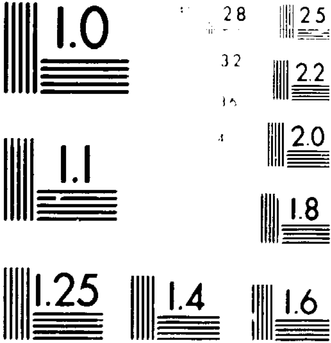
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org



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UNITED NATIONS CENTRE FOR HUMAN SETTLEMENTS (HABITAT)

FIRST CONSULTATION ON THE BUILDING MATERIALS INDUSTRY

Athens, Greece
25-30 March 1985

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OUTLINE OF A POLICY FOR MASTERY AND SELECTION OF TECHNOLOGY IN RELATION TO CAPITAL GOODS FOR CEMENT, BRICK AND PLASTER MANUFACTURING - INTERNATIONAL CO-OPERATION IN THESE INDUSTRIES**

by

Sid Boubekeur***
UNIDO consultant

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**The views expressed in this paper are those of the author and do not necessarily reflect the views of the UNIDO secretariat. The document has been translated from an unedited original.

***Researcher in the economics of technological change. Research team associated with CNRS 872 - Department of Economics and Management, University LYON II, France.

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Corrigendum

Replace cover page of document ID/WG.425/4/Rev.1, dated 11 January 1985, by the cover appearing overleaf.

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INTRODUCTION

The establishment of a coherent industrial system 1/ in which the technology is fully mastered remains the prime objective for many developing countries.

But today there are two groups of obstacles to the emergence of such a system.

- External obstacles linked to the world economic crisis.

The fragile nature of the world economy, particularly monetary imbalances, the drop in exports of manufactured products, and the reduction of outlets, has resulted in the industrialized countries altering their production systems, thus modifying production methods and the distribution of industrial products.

The shocks experienced by the industrialized countries rebound on the developing countries and are sometimes amplified there.

The situation is aggravated by chronic deterioration in the terms of trade, increasing indebtedness and the impossibility for many countries of paying their debts.

We know today that inordinate increases in interest rates are causing considerable problems for the developing countries most deeply in debt. Some of them have had to institute austerity policies in order to avoid bankruptcy.

- Internal obstacles linked with the production system in the developing countries.

This crisis can be defined as the incapacity of supply in agriculture, industry and services (transport, schools, hospitals, particularly) to meet the needs of the constantly growing population.

But the difficulty of achieving mastery of technology in relation to capital goods is undoubtedly one of the most serious hindrances to the birth of an industrial system such as we have defined it.

Over the past 20 years, many developing countries have invested heavily though unequally in the acquisition of capital goods.

Capital goods are deemed to be manufactured goods intended for the constitution or reconstitution of the productive capital: machinery and materials of all sorts.

Capital goods are also defined by the technical nature of the goods or the product and by their use.

- Technically, they can be grouped under:

  - Metal capital goods,

  - Mechanical capital goods,

  - Electrical and electronic capital goods.

1/ Industrial system: the body of capital goods industries (metallurgy, engineering, building and public works ...), of intermediate goods (construction materials, semi-processed products ...) and consumer goods, which are linked together by buying-selling relationships.

- As regards use, they can be classed as:

  - Capital goods for producing capital goods,

  - Capital goods for producing intermediate goods,

  - Capital goods for producing consumer goods.

Metal, engineering and petrochemical capital goods acquired by certain developing countries over the past few years should produce a momentum for the down-stream creation of intermediate goods and consumer goods constituting a basis for the industrialization process.

The ultimate target of decision-makers in those countries was to create synergetic effects within the nascent industrial system; in other words, to establish buying-selling relationships between the metallurgy, engineering, electricity, building and public works industries, with each industry assisting development in the others.

Close analysis of work on the problems of industrialization in the developing countries shows that planned objectives have not always given the desired result.

Worse again, they have had the very opposite effect: lack of relations between industries, poor employment creation, lack of technological expertise in the imported capital goods and increased technological dependence on the outside.

These difficulties have recently resulted in most developing countries modifying their trade relationships with the industrialized countries.

Indeed, compared with the period from 1960 to 1970, few developing countries have acquired large industrial complexes.

Furthermore, these countries are increasingly demanding presentation of the entire range of technologies possessed by the industrial countries in order to make their selection.

Growth and agricultural and industrial development are still the chief objectives for many developing countries, but today it seems that this development is now focussed mainly on selection and technological expertise.

This report is not intended to make a survey of all capital goods 1/ but to concentrate on those to which decision-makers should pay particular attention.

We shall therefore be considering capital goods for the production of intermediate goods: cement plants, brick and plaster works.

1/ For this, see:

- GONOD: "Un outil: l'analyse de la complexité technologique" in the Revue de l'Economie Industrielle No. 20 - 2nd quarter 1982.

- UNIDO: Seminar on Strategies and Instruments to Promote the Development of Capital Goods Industries in Developing Countries. Prepared by the International Centre for Industrial Studies (ICIS), Algiers, 7-11 December 1979.

- UNIDO: Technology in the service of development. Prepared by the Division for Industrial Studies, Warsaw, 24-28 November 1980.

There are two reasons for the choice of these industries:

They all have been greatly affected by technological innovations. The use of large capacity kilns has permitted improved productivity. In addition, the use of new firing methods has resulted in energy saving. However, productivity gains have been possible only through the use of complex installations, but those acquired by developing countries are today causing serious problems. The low level of factory production, and the difficulty of mastering the technology are inducing us to identify multiple blockages in these industries and then possibly to reconsider the choices of technology.

Furthermore, this choice is justified by the fact that the cement industry remains a strategic industry: cement is used in almost all economic activities: housing, industrial and agricultural buildings, port and road infrastructures, etc. Moreover, the brick and plaster industries are complementary industries. Of course, brick and plaster are less widely used than cement, but their qualities make them excellent substitute materials in housing.

It would seem important to make one basic remark:

> It is a mistake to look upon cement as the only available material for work of all kinds, thereby abandoning local materials such as fired and unfired brick, lime, plaster, wood, etc.
>
> It is also a mistake to consider that local materials can be substituted completely for cement, underestimating the role it can play.

A coherent policy for developing a building materials industry should take into account all these materials and lay down the circumstances when each should be used.

This can only be achieved by a planned national building materials industry, by the programming and development of strategic and complementary units, and by efficient production management and materials distribution.

With that in mind, our report will revolve around four axes:

(1) To show that the cement industry is a strategic industry and that it is therefore necessary:

- To develop a policy of technological mastery of plants operating in the developing countries;

- To encourage the establishment of a cement industry in the developing countries where there is none.

(2) To make a general diagnosis of cement, brick and plaster production units in the developing countries. This will mean highlighting the main bottlenecks, and the sources and causes of the difficulties experienced by these units.

(3) On the basis of this diagnosis, to outline a policy for selection and mastery of technology as the prerequisite for the development of a building materials industry.

(4) Finally, to draw up a balance-sheet of international co-operation in this field, and to define possible ways of creating new relations between countries which are manufacturers of capital goods and those which are buyers.

CHAPTER I. ROLES OF THE BUILDING AND PUBLIC WORKS SECTOR AND THE CEMENT INDUSTRY IN THE INDUSTRIAL SYSTEM

First of all the cement industry must be situated in the building and public works sector, and more globally in the industrial system, then some useful details must be given on recent trends in the world cement market.

I. Upstream-downstream relations between the cement industry, the building and public works sector, and other industries

Interactions between economic activities are usually shown by an inter-industrial exchange table or by the Leontieff Matrix which shows clearly the inputs and outputs of each industrial, agricultural or service activity.

Other work starts from a complex situation: the industrial system composed of varying industries which, nevertheless, have buying-selling relations with each other.

The diagram on the next page shows that the buildings and public works sector is a consumer of capital goods or products from the metallurgical, engineering and electronic industries.

For example, they supply:

- Capital goods needed for site work (earth moving, foundations): bulldozers, excavators, levellers, power shovels;

- Mechanical capital goods for transport and assembly (lorries, dumpers, cranes ...);

- Capital goods for the production of intermediate goods: cement works, brickworks, lime and plaster kilns;

- Capital goods needed for shaping materials: shuttering, moulding and pressing processes ...

Similarly, the building and public works industry is a supplier and responds to three types of demand:

- Demand stemming from social and educational needs: housing, schools, universities, sports complexes, hospitals ...;

- Demand linked with the needs of industrial, agricultural and service activities: buildings for iron and steel, mechanical, petrochemical, electronic complexes; agricultural buildings, sheds, storage silos, administrative buildings ...;

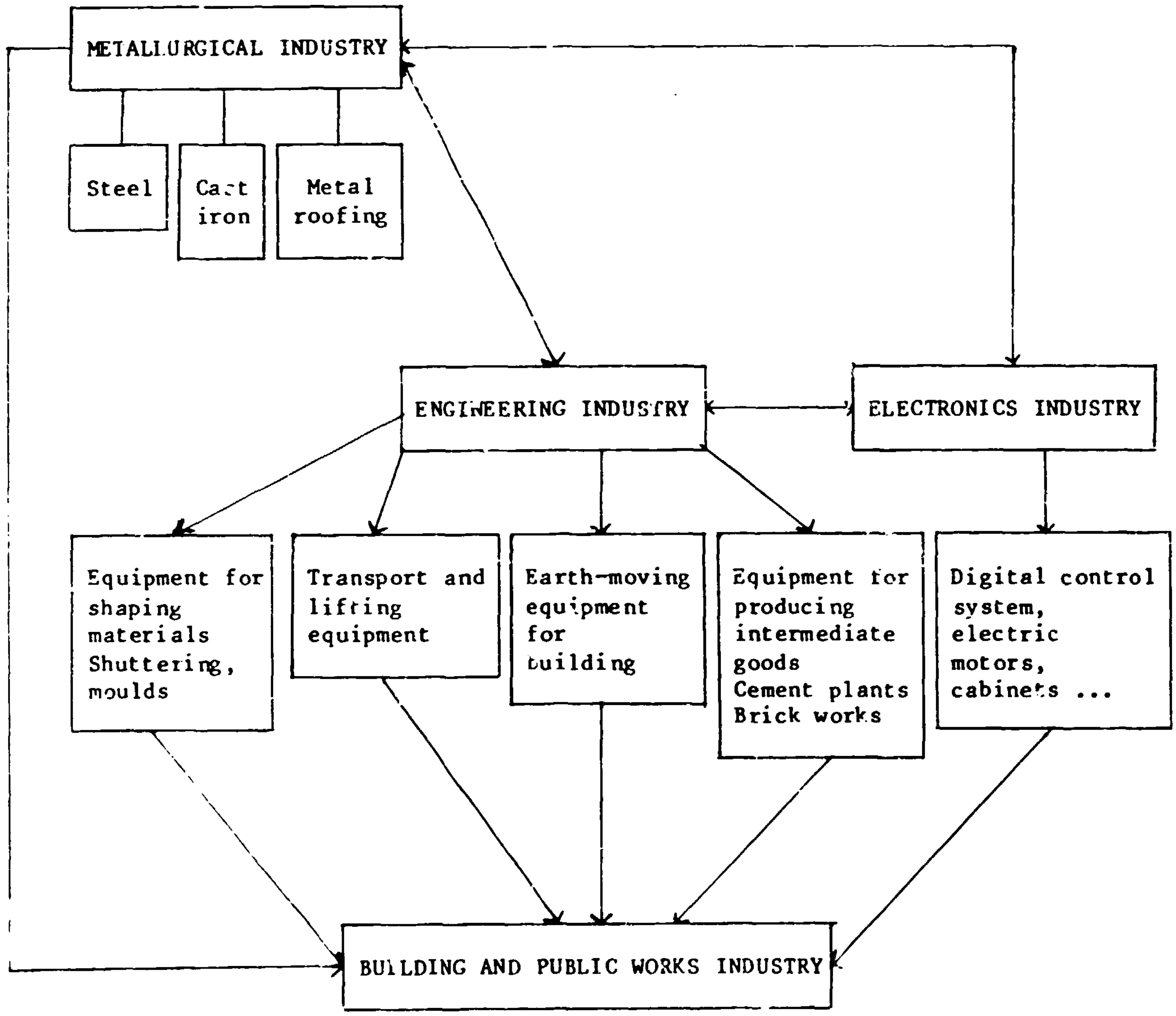
- Demand connected with communication needs: civil engineering works (dams, aerodromes, ports, roads, railways ...).

We see that the building and public works industry is not only a supplier of goods but that it plays a dynamic part in economic development.

Through port and road infrastructures, etc., it facilitates movement of agricultural and industrial products and communication between people.

Furthermore, the building and public works industry can stimulate and develop craft activities, encouraging initiative and the establishment of trades.

RELATIONS BETWEEN THE CHIEF INDUSTRIES WITHIN THE INDUSTRIAL SYSTEM
BUILDING AND PUBLIC WORKS AS AN INDUSTRY CONSUMING
CAPITAL GOODS AND PRODUCTS



An industrial system may come into being constituting a starting-point for the development of the building and public works sector. It may be concerned with the production of components (building blocks: cement, pipes, bricks ...), moulds, presses, various tooling and trades connected with house building: masons, plasterers, carpenters, transporters, ...

Small and medium-sized firms can also subcontract. They may play an important part in the manufacture of certain products (plastic materials, accumulators, small mechanical and electrical equipment, fastenings, furniture, paints, ...), accessories, spare parts, etc.

The building and public works industry is thus an excellent basis for the emergence of a network of craftsmen and for training skilled labour.

Finally, as against other industries which continue to evolve towards high capital-use production methods (automation, robotization ...), the building and public works industry remains relatively unconcentrated and not highly capital-dependent.

Therefore it is still a labour-using and employment-creating industry.

The various points mentioned above show that the building and public works industry can constitute one of the kingpins on which development depends.

Therefore, criticism which can be made of the development theories of the 1960s is that iron and steel, engineering and petrochemicals were considered as the only industrializing industries while the place and role which the building and public works industry can play in an economy were underestimated.

Today, it is not a question of considering that building and public works is the only industrializing industry, nor of giving it a virtually total priority over other industries, but of giving it the importance it merits.

In other words, building and public works can be considered as a dynamic industry, along with the others, an industry which can have a stimulating effect on the industrial system of the developing countries and which can promote growth.

In the building and public works industry, cement plays a primordial role.

II. The cement industry: a strategic industry

It is generally recognized that cement is a clear indicator of how lively a given industrial system is. There is a relationship between the development level of a country and the per capita consumption of cement.

The cement industry is an upstream industry. Its activity affects most other industries. In fact, the main strategic sectors - industry, agriculture, transport, energy - are large consumers of cement. In addition, it may have a stimulating effect on the building and public works industry and on the other construction materials industries (diagram on next page).

