area.

No general statistics are presently available regarding the volume of cement which is handled in the form of bulk cement or clinker. However, available information permits to state that this trend is due to continue, as new clinker grinding stations are being installed in West Africa, Martinique and Guadeloupe, New Caledonia, Middle East, etc.

## SECTION 3 - THE EXPORTING COUNTRIES

Table 31 indicates the 25 major exporting countries in 1969 and 1960. These 25 countries accounted for 89% of the total world trade in 1960 and 84% in 1969.

In Table 31, the exporting countries are listed according to the volume of their export business. One can however notice three distinct categories of exporting countries :

1) the countries with large production capacity which export but a small share of their production : USSR, Japan, France, Germany (W. and E.), United Kingdom, Poland.

1) See Industrie et Travaux d'Outre Mer - Paris, Oct. 1970.

Table 31 : Major cement exporting countries and percentage of their export business in relation with their production.

(thousand tons)

| 1969 | | | % of prod. | 1960 | | | % of prod. |
|---|---|---|---|---|---|---|---|
| 1. | USSR | 2'700 | 3,0% | 1. | Japan | 1'617 | 7,2% |
| 2. | Japan | 2'054 | 4,0% | 2. | France | 1'351 | 9,6% |
| 3. | W. Germany | 1'649 | 4,7% | 3. | Belgium | 1'324 | 28,7% |
| 4. | Rumania | 1'500 | 20,0% | 4. | Un. Kgdom | 1'107 | 8,1% |
| 5. | Belgium | 1'400 | 21,0% | 5. | W. Germany | 953 | 3,7% |
| 6. | Norway | 1'089 | 44,0% | 6. | Egypt | 353 | 17,3% |
| 7. | France | 1'006 | 3,6% | 7. | Poland | 273 | 4,1% |
| 8. | Egypt | 885 | 24,5% | 8. | USSR | 250 | 0,5% |
| 9. | Bahamas | 680 | 98,0% | 9. | Sweden | 244 | 8,7% |
| 10. | Greece | 618 | 12,5% | 10. | Tunisia | 231 | 57,7% |
| 11. | Canada | 575 | 7,9% | 11. | Ireland | 229 | 40,2% |
| 12. | Taïwan | 553 | 13,8% | 12. | Yugoslavia | 227 | 10,5% |
| 13. | Iraq | 550 | 35,5% | 13. | Denmark | 223 | 15,5% |
| 14. | E. Germany | 420 | 5,3% | 14. | Israël | 213 | 26,6% |
| 15. | Pakistan | 400 | 14,8% | 15. | Colombia | 188 | 13,6% |
| 16. | Kenya | 379 | 59,3% | 16. | Canada | 164 | 3,0% |
| 17. | United Kingdom | 357 | 2,0% | 17. | Kenya | 158 | 55,3% |
| 18. | N. Korea | 350 | 12,5% | 18. | Italy | 157 | 1,0% |
| 19. | Lebanon | 318 | 25,4% | 19. | Lebanon | 125 | 14,7% |
| 20. | S. Korea | 291 | 5,9% | 20. | India | 116 | 1,5% |
| 21. | Malaysia | 275 | 28,0% | 21. | Rumania | 100 | 3,0% |
| 22. | Colombia | 260 | 10,4% | 22. | Portugal | 96 | 8,0% |
| 23. | Hungary | 250 | 10,0% | 23. | Iraq | 95 | 13,7% |
| 24. | Poland | 225 | 2,0% | 24. | Greece | 79 | 4,8% |
| 25. | Venezuela | 200 | 8,0% | 25. | Switzerland | 73 | 2,5% |
| Total (rounded) | | 19'000 | | Total (rounded) | | 10'000 | |
| Total world | | 22'450 | | Total World | | 11'200 | |

Source : Cembureau : World Cement market in figures 1913-1966 Statistical Review 1969

Most of these countries (with the exception of W. Germany) were exporting a larger share of their production in 1960 than in 1969. This means that their own consumption has increased at a faster rate than their capacity of production and that the revenue from their export sales was not considered high enough to justify the installation of new capacities serving the export market.

Developing countries may find in these facts additional reasons for installing their own cement industry.

2) The countries which export a very significant share of their production are : Bahamas, Norway, Kenya, Iraq, Lebanon, Malaysia, Egypt, Belgium, Rumania, Pakistan, N. Korea, Greece.

In the case of the Bahamas, the cement plant was built with export business in view (East Coast of the USA and West Indies).

The location of the Norvegian cement plant on deep water, the availability of very favorable freight rates and of special bulk (cement and clinker) carriers, makes Norway one of the largest world cement exporters. The Norvegian cement industry has acquired a large captive market in Ghana by participating in the state owned company which operates local clinker grinding stations. Furthermore, this norvagian company has created large cement silos in New-York harbor, from which it services the New-York area with imported cement.