Cement has exceptional characteristics and that is why it is the basic material for the building and public works sector.

We have noted four characteristics:

- Cement is economical because it accounts for only 2 to 3 per cent of total building costs in the industrialized countries;

- It is a strong and durable material;

- It is flexible in use because its malleable nature before setting allows it to be moulded into various shapes;

- It is a safe material to use. Considerable research to improve its quality and national and international regulations ensure a high degree of reliability.

Of the various hydraulic binding materials, Portland cement is the one for which there is greatest demand. This is the result of baking at 1450° a measured, homogenized mixture of limestone (80 per cent) and clay (20 per cent), minerals composed chiefly of chalk, silicon dioxide, and to a lesser degree aluminium oxide and iron oxide.

The resulting product is called clinker.

Artificial Portland cement (APC) is obtained by grinding this clinker after adding gypsum (about 5 per cent), to assist in even setting.

During grinding secondary ingredients are often added: blast furnace slag, a granular product from iron ore processing, fly cinder from power stations or volcanic material called pozzolanas.

Briefly, cement manufacture can be said to consist of five operations: quarrying of materials, preparation and homogenization of materials, baking, grinding, conditioning and transport.

There are several quick ways of processing the raw materials: the wet process where the mixture is in the form of a liquid paste, the dry process where it is in the form of a powder, semi-wet where it is in the form of a stiff paste, and semi-dry in the form of granules.

Cement is rarely used alone. Its chief derivative, concrete, an artificial mixture of gravel, sand, cement and water, has very varied uses.

Cement is used in three forms: raw cement, ready-mixed concrete and manufactured concrete products: building blocks, prefabricated panels and slabs, asbestos cement, kerb stones ...

Concrete has very specific uses according to the quality and amounts of cement employed.

There are four types of concrete for specific uses:

- Non-reinforced concrete,

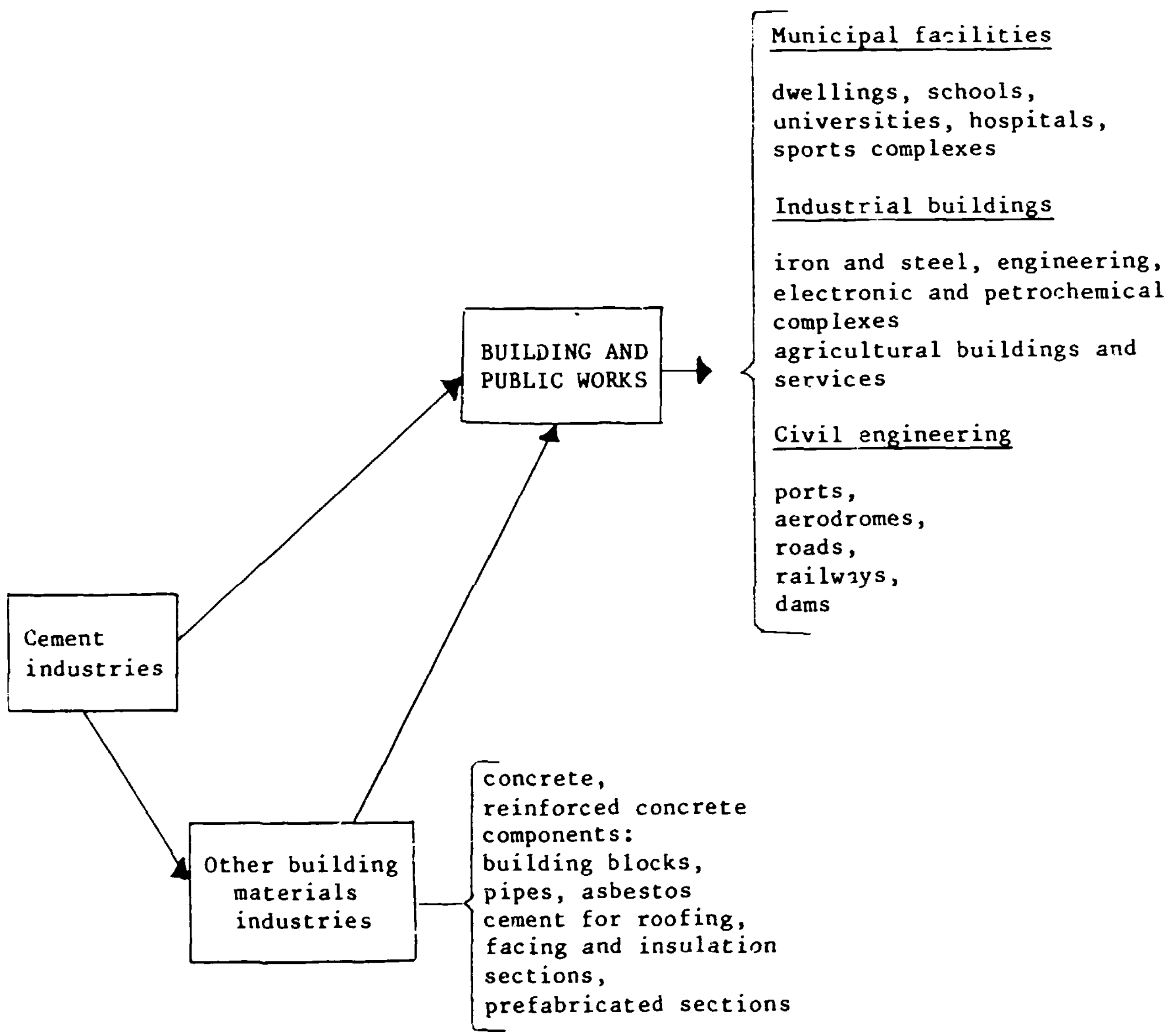
- Reinforced concrete consisting of concrete and a reinforcement of iron bars to resist pressure and loads,

- Prestressed concrete with very high resistance,

- Special concretes generally used for particular situations: cold, heat, water, fire ...

Cement is used virtually universally and demand for it has been on the increase ever since the 1960s.

CEMENT PLANTS - BUILDING AND PUBLIC WORKS: THE SUPPLY INDUSTRIES



III. The world cement market: recent trends

World cement production rose from 300 million tonnes in 1960 to 590 million tonnes in 1970 and amounted to 883 million tonnes in 1980, averaging an increase of 50 per cent every ten years.

1. General aspects of world cement supply

Approximately 33 per cent of world production is from the Asian continent.

Western and Eastern Europe (including the USSR) share half of world production.

North America accounts for about 17 per cent of production.

In the period from 1970 to 1981, production has moved from the industrialized countries towards the countries of Asia and Latin America.

This move is explained by the increasing needs of industrialization. For example, Western Europe's share of the world total fell by 6.8 per cent between 1970 and 1981, and North America's by 4.4 per cent, while that of the Asian continent (excluding Japan) increased by 10 per cent and Latin America's by 2.6 per cent. The share of the countries of Africa omcreased by only 0.7 per cent.

In spite of the increases in Asia and Latin America, the most industrialized countries of Western Europe, North America, the USSR and Japan still held more than 56 per cent of world production in 1981.

The cement market is dominated by large firms. The site of the firms is partly explained by the fact that cement production is much more dictated by demand than the other sectors of economic activity because it is impossible to store the product for long periods.

Because of the enormous capital involved, these firms are few in number. In most cases they are integrated both horizontally (by the variety of cements they offer) and vertically (by the concentration of activities: extraction, processing and distribution).

Finally, these firms control the building and public works firms, often through participation, particularly in firms which produce prefabricated components or cement products.

The Asian continent (South-East Asia, China and the Middle East) is the chief world producer with over 285 million tonnes in 1981. This position is explained by the fact that in that area of the world the needs of industrial infrastructure (dams, ports, roads, railways, underground railways) and housing have increased greatly in recent years, particularly in India and China.

Production in these countries doubled and quadrupled respectively between 1970 and 1980. Because of available financing, the Middle Eastern countries have increased production considerably: in Saudi Arabia (from 675,000 tonnes in 1970 to 3.4 million tonnes in 1981), in Iran (from 2,577 million tonnes to 8 million tonnes) and in Iraq (from 1.4 million tonnes to 6.5 million tonnes).

Finally the Asian continent contains three of the ten largest world producers: Japan, second; China, third and India, tenth. Western Europe is the second largest cement-producing area. With 210 million tonnes in 1981 it provided 24 per cent of world supplies. The most significant increases were in Spain (from 16.5 million tonnes in 1970 to 30.5 million in 1981), Greece (from 4.9 millions to

13.6 millions), Turkey (from 6.4 millions to 15.1 millions) and Portugal (2.3 millions to 6 millions). Apart from Italy, where production increased by 10 million tonnes between 1970 and 1981, production in other countries of the West - France, Germany and Great Britain, was stagnant or fell over the same period.

The countries of the East are in third place with 200 million tonnes in 1981. The USSR provides 63 per cent of this total. Furthermore, it is the largest world producer with 127 million tonnes in 1981.

North America and Latin America are in fourth position with 151 million tonnes in 1981. The United States of America, with 65 million tonnes, is the fourth producer in the world. But it is particularly in Latin America where production has increased considerably: by 120 per cent between 1970 and 1981. The market share of the Latin American countries rose from 5.8 to 8.6 per cent during that period. This amazing jump is due to the considerable work in providing plant in Brazil, Mexico, Argentina, and to a lesser degree, to the housing programmes carried out by the various countries.

To satisfy increasing needs, capacities have been considerably increased, either by establishing new cement works or by improving plant in existing ones.

Because of the high cost of transport, companies have favoured the construction of medium-sized cement works throughout their countries rather than setting up large cement works. It should be noted that most countries in Latin America have rejected the enormous production units found in the USSR, the Western countries and sometimes in certain developing countries (Saudi Arabia, Iraq, Iran and Algeria). 1/

It should be added that these units produce today a wide range of cements: portland cement, white cement, special cements ...

In Africa production increased from 18.3 to 34.1 million tonnes between 1970 and 1981, an average annual growth rate of 7.20 per cent, almost twice that of world producers as a whole (4 per cent).

Still, its part in world production represents only 0.7 per cent in 1981. For comparison, West Germany alone accounted for 0.7 per cent in the same year.

The increase in African production is due to South Africa (2,367 million tonnes in 1970 to 8.2 in 1981), oil-producing countries which have begun civil engineering work (ports, roads, airports) and housing: Nigeria (from 1.9 to 2.5 million tonnes), Libya (from 970,000 to 2 million tonnes), Morocco (from 1.4 to 3.6 million tonnes), Tunisia (547,000 to 2.02 million tonnes) and Algeria (924,000 to 4,460 million tonnes).

Most African countries produce a very small amount:

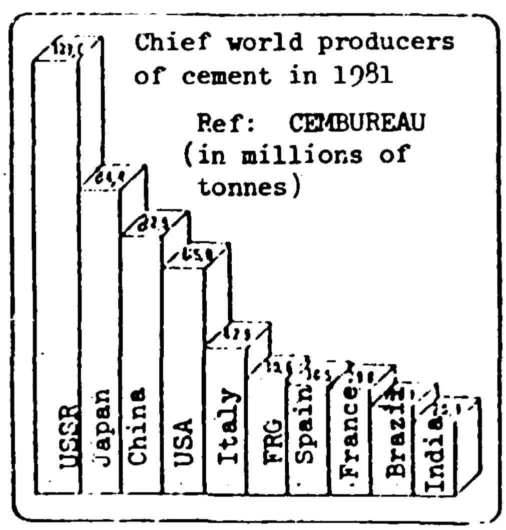
1/ Cf. Le marché mondial du ciment et l'Amérique Latine. Etudes économiques No. 5, Banque Sudameris - 1983.

Table 1

Cement production in some African countries

Country	1981 production in t
Ghana	300 000
Mozambique	260 000
Angola	250 000
Gabon	180 000
Sudan	150 000
Uganda	70 000
Congo	70 000
Niger	35 000
Mali	30 000

Other countries in Africa, such as the Gambia, Burkina Faso, Somalia, Chad, Guinea Bissau, Rwanda, Burundi and the Central African Republic, produce virtually none.



Source: CEMBUREAU

Table 2

World cement production and consumption per capita in 1981

	Production (1000t)	Production Classification	Consumption kg/h	Consumption Classification
USSR	127 000	1	465	35
Japan	84 406	2	659	17
China	82 000	3	(80)	104
United States	85 055	4	292	59
Italy	42 996	5	746	10
Spain	30 493	6	491	29
FRG	30 208	7	475	34
France	29 807	8	501	27
Brazil	26 050	9	204	78
India	20 120	10	(33)	123
Mexico	12 378	11	255	68
South Korea	15 600	12	321	55
Turkey	15 149	13	259	66
Romania	15 000	14	532	24
Taiwan	14 360	15	685	15
Poland	14 200	16	389	41
Greece	13 117	17	670	16
United Kingdom	12 788	18	221	74
GDR	12 204	19	652	18
Czechoslovakia	(10 546)	20	(708)	11
Canada	10 152	21	339	53
Yugoslavia	10 080	22	444	37
North Korea	(9 500)	23	(437)	38
South Africa	(8 119	24	269	65
Iran	(8 000)	25	(209)	77
Indonesia	6 844	26	(44)	122
Belgium	6 691	27	486	30
Argentina	8 851	28	240	71
Iraq	8 500	29	(910)	7
Thailand	6 230	30	(127)	93
Portugal	6 029	31	635	20
Australia	5 560	32	400	41
Bulgaria	5 448	33	568	21
Austria	5 327	34	699	12
Venezuela	4 876	35	348	50
Hungary	4 630	36	460	33
Colombia	4 623	37	145	89
Algeria	4 460	38	279	61
Switzerland	4 419	39	689	13
Philippines	4 008	40	(71)	109
Pakistan	3 660	41	(49)	120
Morocco	3 606	42	170	85
Egypt	3 432	43	159	88
Saudi Arabia	3 400	44	1 670	5
Netherlands	3 353	45	361	48
Cuba	3 050	46	278	62
Malaysia	2 833	47	(237)	72
Peru	2 650	48	135	90
Nigeria	2 500	49	(91)	100
United Arab Emirates	2 500	50	3 900	1
Sweden	2 333	51	257	67
Syria	2 310	52	367	48
Singapore	2 093	53	687	14
Tunisia	2 020	54	319	58
Libya	2 000	55	1 030	6
Ireland	1 938	56	340	23
Israel	1 919	57	484	31
Chile	1 850	58	168	86
Norway	1 837	59	380	44
Finland	1 787	60	354	49
Lebanon	1 700	61	(372)	45
Hong Kong	1 517	62	850	19
Denmark	1 428	63	235	73
Kenya	1 280	64	(39)	127
Ecuador	1 180	65	181	83
Puerto Rico	1 152	66	(284)	60
Dominican Republic	1 050	67	179	84

	Production (1000t)	Production Classification	Consumption kg/h	Consumption Classification
Cyprus	1 036	68	895	9
Luxembourg	1 005	69	786	9
Ivory Coast	1 000	70	100	99
Jordan	964	71	496	28
Togo	886	72	82	103
Albania	860	73	(270)	64
New Zealand	830	74	235	73
Sri Lanka	707	75	57	115
Viet Nam	700	76	24	134
Costa Rica	694	77	(230)	74
Uruguay	619	78	(201)	79
Panama	529	79	274	63
Cameroon	516	80	65	111
Guatemala	514	81	(76)	107
Salvador	500	82	(88)	101
Zimbabwe	470	83	(55)	117
Zaire	408	84	(12)	144
Tanzania	393	85	(22)	135
Bolivia	375	86	73	108
Senegal	372	87	64	112
Burma	372	88	7	153
Martinique-Guadeloupe	363	89	518	26
Bahamas	345	90	300	58
Bangladesh	345	91	(10)	145
Zambia	300	92	(52)	118
Ghana	300	93	(33)	130
Benin	297	94	77	105
Mozambique	260	95	14	143
Qatar	255	96	2 608	2
Angola	250	97	(21)	136
Haiti	230	98	44	123
Honduras	225	99	47	121
Bahrain	200	100	1 800	3
Gabon	180	101	(430)	40
Mongolia	180	102	(127)	92
Nicaragua	167	103	59	113
Reunion	162	104	388	43
Jamaica	158	105	(77)	106
Paraguay	156	106	(86)	102
Sudan	150	107	(14)	141
Ethiopia	140	108	(6)	154
Trinidad and Tobago	139	109	367	47
Iceland	115	110	520	25
Liberia	108	111	57	114
Fiji	80	112	132	91
Malawi	78	113	(17)	139
Surinam	70	114	(200)	80
Uganda	70	115	(7)	152
Congo	70	116	(95)	101
North Yemen	85	117	110	95
Nepal	55	118	(10)	146
New Caledonia	50	119	345	51
Niger	35	120	(25)	132
Madagascar	35	121	(10)	147
Mali	30	122	(25)	133

	Consumption kg/h	Consumption Classification
Andorra	1 780	4
Oman	560	22
Macao	480	32
Borneo	458	36
French Polynesia	435	39
Curacao-Aruba	360	49
Seychelles	344	52
French Guyana	328	54
St. Pierre et Miquelon	300	57
Barbados	247	69
Cape Verde	240	70
Gibraltar	217	75
Mauritius	210	76
Netherlands Antilles	200	81
Botswana	(189)	82
Namibia	(161)	87
Malta	114	94
St. Kitts	110	96
Equatorial Guinea	(110)	97
Belize	106	98
Mauritania	71	110
New Herbides	56	118
Swaziland Lesotho	50	119
Gambia	44	124
Comoros	41	125
South Yemen	(40)	126
Solomon Islands	33	128
New Guinea	(28)	131
Sierra Leone	(19)	137
Guyana	17	138
Guinea	16	140
Burkina Faso	(14)	142
Somalia	(8)	148
Chad	(8)	149
Central African Republic	(8)	150
Guinea-Bissau	7	151
Rwanda and Burundi	(6)	155

N.B. Many of the data are uncertain and given in brackets.

Source: CEMBUREAU.

This overview of world cement supply leads us to examine demand.

2. General characteristics of world cement demand

Today, cement consumption is still concentrated in the industrialized countries. The United States, Japan, the Federal Republic of Germany, France and Italy alone use 30 per cent of world production.

Since the 1970s, however, a clear development has been noted: there has been an extraordinary increase in demand in the Asian, Latin American and African countries. Cement consumption has increased by 125 per cent in Asia and Africa between 1970 and 1980.

In 1982, world cement consumption is assessed at 860 million tonnes. Estimates for the year 2000 give a consumption of 1.3 billion tonnes. 1/

This world consumption is broken down as follows:

Industrialized countries	10%
OPEC countries	15%
Eastern bloc countries	30%
Developing countries	45%

These data show that the cement industry will make immense strides in the next few years. The developing countries and OPEC countries alone will account for 60 per cent of world demand.

Firms in the industrialized countries which are today suffering a recession could, if they modify their export strategies (adaptation of their technology to the developing countries, staff training ...), play an important role.

Since the 1970s, trade in cement has trebled by volume, rising from 23.5 million tonnes to 73 million tonnes in 1981. This growth is the result of demand from the countries in the Middle East, South-east Asia and certain African countries.

3. International trade in cement

Generally speaking, trade in cement is carried on between adjacent geographical zones owing to the perishable nature of the product and the high transport costs.

Spain was the leading exporter in 1981 with 12 million tonnes, Greece third with 6.6 million and Turkey fifth with 3.4 million.

The countries of the Middle East are among the largest importers of cement. For instance, Saudi Arabia became the largest importer in 1981, overtaking the United States. At that date, it purchased 12.5 million tonnes, 17 per cent of the world total. Other petroleum-producing countries, Kuwait, Iraq and Bahrain, have considerably increased their imports.

1/ Banque Sudameris: Le marché mondial du ciment l'Amérique Latine. Economic Studies No. 5 - 1983.

Table 3

Chief petrol-consuming countries outside Latin America
(in millions of tonnes) *

Country	1975	1976	1977	1978	1979	1980	1981
Canada 1/	9 165	9 293	8 916	9 058	(8 947)	(8 435)	(8 222)
United States	63 560	67 256	73 970	79 488	79 651	70 398	66 517
Federal Republic of Germany	31 807	32 594	31 022	31 882	33 874	32 500	29 300
Spain	20 752	21 292	21 694	22 028	20 791	19 751	18 509
France	28 634	28 712	27 893	27 736 2/	27 693 2/	28 088 2/	27 017 2/
Italy	33 948	35 870	37 800	37 200	37 906	41 215	42 657
United Kingdom	16 853	15 581	14 498	14 900	15 221	14 287	12 402
Turkey	9 953	11 579	12 924	14 187	12 727	12 089	11 772
German Democratic Republic	10 123	10 565	11 029	11 422	11 103	11 219	(10 919)
Poland	18 937	19 530	20 728	19 695	17 178	17 227	(13 930)
Romania	8 685	9 835	10 030	10 959	11 918	12 820	(11 950)
USSR	119 529	121 630	124 198	126 324	120 279	122 078	(124 600)
China	(45 600)	(54 000)	(63 050)	(67 200)	(74 460)	(79 400)	(81 100)
Korea (Republic)	8 435	9 080	11 177	14 762	15 825	13 172	12 439
India	15 839	17 864	18 [illegible]77	20 747	19 611	19 988	(22 260)
Japan 1/	63 222	64 552	69 381	79 187	81 842	82 425	77 870
Taiwan	6 552	8 107	8 791	10 192	11 563	13 326	12 458
South Africa 1/	6 897	6 750	6 066	5 840	6 067	7 368	8 107
Algeria	2 938	3 280	3 880	4 066	4 852	5 035	5 460
Egypt	3 599	3 941	(4 170)	(4 438)	5 550	(5 916)	(6 932)
Nigeria	(3 000)	3 293	5 870	(5 570)	(5 600)	(6 100)	(7 200)
Australia	5 020	5 208	5 099	5 024	5 622	5 780	5 786

* Apparent consumption.

1/ Consumption calculated on domestic deliveries plus imports.

2/ These totals cover all hydraulic binding materials.

Source: World Cement Market in Figures 1913-1981, published by CEMBUREAU.

Table 4

Apparent cement consumption in the chief countries of Latin America
(in millions of metric tons)

Country	1970	1975	1976	1977	1978	1979	1980	1981
Total	36 090	50 630	54 450	55 460	62 050	66 100	75 270	76 310
including:								
Argentina	5 037	5 481	5 673	6 026	6 314	6 672	7 319	6 535
Brazil	9 331	16 737	19 147	21 199	23 343	24 847	26 911	25 958
Chile	1 323	906	911	1 004	1 120	1 304	1 525	1 900
Colombia	2 561	2 752	2 953	2 995	3 527	3 632	3 811	3 981
Mexico	7 285	11 521	12 184	12 030	14 310	14 725	16 260	18 125
Peru	1 135	1 966	2 044	1 941	1 746	1 813	2 075	2 469
Uruguay	380	458	441	497	526	579	579	508
Venezuela	2 434	3 471	4 043	4 311	5 115	5 032	5 062	5 437

Source: World Cement Market in Figures 1913-1981, published by CEMBUREAU.

Table 5

Per capita consumption of cement - countries with the lowest consumption
(kilogrammes)

Countries	1970	1975	1980	1981	Countries	1970	1975	1980	1981
Ethiopia	7	(4)	5	6	Liberia	(62)	53	54	44
Rwanda-Burundi	4	4	5	6	Pakistan	(44)	(47)	48	49
Burma	6	6	8	7	Zambia	97	94	51	52
Uganda	22	9	(7)	(7)	Sri Lanka	(31)	28	(51)	(57)
Somalia	6	31	(8)	(8)	Zimbabwe	(79)	107	55	(64)
Central African Republic	(-)	11	(7)	(9)	Senegal	44	67	64	64
					Cameroon	(24)	39	61	66
Chad	4	3	(7)	(10)	Philippines	65	83	77	71
Bangladesh	2	4	10	10	Benin	31	(42)	75	77
Zaire	20	24	14	12	China, People's Republic	39	54	(80)	(80)
Burkina-Faso	4	8	(11)	(14)					
Mozambique	50	19	(16)	(14)	Togo	44	68	95	82
Sudan	13	20	12	14	Nigeria	16	48	(79)	(91)
Malawi	17	23	21	17	Congo (Republic)	100	62	86	95
Angola	69	(45)	(21)	(21)	Ivory Coast	93	125	(125)	(100)
Tanzania	27	21	16	22	Thailand	73	79	118	126
Mali	8	12	(21)	(25)	Mongolia	73	106	124	(127)
Afghanistan	6	4	15	(26)	Egypt	100	97	(141)	(159)
Niger	8	8	26	30	Namibia	155	250	173	161
Ghana	50	67	23	33	Morocco	93	130	180	176
India	26	26	30	33	Botswana	-	107	198	189
Indonesia	10	21	36	44					

Source: World Cement Market in Figures 1913-1981, published by CEMBUREAU.

Table 6

Per capita consumption of cement in selected representative countries
(kilogrammes)

Countries	1970	1975	1980	1981	Countries	1970	1975	1980	1981
Jordan	142	188	(498)	496	Netherlands	449	404	430	361
Spain	499	585	528	491	Finland	396	432	364	354
Belgium	543	593	570	486	Canada	320	401	352	339
Israel	492	(717)	520	484	Tunisia	112	199	323	319
Hungary	384	433	498	480	United States	326	297	310	289
Germany, Federal					Algeria	99	175	270	279
Republic of	602	514	528	475	South Africa	263	270	251	269
USSR	381	470	460	465	Turkey	170	248	260	259
Yugoslavia	287	336	434	444	Sweden	497	365	278	257
Australia	364	365	395	395	New Zealand	295	349	235	244
Poland	379	557	480	388	Denmark	427	390	313	235
Norway	393	424	394	380	United Kingdom	307	301	256	221
Lebanon	327	360	(308)	(372)	Iran	(89)	(220)	(216)	(209)
Syria	(174)	252	364	(367)					

Source: World Cement Market in Figures 1913-1981, published by CEMBUREAU.

Table 7

Per capita consumption of cement - countries with the highest consumption (kilogrammes)

Countries	1970	1975	1980	1981
United Arab Emirates	-	(4 000)	(2 740)	(3 900)
Qatar	1 200	1 500	1 604	2 608
Bahrain	477	(580)	(1 610)	(1 700)
Saudi Arabia	190	(550)	(1 430)	(1 670)
Kuwait	723	690	(1 240)	(1 300)
Libya	260	(1 267)	(890)	(1 030)
Iraq	(115)	(191)	(612)	(910)
Cyprus	471	279	783	895
Luxembourg	659	912	828	786
Italy	603	607	723	746
Czechoslovakia	515	661	702	702
Austria	613	733	719	699
Switzerland	759	610	673	689
Singapore	366	(549)	583	687
Taiwan	242	405	748	686
Greece	513	528	705	670
Japan	528	547	704	659
German Democratic Republic	(466)	600	670	(652)
Hong Kong	221	272	643	650
Portugal	258	374	604	636
Bulgaria	426	513	564	566
Ireland	315	480	534	540
Romania	342	409	577	(532)
Iceland	439	739	574	520
France	551	543	524	501

Source: World Cement Market in Figures 1913-1981, published by CEMBUREAU.

Table 8

Principal world exporters of cement excluding Latin America
(thousands of tonnes)

Groups of countries and countries	1975	1976	1977	1978	1979	1980	1982
World total	40 500	45 600	57 450	64 650	66 450	65 300	73 600
Total, Western Europe	17 100	18 800	24 850	30 450	28 700	27 800	32 900
including:							
Germany, Federal Republic of	2 071	2 078	2 217	2 644	1 936	1 763	2 110
Spain	3 575	4 868	7 919	9 762	8 943	9 938	12 026
France	2 103	1 901	2 182	3 786	3 547	2 593	2 882
Greece	3 010	3 337	4 442	4 898	4 900	5 833	6 663
Turkey	922	910	941	821	1 072	788	3 389
Total, Eastern Europe	4 150	4 450	5 900	7 500	7 400	6 800	6 500
including:							
German Democratic Republic	600	797	1 102	1 131	1 144	1 126	(1 300)
Poland	282	584	1 591	2 242	2 044	1 352	(400)
Romania	2 835	2 713	3 098	2 933	2 738	2 791	(2 800)
USSR	3 322	1 882	3 438	3 548	3 084	3 245	(3 000)
Total, America	3 550	3 800	4 600	5 200	7 600	5 450	4 900
including:							
North America	2 117	1 993	2 269	2 695	4 235	2 547	2 737
Canada	1 667	1 570	2 055	2 645	4 100	2 378	2 465
Total, Africa	1 350	1 450	2 000	2 100	1 500	1 950	2 100
including:							
Kenya	539	615	662	610	526	(575)	652
Total, Asia	10 850	14 600	16 900	15 800	17 800	19 700	28 850
including							
Korea (Republic)	2 435	3 666	4 035	1 845	2 081	4 351	5 757
Japan	3 932	5 593	6 411	8 342	10 570	8 554	9 731
Total, Oceania	150	150	50	50	250	350	350
including							
Australia	121	53	23	38	248	247	250

Source: World Cement Market in Figures 1913-1981, published by CEMBUREAU.