The case of Kenya is somewhat similar to the one of Norway; the cement industry is oriented toward export

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business and supplies a vast area in the Indian Ocean region, through privately owned vessels and cement terminals.

Iraq and Lebanon have a long tradition as cement exporters. The additional production capacity, these two countries have installed during the last ten years, was mostly intended for the export market. Lebanon has recently found a very large market in Algeria in addition to its W. African outlet. Iraq's largest customers are Kuwait and the Emirates of the Arabic Peninsula.

For many years, Belgium was the largest cement exporting country in the world (1'900'000 tons in 1929). Its largest customer was the Netherlands which, for a long time, had no cement industry of their own. With the Netherlands getting progressively equipped, Belgium has been faced with a serious surplus capacity. Today Belgium exports cement all over the world.

Rumania is the largest cement exporter of Eastern Europe (USSR not included) where it finds its main customers (especially Yugoslavia). Rumania is also shipping cement to Turkey and to North and West Africa.

The Greek cement industry has considerably developed its capacity during the past years. Its desire to increase the export business is facilitated thanks to the excellent geographical location of some of its plants.

Egypt and Taïwan, each in its own sphere of influence, are very much oriented toward the export of cement, which for them is an important source of foreign exchange.

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3) Some of the East European countries are both cement exporters and importers : Hungary, Bulgaria, Poland, USSR, as well as Pakistan and West Germany (because of W. Berlin).

## SECTION 4 - THE IMPORTING COUNTRIES

Table 32 indicates the 25 major cement importing countries. In 1969 and 1960, they accounted for approximately 75% of the world cement trade.

It can be expected that the developed countries of Europe (W. and E.) and North America, which are importing large quantities of cement, are only occasional importers and that they are taking (or will take) steps to remedy a situation considered as temporary. This has already been the case with Spain, whose cement imports amounted to two and half million tons in 1965. Following a large increase of its own production capacity, Spain had reduced its cement imports to 400'000 tons by 1969. In 1971, Spain will likely be a cement exporting country.

The largest and the most prosperous of the developing countries, such as Brazil, Argentina, Indonesia, Ghana, Kuwait, Saudi Arabia, Algeria, can be classified in the same category. These countries have access to financial and technological resources which will enable them to become self-sufficient within a not too distant future.

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Table 32 : Major cement importing countries

| (thousand tons) | | | | | |
|---|---|---|---|---|---|
| 1969 | | | 1960 | | |
| 1. | Netherlands | 2'182 | 1. | Netherlands | 1'602 |
| 2. | USA | 1'550 | 2. | Saud. Arab.& Kuwait | 850 |
| 3. | Kuwait | 1'500 | 3. | USA | 639 |
| 4. | Pakistan | 1'400 | 4. | Nigeria | 637 |
| 5. | Yugoslavia | 1'075 | 5. | Algeria | 528 |
| 6. | S. Vietnam | 1'000 | 6. | Ghana | 466 |
| 7. | Lybia | 750 | 7. | United Kingdom | 466 |
| 8. | Brazil | 607 | 8. | W. Germany | 460 |
| 9. | Singapore | 610 | 9. | Indochina | 435 |
| 10. | Saudi Arabia | 560 | 10. | Hong Kong | 414 |
| 11. | Hungary | 550 | 11. | Korea | 225 |
| 12. | W. Germany | 532 | 12. | Ryukyu | 216 |
| 13. | Czechoslovakia | 536 | 13. | Malaysia | 201 |
| 14. | Italy | 475 | 14. | Pakistan | 200 |
| 15. | Hong Kong | 417 | 15. | Ceylon | 161 |
| 16. | Spain | 406 | 16. | Ivory Coast | 150 |
| 17. | Indonesia | 417 | 17. | Lybia | 140 |
| 18. | Ghana | 400 | 18. | Tanzania | 136 |
| 19. | USSR | 380 | 19. | Br. W. Indies | 129 |
| 20. | Ivory Coast | 356 | 20. | Burma | 100 |
| 21. | Argentina | 332 | 21. | Mauritius | 96 |
| 22. | Poland | 320 | 22. | Czechoslovakia | 90 |
| 23. | Algeria | 300 | 23. | Malagasy | 86 |
| 24. | Turkey | 269 | 24. | Fr. W. Indies | 86 |
| 25. | Ryukyu | 215 | 25. | Porto Rico | 65 |
| Total (rounded) | | 17'000 | Total (rounded) | | 8'500 |
| Total world | | 22'450 | Total world | | 11'200 |

Source : Cembureau : World cement market in figures 1913-1956
Statistical Review 1969

As an example, the cement industry of Mexico, Colombia, Venezuela and India are at present in a position to satisfy the cement requirements of these countries.

The developing countries not listed in Table 33 and importing less than 200'000 tons of cement in 1969 are the ones which either complement their own production with imported cement or countries with no production of their own.