Table 9

Trade in cement in the principal Latin American countries
(thousands of tonnes)

Countries	1970	1975	1976	1977	1978	1979	1980	1982
Exporting Countries								
Total	1 542	1 433	1 807	2 331	2 505	3 365	2 903	2 163
including:								
Brazil	–	46	51	28	127	182	204	164
Chile	27	33	52	122	57	49	63	(30)
Colombia	290	408	718	439	688	866	753	664
Mexico	98	208	409	1 197	985	537	250	76
Peru	3	1	2	44	304	615	695	242
Uruguay	121	174	244	204	146	108	68	22
Importing countries								
Total	1 806	2 022	2 982	4 544	3 857	3 979	3 743	3 415
including:								
Argentina	296	(10)	–	–	–	100	210	22
Brazil	328	235	338	261	190	72	26	7
Peru	–	4	82	6	–	–	–	–
Venezuela	1	34	984	1 378	1 819	1 951	799	1 163

Source: World Cement Market in Figures 1913-1981, published by CEMBUREAU.

Table 10

Principal world importers of cement excluding Latin America
(thousands of tonnes)

Groups of countries and countries	1975	1976	1977	1978	1979	1980	1982
World total	38 400	43 500	54 000	62 600	66 400	65 200	73 20[illegible]
Total, Western Europe	3 650	4 450	5 400	6 500	7 000	6 850	6 75[illegible]
including:							
Germany, Fed. Rep. of	796	894	1 184	1 465	1 563	1 650	1 7[illegible]
Netherlands	2 017	2 555	3 084	3 213	3 157	3 308	2 96[illegible]
Total, Eastern Europe	3 400	2 500	3 800	2 550	3 200	2 450	1 60[illegible]
including:							
Hungary	981	762	799	815	765	861	69[illegible]
Yugoslavia	529	374	697	642	1 040	793	66[illegible]
Total, America	5 750	6 100	7 500	10 100	12 700	8 700	7 20[illegible]
including:							
North America	3 728	3 118	2 956	6 243	8 721	4 957	3 78[illegible]
United States	3 299	2 789	2 693	5 986	8 521	4 757	3 59[illegible]
Total, Africa	10 650	12 200	16 700	16 000	15 100	13 600	16 20[illegible]
including:							
Algeria	2 084	1 959	2 155	1 367	1 078	879	1 00[illegible]
Egypt	97	603	(1 000)	1 416	2 565	(2 810)	(3 50[illegible]
Nigeria	1 738	2 051	4 500	(4 100)	4 000	(4 000)	(5 00[illegible]
Total, Asia	13 700	17 050	22 800	26 300	27 400	32 500	40 20[illegible]
including:							
Saudi Arabia	(3 700)	(5 000)	(7 000)	(8 000)	(9 000)	(10 500)	(12 50[illegible]
Hong Kong	1 153	1 625	2 102	2 352	2 155	3 220	3 39[illegible]
India	-	-	-	1 316	1 420	2 286	(2 20[illegible]
Kuwait	699	(1 350)	1 665	2 346	(2 400)	(2 700)	(3 20[illegible]
Singapore	1 390	1 599	1 442	1 661	1 637	1 831	1 93[illegible]
Total, Oceania	400	450	400	550	650	650	60[illegible]

Source: World Cement Market in Figures 1913-1981, published by CEMBUREAU.

Examination of these tables shows that there are three groups of countries:

3.1 The leader countries: USSR, Japan, China, USA, the other industrialized countries (Federal Republic of Germany, France, Italy, Spain, Portugal ...), Eastern European countries (German Democratic Republic, Poland, Romania ...) and certain developing countries with the highest level of activity, which on the average supply their own needs of cement: Turkey, Brazil, Mexico, Colombia, Peru, and, shortly, India. Generally speaking, this group corresponds to the countries that have mastered cement technology.

3.2 The developing countries that have set up a cement industry but in which supply covers only a very low proportion of demand. These are the countries of the Middle East and the Maghreb that have not yet totally mastered this technology.

3.3 Countries whose per capita consumption of cement is extremely low and that have not yet developed a cement industry. In this group we find certain African countries.

On the basis of these remarks on recent trends of the world market for cement, we can formulate two important remarks:

Among the developing countries, it is the Latin American countries that have best mastered the technology related to capital goods in the cement industry.

On the average the production units operate at 80 per cent of installed capacity. In Mexico, for example, the rate was of the order of 84 to 89 per cent from 1972 to 1975, 90 per cent from 1976 and 95 per cent from 1977 to 1981. It should be pointed out that the reason why cement works do not operate at full capacity does not lie in a deficiency in the mastery of technology but in constraints related to the domestic situation of these countries and unsatisfactory international economic developments.

In fact, the cement industry in these countries suffers from the repercussions of budgetary restrictions, and a reduction of civil engineering and housing programmes.

"The Latin American countries are now experiencing a marked slow-down in their economic growth, with severe budget deficits, serious indebtedness and major monetary problems ... As a result of a slump in sales, the liquidity position of many construction enterprises is quite inadequate to cope with repayment of loans contracted during years of growth, and some Governments have even abandoned the implementation of major construction projects." 1/

Hampered by the domestic economic situation, the cement industry is then forced to find external markets. But in that case, it is confronted with international competition, which is already greatly dominated by the other industrial countries.

The situation of the cement industry in Latin America is a good example in two respects:

1/ Le marché mondial du ciment et de l'Amérique Latine. Etudes économiques No. 5, Banque Sudameris - 1983.

In the first place it is interesting to ascertain how it was able to master technology.

Secondly, the difficulties encountered by this industry in the field of exports leads us to raise two fundamental questions:

Should national production capacity be increased indefinitely? In the long run, the developing countries that have mastered the technology and in which supply exceeds demand may themselves also be confronted with the the severe constraints of the international cement market.

On the contrary, by means of efficient planning, should a policy of self-sufficiency in cement be pursued?

Bearing this in mind, this paper will concentrate on the latter two types of countries.

In the case of the second group, it is necessary to give guidelines for increasing the rate of capacity utilization of cement works and thus enabling the cement industry to play its full part in the industrial system of these countries.

As far as the third group is concerned, it is necessary to provide the maximum amount of information so that they do not repeat the same mistakes as those committed by the second group, and can develop a coherent cement industry in which technology is fully mastered.

Before these targets can be met it is necessary to diagnose cement industries in these countries in order to understand why there is an imbalance between actual production and the theoretical capacity of the plants installed.

CHAPTFR II. DIAGNOSIS OF THE CEMENT INDUSTRIES IN THE DEVELOPING COUNTRIES

Here it is necessary to identify the bottlenecks of every kind faced by cement production in these countries and then to show the economic implications of failure to master cement industry technology.

In order to understand better the difficulties being encountered by this industry, we shall consider in depth some technical characteristics of the capital goods necessary for the manufacture of cement.

I. General characteristics of the cement industry

During recent years there have been profound changes at the technological level in the cement industry. The most remarkable innovations have affected improvement of production capacity and above all energy savings. The objective aimed at was to reduce production costs.

1. Improvement of production capacity

It is largely to meet ever-increasing demand and to reduce the costs of operating the installations that the cement industry has progressively begun to use large-capacity machines, thus substantially improving productivity.

On the average, installed capacity rose from 50,000 tonnes in 1950 to 500,000 tonnes in 1970. At present, the minimum capacity in Europe is 300,000 to 350,000 tonnes and there are many plants with more than 1 or even 2 million tonnes capacity.

That development has been accompanied by a substantial decrease in manpower. At the handicraft stage of cement manufacture, of labour accounted for up to 25 per cent of the cost of production. The substitution of fixed capital for labour has had the effect of reducing the share of this factor in the overall cost.

2. Energy saving

The cement industry is a large consumer of energy. According to the process chosen, energy represents between 10 and 30 per cent of total production costs. It is for that reason that the most important improvements have been related to methods for the burning of clinker. In a related field, efforts have been made to develop processes using available fuels cheaper than oil: gas, coal, industrial and agricultural waste.

Table 11

Method of burning and energy consumption

Method of burning	Type of kiln	Energy
Wet process (paste)	Rotary, long	1 200 cal/t
Semi-wet process (filtered paste)	Rotary, short	950 cal/t
Semi-dry process	Shaft kilns	750/850 cal/t solid fuels only
(granulated powder)	Rotary, long and short	750/850 cal/t any fuel
Dry process (powder)	Rotary, long and short	750/850 cal/t any fuel

However, these advantages are subject to a constraint regarding size: the cement industry is a heavy industry and therefore needs major investments.

3. Substantial investments

The installations necessary for the production of cement demand an investment almost as large as that for the establishment of an iron and steel industry. As an example, a modern cement works with a capacity of 750,000 t/year set up near a port cost $125 million in 1982.

The basic investment is thus very considerable. However, it should be pointed out that cement works can pay off over a long period because the operational life of the equipment is greater than in other industries (25 to 50 years).

On the other hand, the cost of fixed investment per tonne of installed capacity tends to decrease as the size of the plants increases.

The cement industry, like the other heavy industries (iron and steel, mechanical engineering ...), has passed through two major technological stages.

4. A developing technology

We distinguish between:

- The level of mechanization, with the substitution of rotary wet-process kilns for shaft kilns at the end of nineteenth century, an improvement of productivity by the use of high-performance machines in the phases of quarrying the raw materials, preparation and burning of the materials, crushing and packing, and improvements in transport.

- The automation level from the years 1950-1960, characterized by:

The use of pre-established operating programmes

Automatic operation and control of machines.

The automatic control of cement manufacture was made possible by the use of computer technology. The essential aim of automation was to reduce manpower requirements, optimize production, improve the quality of the product and reduce energy consumption.

In this context, dry-process rotary kilns have replaced wet-process rotary kilns in the last two decades.

Finally it should be remarked that the structure of skills at this technological level has changed: engineers and technicians represent nearly 40 per cent of the staff of modern cement works.

Several observations are in order regarding these general remarks:

Large-scale cement works have a very long start-up period. In fact, they do not begin to operate at full capacity until four to six years after construction.

The location of cement works is a very important factor and depends on the existing infrastructure (ports, roads, railways ...).

The perishable nature of cement makes necessary good management and good organization of supplies.

Finally, modern cement industries demand very highly-qualified manpower and supervisory staff.

The reason is that the use of more and more complex capital goods has been accompanied by a growing complication in the organization of production (definition and implementation of programmes, control of production phases) and complication of executive tasks.

In view of this last point we have made a diagnosis of cement industries in three regions of the world, which are today most affected by the inadequacy and sometimes the almost total absence of cement manufacture: the countries of the Maghreb, the Middle East and sub-Saharan Africa.

II. The cement industry in the Middle East and the Maghreb

There were two reasons for choosing these particular regions:

Major civil engineering projects (ports, aerodromes, roads ...) as well as very large housing programmes make these countries major consumers of cement today.

In 1981, seven Arab countries were among the ten leading world consumers of cement in terms of kilogrammes per capita: the United Arab Emirates, Qatar, Bahrain, Saudi Arabia, Kuwait, Libya and Iraq.

Cement demand in Saudi Arabia was 14 million tonnes in 1982, whereas domestic production was scarcely 6 million tonnes in the same year.

Iraq, the leading producer of cement in the Arab countries, with 6.5 million tonnes, has to import half of its consumption.

Algeria produced 4.5 million tonnes in 1981, whereas demand was 8 million tonnes.

Most of these countries have opted for large-scale cement works. For instance, two cement works, the first with a capacity of 750,000 tonnes at Kursaniyah and the second of 1.5 million tonnes north of Jeddah, are under construction in Saudi Arabia.

Six cement works with an average capacity of 780,000 tonnes were installed in the United Arab Emirates between 1975 and 1980. In the same country three projects are in hand: one plant for 1 million tonnes at Hit, the 1 million tonne expansion of the unit located at Badoosh and a gigantic plant of 2 million tonnes.

Qatar and Oman have cement works with an average capacity of 600,000 tonnes.

Most of the cement works in these two regions operate at a low level of capacity utilization.

1. The imbalance between actual production and theoretical production capacity

A rapid survey of cement works in the Maghreb shows that most of them are experiencing serious difficulties. In Algeria the plants at Hadjar, Meftah, Beni-Saf, El Asnam, Zahana I and II and Constantine rarely operate at above 50 per cent.

Up to 1977, the two cement works at Meftah and Hadjar were operating at an extremely low level - 35 per cent.

In Morocco, while the cement works at Casablanca and Agadir operate at full capacity, those in Marrakech and Temara, which went on stream in 1976 and 1979 respectively, both using the integral dry process, are experiencing difficulties. Their rate of capacity utilization lies between 50 and 70 per cent.

For a long time, Tunisia was one of the few cement exporting countries. The average capacity of the plants installed between 1960 and 1970 rarely exceeded 500,000 tonnes. Two projects were completed during the period 1970-1980:

The expansion of the plant in Bizerta in 1976, whose present capacity is 870,000 tonnes;

The construction at Enfidha in 1980 of an ultra-modern cement works with a capacity of 1 million tonnes, using the integrated dry process.

The first plant is operating at 72 per cent of capacity and the second at 50 per cent. Another large cement works at Gabes operates at only 70 per cent of capacity.

2. The origin of malfunctions

Most of the causes that we shall refer to are of widespread occurrence in the Middle East countries.

Generally speaking, there are two types of problems:

2.1 Unsuitable equipment

The cement works at Meftah in Algeria, for example, experienced major bottlenecks in supplies of raw materials. The storage silo was not designed to take into account local environmental conditions. Particularly in winter, the limestone absorbed humidity and caked, so that discharging was impossible.

The rate of use of the silo was 20 per cent. Obviously, this problem has repercussions on the other activities in the cement works. For that reason, the works is operating at a slow rate and is even frequently shut down.

The Hadjar cement works has often had breakdowns because of the unsuitability of the crushing equipment. In Tunisia, the Enfidha cement works experienced difficulties from the very start: the kilns were out of operation for several months owing to a serious explosion.

2.2 The absence of know-how and deficiencies in the organization of production

Large cement works call for skilled manpower and supervisory staff (technicians, engineers, ...) trained to operate plants. However, such manpower is lacking in almost all of the plants.

As an example, there are frequent electricity cuts, and kilns are not operating because either on the upstream or the downstream side the silos of raw materials or clinker are full.

Breakdowns are also the result of the lack of maintenance; the absence of spare parts means that cement works are out of operation until the spares are delivered.

III. Cement works in sub-Saharan Africa

Situations in the cement industry in African countries vary. Certain sub-Saharan countries have no limestone. In other regions, there has been no systematic prospecting for deposits. 1/

1/ Chaponnière: Les cimenteries en Afrique - Les mini-cimenteries: une alternative? MCD IREP, January 1982.

It is for that reason that some of them have imported clinker crushing plants. In 1981, seven countries in Africa had neither cement works nor crushing plants.

There are about 50 cement works using either rotary kilns, with the dry process, as in Western and Equatorial Africa or wet process kilns, as in English-speaking African countries.

With the exception of CIMAO (Ciment de l'Afrique de l'Ouest), which covers Ghana, Togo and the Ivory Coast and the capacity of whose cement works reaches the level of 600,000 tonnes/year, most of the other units have a capacity below 100,000 tonnes/year and are only rarely higher than 300,000 tonnes/year.

The investment cost per tonne is very high in these cement works: it is 1.5-2.5 times higher than that of cement works in Europe.

As an example, the investment per tonne of installed capacity in CIMAO is of the order of $400, whereas it is $150 in North Africa.

Investment per tonne depends largely on the infrastructure available locally. If the latter is inadequate, supplementary civil engineering work must be undertaken: ports, roads, railways ...

Generally speaking, the African countries cannot satisfy their needs. Most of the plants operate at only 50 per cent of capacity. The absence of maintenance is one of the essential causes for stoppages.

In the countries that have crushing plants, investment per tonne of installed capacity represents 30-50 per cent whereas the investment is $120-200 for a 50,000 tonne cement works. That is incontestably an advantage. But here also, these plants produce cement that is more expensive than the imported product because of the high price of clinker (representing 70 per cent of the cost of production of cement) and the low level of capacity utilization in the plants.

On the basis of this brief review of cement works in these three regions of the world, we can now give an account of the economic consequences of the underutilization of cement works.

IV. The economic consequences of the underutilization of cement works

The inadequate level of cement production in the countries considered is directly linked to the low level of productivity in cement works. The immediate consequence is an increase in the cost of production of cement.

As a comparison, the price per tonne of cement produced in France was 264 francs in 1980 and 334 francs in 1981.

This table shows that the cost of production of cement is two to three times higher than in the industrialized countries.

Moreover, the price of cement at the distribution stage may be double at distances of more than 200 km from the works.

Some studies 1/ even affirm that the ex works price per tonne of cement can be multiplied by 10, 100 or even more at the distribution stage.

1/ Industries et Travaux d'Outre-Mer: ciment et chaux dans le monde, No. 350, January 1983, Paris.

Table 12

Cement works in Africa: main characteristics

	No. of units + projects	Crushers	Cement works	No. of kilns	Size of kilns: 100 10^3 t/year	Size of kilns: 100-300 10^3 t	Size of kilns: 300-500	Size of kilns: 500+	Technology: Vo	Technology: R	Process: S	Process: S.H	Process: H
West Africa													
Benin	3+1	2	1	1			1			1	1		
Ghana	2	2											
Guinea	1	1											
Ivory Coast	2+1	2+1											
Liberia	1	1											
Mali	1+1		1+1	1+5	.+5				5	1		5	1
Niger	1		1	1+1	1	1				1+1	1+1		
Mauritania	1	1											
Senegal	1		1	3+2		3+2				3+2	3+2		
Sierra Leone	1	1											
Togo	2	1	1	2				2		2	2		
Burkina Faso	1	1											
Equatorial Africa													
Congo	1		1	1	1								
Gabon	3	2	1				1			1			1
Nigeria	7		7	18		11	7			18	10		8
Zaire	5	1	4	6	4		2			6	3	1	2
Cameroon	2	1	1	1+1	1+1					1+1	1+1		
Uganda	2		2	4	4					4	4		
East and North Africa													
Ethiopia	3		3	3	3					3	3		
Sudan	2		2	3	2	1				3	3		
Kenya	2		2	10	6	2	2		6-	4	2	6	2
Tanzania	1+2		1+2	2+4	2	4				2+4	2+4		
Zimbabwe*	3	1	2	4	3		1*			4	1	3	
Angola	2		2	4		4				4			4
Malawi*	2	1	1	2	2					2	1	1	
Madagascar*	1+1		1+1	1+2	1+2				2	1		2	1
Zambia*	2		2	5	5					5	2		3
Mozambique*	3		3	3	1		2			3	1	1	1
TOTAL	56+8	16+3	40+5	74+16	37+8	21+7	15+1	2	6+7	68+9	39+9	12+7	23

Legend:
- o = project
- * = coal-fired
- V = vertical
- R = rotary
- S = dry process
- S.H = semi-wet process
- H = wet process

Source: Chaponnière: ciment et cimenteries
Les mini-cimenteries: une alternative? (Cement and cement works. Mini-cement works: an alternative?).
Ministry of Co-operation - IREP.
November 1981.

Table 13

Price of cement in Africa

Years	Countries - Cities	Price of cement per tonne
1980	Togo (Cimao)	420 francs ex works
1981	Cameroon	540-600 francs ex works
1981	Senegal	580 francs
1981	Congo	760 francs
1981	Ghana	900 francs ex works
1980	Nairobi	953 francs

Source: Chaponnière, *op. cit.*

Several factors may contribute towards increasing the price: the scattered nature of the markets, difficult conditions, the transport, storage and conservation of the product.

In order to meet demand, these countries are forced to import and are thus dependent on foreign countries.

Finally, shortages of cement open the door for speculation and lead to the emergence of a black market that is very difficult to control.

At the macro-economic level, we have seen the role played by the cement industry in an industrial system. The absence of an efficient cement industry in the countries considered hampers the emergence of a coherent industrial system.

This diagnosis of the regions of the world most affected by the cement crisis now leads us to ask questions regarding the mastery of technology for capital goods in this industry on the one hand, and technological options on the other.

It is all the more essential to take these questions into account because many developing countries have become aware of their importance. Therefore our paper has two objectives:

- To provide recommendations for improvement of the production level of the cement works already installed,

- To develop guidelines for coherent choices regarding the acquisition of capital goods in the cement industry.

V. Ways and means of a olicy for mastering capital goods technology in the cement industry

The identification and implementation of effective measures to achieve mastery over the technology are essential.

In fact, an important principle is at stake: to strike a balance between theoretical capacity and actual production.

Operation of existing cement works at full capacity can contribute towards:

- Reducing the cost of production of cement;
- Reducing the gaps between supply and demand in cement;
- Reducing speculation;
- Making a partial contribution to the dynamism of the industrial system.

Thus technological mastery proves to be the necessary condition for improving the performance of cement works and, to a certain extent, for giving fresh impetus to the economy.

There are two aspects: mastery of know-how and the organization of production, and mastery of engineering.

1. The promotion of individual and collective know-how

We have seen that the main bottlenecks encountered by cement works are the result of the absence of know-how and defective organization of work.

Know-how is defined as the application of practical and technical knowledge to a given production process.

In certain wet-process cement works, the tasks of preparation and dosage of materials are still carried out manually. The skilled worker remains responsible for certain functions: by means of tables indicating the production programme, he supervises, corrects and regulates supplies by controlling the parameters of temperature and speed of flow. 1/

In this type of cement works, the main function of the worker is the execution and supervision of tasks. Know-how can to a large extent be acquired on the job.

In cement works that use the integrated dry process, the handling of raw materials, supply of the silos and kilns, crushing and bagging are carrried out automatically and continuously.

The plant is controlled from a central point. The workers operate the installations by remote control.

1/ With regard to the operation of cement works - know-how, organization of work required - see the paper by M. Samiri: Transfert entre systèmes techniques d'inégal développement et maîtrise de la technologie cimentière: le cas du Maroc. Third-year thesis - Department of Economics and Management - University of Lyon II - December 1983.

The high level of automation has considerably reduced the work content. Dosing, regulation, supervision, and maintenance require high skills in the workers. In particular, they must have mastered certain technical knowledge and skills: reading gauge dials, the laws of electricity, measuring instruments, maintenance standards.

Manual workers in this type of plant have duties that supplement the work of the technicians, and work closely with them.

In fact, at this level of complexity of cement works, the essential part of the work is carried out by the technicians and engineers. The technicians must have a knowledge of mathematics, programming and electronics.

The training of skilled workers for new tasks and the training of technicians is receiving more and more attention from decision-makers in certain developing countries and in foreign companies that have carried out transfer operations.

In order to increase the performance of cement works, a number of major European firms have concluded assistance contracts with countries of the South. As an illustration, Morocco periodically sends part of the staff of the Casablanca cement works to France so that a cement company can take charge of their training and the preparation of seminars for the transfer of know-how. Analogous assistance contracts have also been concluded between the same company and cement companies in Algeria (training of trainers). These initiatives incontestably constitute a step forward towards the mastery of individual know-how and must therefore be encouraged.

This type of training will enable manual workers and technicians to acquire knowledge of electricity, measuring instruments and maintenance standards. This basic knowledge is important.

But will they be able to apply their knowledge and adapt it in the country of origin, in which the environment is different? The answer to that question is not clear.

Observation of the factual situation shows that the mere acquisition of individual know-how, although necessary, is not sufficient.

In plants as complex as cement works, know-how cannot be confined to single operations - no type of know-how can be expressed independently of other types. In fact, despite differences in content, manual workers, technicians and engineers have know-how that is interrelated - and mutually complementary in the manufacture of the finished product. Companies in the industrialized countries must certainly transmit knowledge regarding the operation of machines, but also and above all their experience regarding the operation of cement works.

In other terms, today it is necessary to train the workforce as a whole: manual workers, technicians and engineers. This objective should be pursued all the more so as it makes it possible to master the organization of production.

2. Mastery of the organization of production

At this level, the cement industry has been affected, like other industries, by the division of labour and the apportionment of tasks.

Despite the splitting-up of the work, however, the workers are in constant contact. This contact results from the complementarity of know-how, i.e. the logical connection between one task and another, and from the mutual supervision of the workers.

Mastery of the organization of production in cement plants largely depends on the transition from individual training (individual know-how) to the training of the workforce (collective know-how). A study of the cement industries in Brazil bears out this idea.

Training of the workforce has made it possible to achieve real mastery of a highly complex unit (totally dry process, complete automation) and thus to operate the unit at full capacity.

"There is no doubt that, in this type of industry, the smooth running of production depends on the existence of a work-force which has some awareness of the plant as a whole, of its limits and its vulnerable and weak points. It is also clear that this can only be achieved if there is some degree of diversity of assignments and jobs and some measure of co-operation between the workers and teams at the various workplaces ... The training of such workforces is a basic requirement for the production activity." 1/

Collective know-how can thus be acquired through the diversity of assignments.

Moving workers from one assignment to another would enable them to see how and by what stages the finished product is achieved, and why an assignment is carried out in one way rather than another. This type of skill can also be enhanced by imparting general technical knowledge, which would enable the worker to acquire not only his own know-how but also some of the know-how needed for the preceding job and the job that follows. This type of training would make it possible to avoid mistakes and accidents.

3. The development of a national engineering capability

Engineeing can be defined as a set of methods and structures which make it possible to master the technical, scientific, economic and financial information needed for the planning, production and commissioning of plant for the manufacture of capital goods and consumer goods.

Few developing countries are interested in establishing a specialized engineering capability for the planning and production of capital goods for making cement. In fact the lack of a national engineering capability in these countries is a serious handicap.

This gap has led them to make regular use of foreign consulting engineers.

In most cases, however, foreign consultants encourage neither the use of local resources for the manufacture of capital goods nor the birth of a national industry. In other words, while it is a positive feature that some firms are currently engaged in training the labour force and management in order to improve the output of units situated in the developing countries, they are still reluctant to transmit all the technical and scientific resources and all their experience in manufacturing capital goods.

There is more to the mastery of technology than the mere transfer of instructions for the use of capital goods. Although necessary, mastery of the use of machines is a partial mastery.

1/ B. Coriat, "Transfert de techniques, division du travail et politique de main-d'oeuvre - Une etude de cas de l'industrie brésilienne", Critique de l'Economie Politique, January-March 1981.

In our view, the real key to technological mastery is mastery of the design and production of capital goods.

In the developing countries, the creation of a national engineering capability which can meet this requirement has a number of advantages:

It would ensure mastery of the operation of capital goods;

It would provide for the manufacture of spare parts, thus ensuring technological independence;

It would make use of technological potential adapted to the levels of training of the work-force and management.

Mastery of engineering can also contribute to greater national self-sufficiency by tailoring technological choices to the adaptation and assimilation of capital goods.

The training of engineers and senior technicians, and the development of research institutes, seem to be prerequisites for the acquisition of a project-study capability.

There is of course no question of the developing countries embarking on the production of highly complex capital goods (cementworks with long rotary kilns using the wet or dry process).

In view of the lack of adequate research and production facilities and the insufficiency of financial resources, this target seems utopian. On the other hand, the developing countries could establish the necessary conditions for the production of capital goods of low technological complexity (mini-cementworks for example).

Mastery of the production of this type of cement works would make it possible to progress gradually towards mastery of the production of cement works which are increasingly complex but adapted to the technological environment or the level of industrialization achieved by these countries.

Finally, a policy favouring the production of capital goods in the national territory would enable the developing countries to make a real "technological leap".

We have shown that the developing countries which have acquired complex cementworks should pursue a policy of technological expertise based on four essential points:

Mastery of individual know-how through technical training provided in specialized schools, and practical training within the enterprise;

Mastery of collective know-how through diversity of assignments;

Mastery of the organization of production;

Mastery of engineering.

These countries must also, however, pursue an objective which is nowadays fundamental: mastery of the technological options, in order to avoid making mistakes with serious consequences.

The question of technological options affects two groups of countries:

Those which already have a cement industry and wish to increase national production capacities by importing other capital goods;

Those in which the cement industry is at a low stage of development, or non-existent, and which wish to strengthen or establish it.

VI. Choice and adaptation of technologies and the emergence of a dynamic cement industry in the developing countries

How should technologies be selected, what technical level should be decided on (traditional, mechanized, automated), and what production capacity should be chosen?

These questions give rise to a number of comments:

Nowadays it is scarcely possible to affirm the superiority of one technology over another. In our view, one technology is only superior to the other in so far as the socio-economic conditions prevailing in the country in which it is to be applied at a given time are taken into account.

The options in fact depend on a large number of factors: the level of industrialization of the country, urban or rural demand, the available infrastructure (ports, roads, railways, etc.), the mode of organization and the cost of distribution.

The question of options is directly related to the issue of adaptation of technologies. At the macro-economic level, we classify as an adapted technology a technology which has been mastered and which can give rise, by chain reaction, to multiplier effects within the industrial system. The problem of adaptation is thus one of integrating technologies in the industrial fabric.