Table 33 : Cement imports in Developing Countries importing less than 200'000 tons in 1969

| Geographical distribution of imports | Producing countries | Non producing countries |
|---|---|---|
| Africa | 625'000 T | 770'000 T |
| Latin America | 500'000 T | 620'000 T |
| Asia | 675'000 T | 380'000 T |
| Oceania | ... | 230'000 T |
| Total | 1'800'000 T | 2'000'000 T |

Source : Cembureau : Statistical Review 1969

## SECTION 5 - FUTURE TRENDS OF THE INTERNATIONAL CEMENT TRADE

The international cement trade is closely related to the levels of production and consumption as well as to the cost and availability of transportation.

In the developing countries, imports of cement are also conditioned by the availability of foreign exchange.

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It is likely that :

- new production capacity in the developed countries, during the period 1970-1980, will be installed to meet the cement requirements of the home markets or those of the economic blocs to which they belong, with not too much concern for the requirements of the developing countries;
- the developing countries will increase their own production. In order to benefit by the economies of scale, many of these countries will install larger capacities than actually required. The resulting surplus will be available to other countries, thus encouraging inter-regional co-operation;
- the share of the developing countries in the international cement trade will continue to grow.

# C O N C L U S I O N

## CONCLUSION

Despite the development of a large number of new building materials, cement will, for a long time to come, maintain its position as the foremost basic product for the construction industry.

As it is easy to use and may be manufactured in most parts of the world, cement is especially well adapted to the local conditions which exist in the developing countries.

The creation of their own cement industry has therefore become one of the main concerns of the developing oountries and appears in almost all of their industrialization programs.

These countries are faced with the technological trends of the modern cement industry, which are : larger equipment size, more sophisticated manufacturing processes and automation. It is anticipated that these trends will not be stopped by continental or ideological boundaries.

Free of many of the restrictive considerations and traditions which hinder the acceptance of progressive designs and methods, less industrialized countries usually reject the idea of passing through the various stages of technical evolution.

The present report shows the benefits which result from large and modern manufacturing units in regard to investments, manufacturing cost and menpower requirements.

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located within their own boundaries. Through economies in transportation and handling, the cost burden can be lowered somewhat. At the same time, the first step is made towards the creation of a new cement industry.

During the last decade, World Cement consumption has been increasing at a rate of 6,3% per annum. If this trend continues, cement consumption will double from 1969 to 1980. In order to meet this prospective demand, the world production capacity will also have to be doubled by the end of the present decade.

Reoent experience indicates that the manufacturers of cement plant equipment have difficulties to follow the demand for new installations. Less than 15 years ago it took 16 to 20 months to build a medium size plant in a developed oountry and approximately 24 to 30 months in a developing country.

Mainly due to much larger delivery time for equipment and machinery, construction time has considerably increased and in some cases has almost doubled.

This situation may have a serious impact upon the programs of some developing countries regarding the expansion of existing or the construction of new plants. As a consequence efforts should be made to promote the creation of manufacturing equipment industries in some of the developing countries.

Before starting construction of a new cement plant, requiring very large investments, developing countries must assure themselves that the proper type of installation is chosen. It must be built at the most favorable location,

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using the most suitable raw materials and be operated by well trained personnel.

Over or under sized plants may prove to be very costly propositions. A realistic market survey must precede such an undertaking. Before deciding on the type of equipment and process, developing countries should try to obtain the necessary and experienced technical assistance from organizations or firms not related to equipment suppliers.

In conclusion, the following recommendations for action may be suggested in order to promote the creation and the progress of the cement industry in the developing countries :

1) To survey the cement markets on a national and inter-regional basis.

2) To make a systematic survey of the raw material resources in the developing countries.

3) To launch a well planned promotion program regarding the application of cement and the training of the prospective users.

4) To contemplate temporary employment by UNIDO of highly qualified marketing people, engineers and operators, made available by cement manufacturers or spezialized consulting firms, who would be put at the disposal of the developing countries.

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5) To promote periodic marketing and technical seminars concerning the cement industry, specifically conceived toward the problems of developing countries.

6) To organize the training of personnel from developing countries in UNIDO selected cement plants (as it was the case with the Colombo Plan).

7) To utilize only highly qualified and up to date informed experts for technical assistance.

8) To promote the creation of cement manufacturing equipment industries in some of the more industrialized developing countries (as it is the case in India).

9) To promote the study and the developmentof a standardized series of small capacity cement plants suited for developing countries with small cement consumption.

10) To investigate and encourage the creation of medium or large size cement plants on a multinational or inter-regional basis.

11) To examine the profitability of installing clinker grinding stations, which might be supplied from multinational or inter-regional cement plants or from other sources.

12) To put sufficient funds at the disposal of the specialized Division of UNIDO covering in particular the cement industry, in order to make the above program possible.

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