At the sectoral level, the most highly adapted technology will be the technology which will stimulate the supply of cement and will have dynamic effects in the cement industry.

We will deal with the question of choices and the adaptation of technologies along three lines. We will see whether mini-cementworks can provide an alternative to the cement crisis affecting the countries under consideration, and to what extent priority should be given to the development of other binders such as lime or pozzolana.

Finally, we will propose guidelines for the selection and adaptation of technologies.

1. Mini-cementworks as an alternative

The complexities involved in operating large-scale cementworks have in the last few years led to renewed interest in smaller and less complex cement factories. There are two types of mini-cementworks:

The vertical kiln, which has been in use since the beginning of the century in Europe and whose output varies between 30,000 and 200,000 tonnes per year. This kiln is fuelled exclusively by coke or charcoal, and can thus be used to exploit small-scale coal deposits. It must, however, be pointed out that the quality of the cement is less even than that produced by large cement works with rotary kilns, and is sometimes ill-suited to the production of structures with a high load-bearing capacity;

The rotary kiln: This type of kiln is the result of efforts made by certain firms to reduce the scale and complexity of the kilns. Rotary mini-kilns have the advantage that all types of fuel (fuel oil, gas, coal, etc.) can be used and that up to 25 per cent pozzolana can be added for the manufacture of pozzolanic Portland cement. The investment per tonne is, however, higher than for vertical kilns.

Many studies have shown that the price of cement produced by the mini-cementworks is not necessarily lower than the price of cement manufactured in large-scale units. For this reason mini-cementworks are particularly justified in regions where roads are poor and in regions to which access is difficult or in which the price of cement is generally too high.

So what are the advantages of the mini-cementworks? We have considered three:

1.1 Low initial investment and rapid take-off of production

The cost of a vertical kiln represents only 20 per cent of the total investment. However, the investment in a mini-cementworks does not necessarily imply a reduction in the investment per tonne. According to studies carried out in Madagascar and Bolivia, this varies between $100 in the former country and $400 or even $720 per tonne in the latter. The uncomplicated nature of the plant allows the works to be brought rapidly into operation (one to one and a half years instead of four to six years for a large cement works) and permits a rapid take-off of production. Finally this technology requires low maintenance and service costs.

1.2 Decentralized production

It is possible by locating production units close to limestone deposits to reduce transport costs for both the raw materials and the finished product to a minimum. Furthermore, with this type of unit production can be adjusted to local demand, and jobs can be created. Finally, they make it possible to exploit small-scale limestone deposits. Thus a cement works with a capacity of 250,000 tonnes per year requires a deposit of 5 million tonnes of limestone, while a mini-cementworks with an annual capacity of 60,000 tonnes requires only a quarter of that amount.

But mini-cementworks of the vertical-kiln type have a distinct advantage in that they can be locally manufactured.

1.3 Mini-cementworks of the vertical-kiln type: a technology that can be reproduced

The low initial investment and the uncomplicated nature of the plant can permit small-scale entrepreneurs to go into the manufacture of kilns, silos, sheds and conveyor belts. This is what has happened in India in particular. In addition, the establishment of a network of capital goods manufacturers, job creation and the transfer of know-how can undoubtedly have positive effects in the industrial system in the form of diminished dependence on the outside world and growing mastery in regard to the manufacture of capital goods.

The choice between mini-cementworks of the vertical-kiln type and the rotary-kiln type is a difficult one.

Some experts opt for the vertical kiln for the reasons set out above.

They also claim that this technology does not require a very high degree of skill. 1/

This reflects a somewhat ill-considered view of the problems.

Of course higher investment is required for mini rotary kilns than for vertical kilns; moreover, the initial technology cannot easily be reproduced locally. But the mini rotary kiln has the advantage of producing cement of consistent quality and is suitable for the production of high-strength structures.

In the second place, there is a correlation between increased complexity of capital goods and simplification of operations. 2/

- The vertical kiln is technologically of low complexity, so highly skilled personnel are required to prepare the materials, oversee the mission, service the plant and in particular adapt know-how to production conditions which can vary widely. The quality of the cement is dependent on this.

- The rotary kiln is of a higher degree of complexity, but some of the operations are integrated in the machine. The labour force must be skilled in the operation and control of machinery.

As we see it, the choice depends in large measure on the finance available in the developing countries, their level of industrialization, and especially whether the product demanded is cement for high strength structures, or cement derivative for certain types of work only.

We are not aware of a vertical kiln technology which allows the consistent production of a wide range of high-quality cements.

For these reasons, the choice of mini-cementworks of the rotary-kiln type should not be irrevocably discarded.

We have seen that mini-cementworks can be of interest to the developing countries. However, they should not be regarded as the only solution. They cannot, for a variety of reasons (such as a less even quality of cement, lower capacity, and higher investment per tonne), take the place of large-scale cement works. On the other hand, they can play a complementary or supporting role.

A consistent policy for cement manufacture should give priority to:

- Cement works with a capacity of between 250,000 and 500,000 tonnes a year in the vicinity of urban centres with a high level of demand. There is one precondition: the labour force and management must be trained in order to achieve technological expertise;

- Mini-cementworks with a capacity of between 30,000 and 100,000 tonnes per year in regions difficult of access;

- Clinker-crushing units, clinker having the advantage that it can be stored for longer than cement.

1/ Cf. Anandane (b), Les mini-cimenteries: la voie indienne, Irbat Plan-Construction, Paris, July 1984.

2/ Cf. S. Boubekeur, Les logements urbains en Algérie: crise et perspectives, phase de 3e cycle, Economie de la production, University of Lyon II, December 1983.

In addition, such a policy should provide for the efficient control of hydraulic binders.

2. An efficient system of control for other hydraulic binders

It is not always worthwhile to use Portland cement for every job. An effective system of control for binders should, for example:

- Use Portland cement for construction work with a high load-bearing capacity;

- Encourage the production of other binders, such as lime and pozzolana, which provide sufficient load-bearing capacity for dwellings;

- Promote research into other binders.

For example, the Institute of Technology at Kampur in India has developed a cement called "Ashmon" using a mixture of cinders, chaff, paddy rice, lime and an additive, the quality being equal to that of Portland cement.

3. Guidelines for rational selection and adaptation of technologies

The problem of options and the acquisition of techniques is related to the question of industrial information, which includes information on the manufacture and the technique (plans, diagrams, instructions for use, maintenance and experiments carried out in the countries where the technique is applied) and on resources for financing and management methods.

3.1 Industrial information - technological choice and project feasibility

Industrial information enables the importing enterprises to determine needs and to formulate a specific strategy during the negotiations with the exporting firms.

In addition, it helps in determining the applicability of techniques and in evaluating the costs and economic and social advantages of a project, and particularly its effect on the environment.

Precise and detailed information would in some measure limit failures of transfer, thus obviating tensions between national and outside agents. In many cases, however, information on capital goods remains inadequate. Patents reveal only fragmentary data: if the technical description and instructions for use of the machinery are correctly prepared, the problems which may arise with the machines are eliminated.

Moreover, the information is often one-sided. Most of it is focused on large-scale technologies, while information on small- and medium-scale technologies is virtually non-existent.

"In recent years, the information has shown a marked tendency to opt for the large scale (the principle of 'scaling up' has virtually become dogma). Three years ago it was still being maintained that it was not justifiable to build a plant for the production of long steel products with a capacity below one million tonnes". 1/

1/ Judet, Obstacles aux transferts de technologie. Colloque sur la formation professionelle et le transfert de technologies, CRID-IREP, Amman, Jordan, May 1979.

The withholding of information on certain techologies has had the effect of diminishing the range of choice. The lack of such information has led to over-inflation of investment costs as well as a high rate of industrial failure.

It is in the interests of countries wishing to develop industrialization and to make technological choices on a rational basis to establish an information drive.

This should be focused on three objectives:

Identifying requirements and sources of information

In the developing countries, the most urgent information needs relate to the most reliable capital goods. Since information on such techniques is accessible only at high cost, it is preferable to exhaust local sources of information first.

For example, in many regions there are small- and medium-scale national units for the production of materials, such as bricks, lime and sand-and-cement breeze blocks. Familiarity with these industries (the type of equipment or machines used, volume of production etc.) would make it possible to study the requirements for strengthening them (financial assistance from the State, use of more efficient machines etc.) and then to define the type of technology to import;

Establishing industrial information services in the national territory

In this connection it is essential to establish relations with the organizations specializing in industrial information. The Development Sciences Information System (DEVSIS-AFRICA) at Addis Ababa (Ethiopia), the International Referral System for Sources of Environmental Information (IRS) at Nairobi (Kenya), the Industrial and Technological Information Bank (INTIB), the Technological Information Exchange System (TIES) at Vienna (Austria) and, lastly, the Socially Appropriate Technology Information System (SATIS-GRET) can provide substantial assistance in establishing these services. 1/

Training industrial documentation personnel responsible for research and verification of data on techniques and the procedures for technology imports.

The reason for the importance attached to these three conditions lies in the fact that information plays a cardinal role in industrial feasibility studies, and more particularly in the appropriateness of the technological options and the decisions to invest.

The table clearly shows the information requirements for each stage of an industrial project.

As can be seen, the industrial information function is present throughout, since it operates from the start to the finish of projects and is the primary requirement for their success.

It is in the interests of the developing countries to embark promptly on a policy of research and development in order to master the requirements for adapting imported technologies and to plan technologies suited to their socio-economic circumstances.

1/ On world industrial information systems, see "Action in the field of industrial and technological information in Africa (ID/WG.332/1), pp. 2-5; "Institutions et technologies industrielles", Vienna, UNIDO, October 1980, p. 16 et 17.

Table 14

Cycle of selection and acquisition of techniques and feasibility of industrial projects

Stages / TARGET	Breakdown of requirements and of technical and commercial information	Preselection of techniques	Feasibility studies	Final choice of techniques and investment decisions
Choice and acquisition of techniques	1. Analysis of the limitations of each technique * materials requirements * level of skill of the labour force * spare-parts requirements * impact on organization 2. Comparative analysis of costs * costs of importing the techniques * production costs	More precise definition of the criteria for evaluating the advantages and disadvantages of each breakdown of the local material and human resources which could be used in the project	Final cost/benefit analysis * total investment costs * means of financing the project * production cost * location of the unit (geological study, cost of site, detailed plan of the plant) * environmental impact (local market, jobs, etc.) * determining the skill-level of the labour force	Recruitment and training of labour and staff Construction of industrial premises Installation of plant Production plan

Table based on the Manual for the Preparation of Industrial Feasibility Studies (United Nations publication, Sales No. E.78.II.B.5) (1979).

3.2 Research-and-development and the dynamics of the industrial system

In the first place, research enables the country to store its technical and organizational experience, thus helping it to retain its individual and collective know-how.

Many texts refer to the need for codification of know-how in the developing countries and for awareness of the close linkage between the codification and transmittal of know-how.

Secondly, research enables national standards to be set for manufacturers and users of capital goods, such as rules for calculation and design, mechanical components, electrical standards, and documentation.

Research would thus help in making choices. Items such as cementworks, brickworks, kilns, formwork and moulds can be standardized for a very long period. This would reduce the volume and cost of project and manufacturing studies and enable local industries to gain greater expertise in the production of such capital goods.

A vigorous policy for the development of the construction sector should thus assign an important role to research-and-development. The effectiveness of research in any development process no longer needs to be demonstrated.

CHAPTER III. BRICKWORKS AND PLASTER WORKS: COMPLEMENTARY INDUSTRIES

I. Brickworks

It should be pointed out from the outset that bricks cannot act as a total substitute for cement.

While bricks admittedly have many positive features, they are less widely used than cement.

From the economic point of view the advantage is not always apparent, since the price of bricks in developing countries is sometimes higher than that of cement.

None the less, a policy for the management of building materials must include the development, as much as possible, of the use of bricks, particularly in housing construction.

After outlining the technical and economic characteristics of the brick industry, we will analyse the brick-making plants operating in Africa in particular. We will then put forward some recommendations on improvement of the production level in the factories and on the technological options.

1. Technical and economic characteristics of the brick industry

Brick-making techniques have made considerable progress in the last 30 years, and there is a trend towards the mechanization and automation of plants.

As we see it, there are four technical levels:

Traditional: the processes of extraction and preparation of the clay are entirely manual. The bricks are made in wooden moulds. Drying is natural and firing is carried out in a stack of hay.

Despite the extemely low level of investment involved, this type of production has three drawbacks:

- The irregular dimensions of the bricks;

- Irregular market supply, small-scale brick manufacture being restricted to dry periods;

- The poor quality and load-bearing capacity of the bricks, basically due to the unevenness of the firing. In Rwanda, for example, an estimated 30 to 50 per cent of losses are attributed to the lack of uniform firing.

Improved traditional: this type is characterized by the use of simple machines: crushers and mixers for preparing the clay, manual presses or extruders, the use of sheds for drying and intermittent kilns for firing. Their capacity can vary from 5 to 20 tonnes per day.

Mechanization using higher-output-machinery: power shovels, bulldozers, crushers, high-capacity mixers, hydraulic presses or worm-screw extruders, artificial drying and intermittent or continuous kilns with a capacity of 20 to 60 tonnes per day.

Automation, using highly efficient equipment. The main feature of this type of production is the use, for firing, of a Hoffmann continuous kiln or a tunnel kiln with a capacity of 60 to 200 tonnes per day.

We will consider the energy problems first of all, and then go on to deal with investments according to the scale of the brickworks.

1.1 Energy consumption of brickworks

Drying and firing consume large amounts of energy.

1.1.1 Drying

In order to dry 1,000 bricks measuring 240 x 115 x 71, between 2,900 and 8,200 kJ are required, representing a cost of between $3.50 and $9.80 in 1979.

Unless heat from a furnace can be recovered, it is not recommended that heat be used for drying purposes.

Despite facilities for building it, the floor drier does not appear to be operational. This process requires a great quantity of heat to warm the air. Compartment driers, however, have the drawback of losing heat if their design, and particularly the design of the doors, makes poor provision for insulation.

1.1.2 Firing

Non-continuous firing kilns (intermittent kilns) use two to three times as much energy as continuous kilns (Hoffmann kilns, tunnel kilns).

In the case of the first type of kiln, which is heated and shut off with each process, 30 to 40 per cent of the energy absorbed by the product and the kiln walls by the end of the process is dissipated in the atmosphere during the cooling phase. In addition, 30 to 50 per cent of the heat, which reaches temperatures of 800°C to 1,000°C at the end of the firing, is lost through the outlet flues at temperatures of 100°C to 200°C.

Table 15

Investments by baked-clay production units in 1981

Capacity of units	Kiln characteristics	Investments (millions of French francs)	Remarks	Thermal efficiency
20 t/d	Improved kiln (direct or side drawing)	1.5		
20 t/d	Hoffmann kiln	3 unit, local labour	Turnkey	
80 t/d	Hoffmann kiln	8	do. heavy oil per t baked-day products	60-70 kg
100 t/d	Tunnel kiln	30-40	do. oil per t baked-clay products	45 kg heavy
200 t/d	do.	60		
400 t/d	do.	100	do.	

Source: Cabannes, Y., Boubekeur, S., Innovation et adaptation de technologies pour l'industrialisation des pays africains au Sud Sahara. Le cas des matériaux de construction alternatifs. GRET, October 1982.

1.2. Comparative analysis of production units

The smallest brick production unit operating in Africa has an output of 1 tonne per day. This output is very low in comparison to units using a locally-designed improved kiln (3 tonnes per day). This type of kiln consumes large amounts of energy when wood is used and is of very little interest to a developing country if it is designed and sold by a foreign manufacturer, the price of the investment per tonne produced being too high.

In a study carried out by a UNIDO expert in connection with a project to set up a brickworks in Gambia, 1/ attention is drawn to the excessive variations in investment and running costs according to unit size.

Table 16

Investments by unit size in Gambia in 1980 (in dollars)

Units	Investment: installation costs	Running costs
Small unit: 300 000 bricks/yr	25 500	32 125
Medium-sized unit: 3 million bricks/yr	700 044	410 175
Large unit: 10 million bricks/yr	2 117 250	1 121 610

Source: Cabannes, Y., Boubekeur, S., op. cit.

The following two points may be made in support of these data:

1.2.1 The costs of building a Hoffmann continuous kiln ($500,000), the costs of forming the bricks ($731,000) and the power costs are the highest items of expenditure at the level of the large unit, which therefore costs 50 times as much as the small unit.

1.2.2 The production costs are roughly similar in all three unit types.

Table 17

Production costs of bricks by unit size in Gambia
(dollars)

	Cost of producing 1,000 bricks	Production cost of 1 brick
Small unit	107	0.10
Medium-sized unit	136.7	0.13
Large unit	112.15	0.11

Source: Cabannes, Y., Boubekeur, S., op. cit.

1/ Rural unit to manufacture burnt building bricks in Gambia. UNIDO

2. Diagnosis of the brick industry in the developing countries

In Africa south of the Sahara units with a capacity of more than 100 tonnes per day are rare. Generally speaking, the brickworks have an average capacity of 20-50 t/d. However, the brick industry in most regions of Africa is characterized by small-scale production (under 5 t/d).

In recent years, renewed interest in this material has been observed, and there are several projects in North Africa, Burundi, Rwanda and Ethiopia and also projects for restructuring old units, like that of Cong..)ric in the Congo.

For the most part, the brickworks are characterized by their poor rates of operation. In Algeria, the level of output depends on the nature of the equipment employed. The older units and those with capacities between 10,000 and 40,000 t/yr equal and sometimes exceed their nominal production capacity, whereas units of 100,000 t/yr, generally using automated processes, such as extrusion forming and tunnel dryers and kilns, have an output level of 14-16 per cent of capacity the first year and only reach 44-67 per cent in the second year.

There are several reasons for the difficulties encountered by automated brickworks, such as poor clay preparation, inefficient organization of work and lack of know-how in controlling the firing. This firing stage is unquestionably the most crucial. After the firing temperature has been raised progressively to about 1,100° C, the cooling-down stage between 700° and 500° C must be particularly closely watched. If the cooling takes place too quickly, there is a danger of product breakage inside the kiln.

Productivity is very low in the handicraft-type brickworks. A workman produces 400 bricks per day in Rwanda, 265 bricks/d in Lesotho and 128 bricks/d in Tanzania. For comparison, a British plant in the Sudan using simple machinery produces 1,600 bricks/d and a fully automated American unit in the same country produces 8,000 bricks/d. 1/

The Aslandis and Jumbere brickworks in Ethiopia, using manual and motorized equipment for extraction and forming, natural drying and a non-continuous kiln, have a production capacity of 5,000-6,000 t/yr. While the speed of the auger machine can reach 3,600 bricks an hour in the former case and 800 in the latter, the productivity is 88 and 138 bricks a day, respectively. The extremely low productivity noted in these units is due to inadequate clay supply, poor preparation of the clay and waste during drying (10 per cent breakage due to bad handling).

The Ceramic Bricks plant, which is fully mechanized and uses a Hoffmann continuous kiln, has a production capacity of 20,000 t/yr. The output is 128 bricks per day, while the auger machine has a speed of 4,800 bricks per hour.

This unit has about one month's down-time per year due to machine breakdowns and the limited operation of the Hoffmann kiln. The plant is stopped for another month for equipment maintenance and repair: electrical equipment, crushers, conveyors and auger machines. The Hoffmann kiln is in operation 20 days per month.

In the Aslandis and Jumbere brickworks, the down-time is no longer accounted for. When the drawing machine is out of action, the workmen devote more time to extraction and kiln maintenance.

1/ Des Lauriers, T., op. cit.

In the brickworks as a whole, a lack of know-how, poor management and assignment of duties, and inefficiency in the manufacturing chain have been noted. The limited activity at the extraction and drying stages, especially during the rainy period, block other activities. For this reason the auger machines and kilns are under-utilized.

Table 18

Sub-utilization of brickworks in Ethiopia

Brickworks	Utilization rate of auger machine (%)	Utilization rate of kiln (%)
Aslandis	35.29	41.48
Jumbere	50.08	76.92
Ceramic Bricks	70.78	73

Source: Des Lauriers, T.: Approche énergétique de la fabrication de la brique cuite dans les pays en voie de développement: Le cas d'Addis Abeba, Ethiopie, GRET, 1978.

All these problems have a direct consequence, the high price of brick. In most African countries, this material usually costs more than its direct competitor, the sand-cement breeze-block.

What, then, are the conditions governing choice of equipment and competent management in the brickworks of these countries?

3. Recommendations for the brick industry

The general recommendations concerning technological skill and the choices already discussed in chapter II apply to the brick industry. We shall confine ourselves to developing recommendations specific to the brick industry on the basis of the diagnosis we have made and then to providing some guidance on the question of choice.

3.1 Recommendations for raising the level of production in existing units

We shall distinguish several levels:

At the demand level

Diversify production by matching the products to user's needs, e.g. full bricks, hollow bricks, perforated bricks, etc.;

Improve the strength and quality of the material; and

Standardize the dimensions of the bricks.

At the manufacturing level

Train the work-force for tasks that need special attention, such as clay preparation, brick firing, product handling and equipment maintenance;

Train the leading hands in management, organization of work and job supervision;

Improve the extraction equipment to ensure a regular feeding of the kilns, using mechanical shovels, bucket excavators and bulldozers;

Increase the drying capacity and improve drying conditions by building artificial drying sheds or chambers using kiln energy recovery;

Use palettes for drying and improve the brick handling and transport equipment to avoid breakages.

At the energy level

As we have seen, the drying and firing operations consume a great deal of energy. Artificial drying in Ethiopia, for example, increases the power consumption by 42 per cent and the manufacturing cost of bricks by 12 per cent.

There is no point in resorting to artificial drying when the brickworks are using traditional equipment or non-continuous kilns. Artificial drying is on the other hand justified in brickworks with continuous kilns, since in this case it has the advantage of reducing weather hazards and insuring regular feeding of the kilns.

Brickworks can use various sources of energy, including agricultural wastes, biogas, wood and oil.

It is essential to make rational use of local fuels, especially wood, the exploitation of which should not be overdone in view of the risk of damaging the environment. In Rwanda, for example, a reduction in energy consumption of about 30 per cent in this sector might save wood equivalent to about 1,500 hectares of forest per annum.

This raises an important question: should wood be burned to bake bricks or should it be used directly as a building material?

3.2 Guidelines for making logical choices of capital goods for brick-making

In brickworks it is possible to combine equipment items of different technical levels. Entirely manual extraction and preparation processes can be combined with forming and firing processes using improved or mechanized presses, auger machines and non-continuous kilns.

Techniques with a high labour content or improved or mechanized techniques for preparing, forming and drying the clay are in some cases more efficient than such highly mechanized or automatic techniques as tunnel kilns and drying.

However, a precondition for this is the existence of a trained work-force able to use the equipment rationally and to insure adequate quality and quantity.

In reality the choice depends to a large extent on demand, capacity and the energy efficiency of the kiln. The profitability of a brickworks is a function of its firing technology.

A close analysis of studies on brick-making equipment justifies us in presenting five brickworks models. We shall explain what each model calls for in terms of energy and in terms of operation, especially know-how and organization of production.

A rather high investment in an efficient and energy-saving kiln of the Hoffmann type considerably reduces the firing costs.

When the demand is concentrated in a few specific places, mobile brickworks for the forming operation may be employed. This kind of unit is suitable for thinly populated regions where it would not pay to establish permanent brickworks. Being designed for easy transport from one region to another, mobile brickworks offer the advantage of great flexibility of use. Their production capacity (1,000-1,500 bricks/hr) is quite respectable. However, a closer study of mobile brickworks would be needed to determine whether such facilities would be feasible in Africa. It would also be necessary to favour technologies for which the presses, auger machines, kiln, handling equipment, etc. could be produced locally.

In view of the importance of the handicraft type of brick production, it is essential to encourage this traditional sector, which offers the advantage of employing the abundantly available labour force.

Finally, in view of the high costs of firing (30-50 per cent of total production costs), any action conducive to reducing energy consumption, or ev... bringing it down to nothing (for example by using stabilized clay) must be encouraged.

Table 19

Presentation of brickworks models

Process / Model	Crushing	Formating	Drying	Firing
Model I	Entirely manual operation	Manual forming and pressing	Natural drying on drying floor	Non-continuous kilns
Model II	Simple motorized crushing and mixing machines	Motorized manual presses or auger machines	Natural drying on drying floor or in covered shed	Separated non-continuous kilns
Model III	Combination of manual and motorized machines	Advanced presses and auger machines	Natural drying in covered shed	High-capacity separated non-continuous kilns
Model IV	Fully mechanized. Use of clump-breaking dispensers, crushers, high-capacity mixers and conveyor belts	Fully mechnized. Hydraulic presses and endless-screw auger machines	Artifical drying with fans or kiln-heat recovery	Hoffmann continuous kilns
Model V	do.	do.	do.	Tunnel kiln

Table 20

General features of the brickworks models

Models / Features	I	II	III	IV	V
Technical know-how required	Simple techniques for unskilled workers. On-the-job training calls for careful quality control.	Simple techniques for workers with limited technical training. Calls for good quality control	More advanced techniques calling for ability in the field of task performance and product control	As III	As III
Energy for:					
Preparation	Practically none	Low energy consumption	Medium energy consumption	As III	As III
Firing	High energy consumption	Medium energy consumption	As II	Low energy consumption	As IV
Transformation processes:					
Clay preparation	Very simple technique - repairs easy	As I	More complex technique calling for regular maintenance. Repairs difficult	As III	As III
Forming	All machines can be manufactured locally. Work easy to learn but physically rather hard. Limited range of products. Brick quality often unsatisfactory.	As I, but physical work not so hard. Good and consistent brick quality.	Machines often imported; the production line stops in the event of breakdowns. Easy physical work. Calls for good training.	As III	As III
Drying	Simple natural drying on a drying floor.	As I	Artificial drying in drying chambers.	As III	As III
Firing	Direct firing with very flexible manual control.	Needs careful control.	Calls for 3-5 experts on combustion and firing in a Hoffmann kiln. Careful control and supervision required.	As III	As III Electronic control. Very careful supervision needed.
Production Management	The large number of workmen calls for good co-ordination, and requires management-trained supervisors.	As I	Calls for technical and engineering staff with ability in labour management and time and work control.	As III	As III

II. The plaster industry

There are several types of plaster industry product:

- Coating plaster: Traditional hand plasters;
  High-strength plasters;
  Sprayed plasters;
  Special plasters: fire resistant, etc.

- Moulding plaster: Plaster for prefabrication
  Plaster for panels or plasterboard
  Plaster blocks, etc.

- Sundry: Finishing plaster;
  Plaster for construction moulding;
  Mortar;
  Bonding, etc.

The revival of this industry has shown itself to be necessary for two reasons. First of all, this material plays a not inconsiderable role in construction, for example, for interior finishing, plasterboard for partitions, for ceilings and so on. In addition, plaster makes an excellent substitute material for cement and brick. We shall not enlarge on the qualities of this material or its applications here, since there have been major works devoted to demonstrating them. 1/ We shall first set out the plaster production process, then the experimental schemes in developing countries.

1. The plaster industry: technical characteristics

The plaster industry has only been affected by technological progress since the Second World War.

The plant employed is largely derived from industries which have undergone technical innovation (e.g. cement and lime) and from industries using heat treatment of powders.

However, because of the lack of certain plant, and the specific properties of the gypsums to be processed, some manufacturers have developed their own production processes.

1.1 Extraction

Extraction methods are determined by the nature of the deposits.

Gypseous crusts and gypseous sands can be recovered manually.

Gypsum beds or large open-cast quarries on the other hand require the use of high-performance equipment, e.g., for drilling and blasting, bulldozers or mechanical shovels for loading and means of transport.

1/ In this connection, see the following studies:
- Syndicat National des Industries du Plâtre: Le plâtre, physico-chimie, fabrication et emploi, Paris, Eyrolles, 1982.
- F. BARDIN: Le plâtre: production et utilisation dans l'habitat, Paris, GRET, 1982
- NOHLIER-DIALLO: Construire en plâtre (article), Colloque L'Habitat economique dans les pays en développement, Matériaux techniques de construction, composants, Plan construction, CSTB, Ecole Nationale des Ponts et Chaussées, Paris, 25-27 February 1983.

1.2 Storage

There are various types of storage, from the simple silo to the homogenization floor (10,000 to 20,000 tonnes). In the case of the latter, a mechanical shovel or a conveyor carries the gypsum to the crusher. This system can be programmed.

1.3 Crushing

The object here is to reduce the blocks of gypsum to small pieces.

A primary crushing to obtain a grain size of 30 mm should first be carried out, followed by a secondary crushing (grain size - 5 mm).

Crushers sometimes include a screen whose purpose is to select the grain size or to extract impurities such as clay and loess.

There is a great variety of plant on the market: jaw crushers, toothed cylinder crushers, hammer crushers.

Some of these have capacities of 1,200 to 1,300 tonnes per hour.

1.4 Burning

Burning is the process by which gypsum is transformed into plaster. A distinction is made between burning by direct heating and burning by indirect heating.

In the first case, the fuel or hot gas emitted from a furnace is in direct contact with the gypsum.

In the second case, burning is by heat transmitted from a hot surface such as a heating plate.

Dry burning is suitable for the manufacture of most currently used plasters, which range from:

- β-hemihydrate obtained at temperatures between 180 and 200°C;

- Hardburned plasters obtained between 450 and 700°C

1.4.1 Burning by direct heat

It is possible to distinguish the following:

- Rudimentary kilns

This process is still used in many parts of the world, particularly in the Middle East and North Africa.

Blocks of gypsum are heaped on the ground and then covered with fuel, such as wood and roots.

In the Touggourt region of Algeria, they dig a cylindrical well, which is then filled with pieces of gypsum and locally available fuel.

This process is notable for a slow combustion. Owing to the unevenness of burning, there is a high proportion of under- or over-burnt pieces.

- Vertical kilns

There are two categories:

The first, which are made of brick, comprise a furnace and a chamber three to four metres high in which the blocks of gypsum are piled.

These kilns have a capacity of $20m^3$ and are wood- or coal-fired.

Two tonnes of wood are needed to produce 19 tonnes of plaster.

Here again, the quality of burning is poor: the interior of large pieces of gypsum as well as those placed too far from the furnace remains unburned.

The second type, known as cylindrical shaft kilns, are different in that they have alternate layers of gypsum and fuel. The fact that the plaster is mixed with the ashes restricts the uses to which the material can be put.

The Steiger shaft kiln uses an improved process: gases emitted by side furnaces heat the blocks, which are thus not contaminated. Production can be as much as 25 to 30 tonnes per day and energy consumption is approximately 70 kg of fuel oil per tonne of plaster.

- Rotary kilns

This automated process links several phases: crushing, calcination, refining, packing.

The crushed blocks are introduced into a dedusting chamber before being transferred to the kiln. The plaster is subsequently pulverized and bagged. 1/

1.4.2 Burning by indirect heat

The following types of burning are used:

- Continuous-operation rotary kilns;

- Kettle-kilns, horizontal axis, continuous or batch operation;

- Kettle-kilns, vertical axis;

- Static kilns.

Finely crushed gypsum is introduced into these fixed or rotary kilns placed over a furnace.

1.5 Energy consumption

In large works, the plaster-burning process is now becoming one of the areas of highest cost.

1/ For further details, see:

- SNIP: Le plâtre, physico-chimie, fabrication et emploi, op. cit.
- F. BARDIN: Le Plâtre: production et utilisation dans l'habitat, op. cit.

Indirect-burning kilns consume more energy than direct-burning kilns:

- 29 to 35 kg of fuel oil per tonne of plaster for the former;

- 25 to 32 kg of fuel oil per tonne of plaster for the latter.

The electricity consumption required for the operation of the works must be added to the consumption of fuel oil in the kilns.

In Senegal, the SIES works uses:

- 44 kg of fuel oil per tonne of plaster for the burning installation;

- 54 kWh of electricity per tonne of plaster for the general operation of the factory.

Expressed in terms of fuel oil, 1/ total energy consumption is 64.5 kg of fuel oil per tonne of plaster.

Nevertheless, despite its high level, the energy consumption required in the manufacture of plaster is well below that required in cement manufacture, which averages 159.2 kg of fuel oil per tonne.

2. The plaster industry in some developing countries: results of experimental schemes

In Africa, this industry can be classified according to the use of different methods of burning:

- Rural kiln (less than 200 kg/day);

- Experimental kilns (0.7 to 1 tonne/day) in Mauritania and Cape Verde;

- Vertical batch-operation kilns (5 to 10 tonnes/day) in Senegal, Mauritania, Morocco and Algeria;

- Rotary kilns (15 to 25 tons/day).

In Mauritania, the Association for the Development of Appropriate Architecture and Town Planning (ADAUA) set up small artisanal plaster works of 3 to 5 tonnes/day at Rosso and Nouakchott in 1980.

Artisanal co-operatives set up and sponsored by ADAUA are in charge of production and operations.

In addition a local building firm is to build 115 dwellings entirely made of plaster.

In Senegal, the SIES works produces approximately 25,000 tonnes/year, while its production capacity is 120,000 tonnes/year.

Most of the difficulties experienced by this works are on the downstream side, where there is poorly organized distribution.

1/ 1 kWh = 0.38 kg of fuel oil.

Moreover, SIES produces phosphor-gypsum, a by-product of the chemical reaction between sulfuric acid and mineral phosphates. Phosphor-gypsum contains impurities such as phosphoric acid and oil which are not present in natural gypsum. This changes the setting time and strength of the plaster.

It is therefore necessary to carry out a purifying process, with a burning at 180°C in a rotary kiln.

This factory produces 4,000 to 5,000 tonnes/year of phosphor-gypsum. The exploitation of phosphor-gypsum is important in regions lacking natural gypsum. The quality of the plaster obtained from phosphor-gypsum is equal to that obtained from natural gypsum.

In Algeria, the Building and Public Works Laboratory (LBTP) has been using a mobile rotary kiln to improve plaster quality.

This type of unit is ideal for remote and inaccessible regions.

But this advance has been checked, as LBTP has not had the financial and human resources to promote this technology.

As a result of the increase in the price of wood, the energy cost of small-scale works remains high: 200 to 250 kg of wood per tonne of plaster.

It is for this reason that in Mauritania, for example, increasing use is being made of rice husks or sawdust mixed with waste oil as a fuel. For a tonne of plaster, $33m^3$ of rice husks are required.

In addition, ADAUA has developed a briquette, a mixture of rice husks, cow dung and waste oil. Compressed in a machine, it burns less quickly than loose chaff, thus producing an energy saving.

Finally, the Association for the Development of Renewable Energy Sources (ADEREM) in Mauritania is using solar energy from collectors which designed it.

3. General recommendations

Micro-units with a production capacity of less than 1 tonne/day and small works producing 1 to 10 tonnes a day are highly energy consumptive.

It is essential to improve burning methods (better kiln insulation, heat recovery, evenness of calcination). On the one hand these measures can reduce production costs and on the other improve material quality.

While small units are necessary they only satisfy a limited demand; it is therefore necessary to stimulate the creation of units with an output of 30 to 100 tonnes/day, which can be classed as intermediate.

Finally, it is helpful to encourage the production of equipment such as crushers, kilns and solar collectors by local manufacturers.

Table 21

Principal centres of plaster production in Africa south of the Sahara

Country	Production	Fuel	Remarks
MAURITANIA Rosso	1 tonne/day	Rice husks + sawdust + waste oil	ADAUA works
Nouakchott	0.7 tonnes/day	Solar energy	French co-operation + UNCHS
Nouakchott	60 tonnes/day		Projected works - finance by Arab funds
CAPE VERDE ISLANDS Ilha do Maio	1 tonne/day	Wood	Technical aid - German non-governmental organization (NGO)
MALI Tessalit	3 kilns of ± 3 tonnes/day each	Gas oil (180 litres per 3 tonnes)	75% of finance from Belgian authorities - technical assistance by Belgian NGO
SENEGAL Psao Dakar	10 tons/day (4,000 tons/year)	Fuel (64 kg/tonne)	Phosphor/gypsum production
GUINEA	Industrial works		Works set up by a French firm
SUDAN Port Sudan	15 tonnes per day		
FRANCE for comparison	800 to 1,000 tonnes/ day		Automated works

Y. CABANNES and S. BOUBEKEUR: Innovation et adaptation de technologies pour l'industrialisation des pays africains au Sud-Sahara, op. cit.

CHAPTER IV. TOWARDS AN EFFECTIVE POLICY FOR INTERNATIONAL CO-OPERATION

In this chapter we shall develop three themes: North-South co-operation, industrial projects supported by international organizations, South-South co-operation.

1. North-South co-operation

For a long time North-South co-operation in the building materials sector has been marked solely by the transfer of capital goods from the industrialized countries to the developing countries, a transfer which in most cases has given very indifferent results.

On the whole, firms are not always willing to export below a certain production threshold. This threshold is 30 tonnes a day for plaster, and 100 tonnes a day for brick.

It is worth recalling that the average size of factories in the industrialized countries is 500 tonnes a day and that the smallest have a capacity of 50 tonnes a day.

Moreover, they regard problems as fundamental as training, co-ordination and local management of factories as being of secondary importance.

Finally, they allow no place in their transfer operations for local manufacturers of equipment, from artisans to small, medium-sized and large companies.

However, since 1980 there has been a notable change in the nature of transfers.

Some firms have made an effort to adapt their supply to the demand of developing countries, by reducing the size and complexity of capital goods (mini-cementworks, mini-brickworks, small industrial plaster works) and using the available biomass in order to restrict the import of energy products.

A critical analysis of the transfers effected in this sector so far and recent developments observed lead to an important observation: if they wish to maintain their exchanges with the developing countries, the industrialized countries must modify their transfer strategy.

Put another way, North-South co-operation should be developed and strengthened but it is essential to give it a new content.

Today what is required is for the industrialized countries to transfer their experience (software) as much as, if not more than, their technologies (hardware).

Co-operation can be defined as the fulfilment of the objectives and interests of North and South alike so that they may develop simultaneously.

One of the objectives of the countries of the South is creating the ability to gain access to technology (techniques, procedures, know-how, organization, management).

This idea comes from a report drawn up in a UNIDO document on Africa: 1/

1/ UNIDO, "Industrial technology in Africa: Towards an integrated approach", Joint OAU/UNIDO Symposium on Industrial Technology for Africa, Khartoum, Sudan, 5-11 November 1980.

- Inadequate planning, programming and evaluation in industry;

- Lack of specific regional policies and plans in the technological field;

- Inadequate mechanisms and organizations at national level for the selection, evaluation, acquisition and transfer of industrial technology;

- Lack of credits;

- Lack of specialists;

- Lack of sources of information on industry.

In view of the difficulties, North-South co-operation should be centred on the creation of a "scientific and technical capital".

We have set out above the key role played by industrial information, research and development, engineering and training. 1/

Using these it is possible to attain three objectives:

- Mastery of technology;

- Mastery of negotiation, especially where technical options are concerned;

- Mastery of decision-making in planning matters (type of materials to be produced, kind of industries to be set up, type of training given to the labour force and cadres, sources of finance, incentives for local companies).

North-South co-operation can therefore cover fields as varied as:

- Assistance with industrial information;

- The strengthening of specialist institutions for engineering, design and manufacture;

- The development of training programmes for decision-makers, entrepreneurs in the field of technology acquisition, accountants and managers for small, medium-sized and large industries and specialists in the preparation, evaluation, financing and implementation of projects;

- Manufacture of some of the capital goods by local manufacturers.

2. Industrial projects supported by international organizations

In this type of co-operation, development banks and international organizations form the interface between industrialized and developing countries.

The Fourth General Conference of UNIDO 2/ accepted a group of projects which might provide interested African countries with assistance in a number of fields: critical examinations of existing pre-investment studies, development of

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1/ Cf. supra. pp. 30-42.

2/ UNIDO, "Industrial Development Decade for Africa: Review of progress, and proposals on ways and means of attaining its objectives, Draft programme for the implementation phase 1985-1990." Vienna, 2-18 August 1984.

specifications and evaluations of submissions relating to proposed feasibility studies, diagnostic studies of existing units of production, the defining of investment project profiles, evaluation and monitoring of contracts.

In the building materials sector, priority has been given to the enlargement or creation of cement works:

- Enlargement of the cement works at Malbaza - Niger;
- Enlargement of the cement works at Loutete - Congo;
- Enlargement of the cement works at Mashyuza - Rwanda;
- Re-opening of the cement works at Katana - Zaire
- Establishment of a cement works in Mauritius;
- Establishment of a cement works in the Liptako-Gourma region;
- Establishment of a cement works at Port Sudan - Sudan;
- Establishment of a factory for white cement - Tunisia;
- Use of waste products from steelworks for the production of slag cement in East and Southern Africa;
- Establishment of pottery works in Togo;
- Manufacture of tiles in Sudan;
- Establishment of mobile brick works in three countries.

Countries such as Botswana, Lesotho, Malawi, Mozambique, Swaziland, Tanzania, Zambia and Zimbabwe have clay deposits.

To exploit this material, UNIDO envisages the establishment of a technological centre whose purpose is:

- The investigation of raw materials, studies, testing;
- The development of technologies appropriate to local raw materials and other conditions;
- Advice relating to the choice of technologies, feasibility of projects, choice of consultants and suppliers of goods and services;
- The training of national consultants, entrepreneurs and technical staff;
- The creation of documentation and training services.

3. South-South co-operation

In the opinion of international trade experts, South-South trade in building materials remains at a very low level, indeed it is almost non-existent.

As far as we know, there are only a few isolated examples of transfers: Brazil and China have agreements with African countries for the establishment of brick works.

In the research field, the Cacavelli Centre in Togo has developed appropriate technologies for firing bricks. The work of the centre is based on the following three principles:

- Use of local materials and local fuels (nutshells, rice husks, etc.);
- Use of techniques that are simple and not very demanding and are easy to master; and
- Production of good quality brick at low prices.

The Cacavelli Centre is endeavouring to disseminate and promote the results of its research in other African countries.

The University of Science and Technology in Kumasi, Ghana and the Centre for Appropriate Technology (CTA) in Bamako, Mali, are pursuing the same objectives. 1/

Finally, ADAUA, as we have seen, is training artisans in the manufacture and use of materials in Mauritania, Burkina Faso and Senegal.

The developing countries are more and more convinced of the need to develop and strengthen their mutual relations. These relations are, however, impeded by four obstacles:

- Lack of information on countries of the South which produce capital goods;
- Lack of information about the kind of goods being produced;
- Lack of a tradition of exports towards other countries of the South; and
- Lack of private or State agencies involved in or guaranteeing the transfers.

The development of South-South trade is needed because it may contribute towards reorienting relations between industrialized and developing countries. Indeed the competition of the developing countries in the field of capital goods may lead the industrialized countries to modify their export policy.

Today some African countries are showing growing interest in mini-cementworks.

Included amongst the developing countries which have embarked on the production of these capital goods are China and India.

In China, two thirds of cement production are accounted for by mini-cementworks, which have an average capacity of 12,000 tonnes/year and are easy to run.

So far, the mini-cementworks in China have responded to the needs of the rural population. The equipment is locally manufactured and is designed to make use of available resources, such as coal.

It should be noted, however, that the quality is not always satisfactory. The kiln design could be improved.

With the assistance of UNIDO, China will set up a mini-cementworks in Rwanda.

1/ Y. Cabannes - S. Boubekeur: Innovation et adaptation de technologies pour l'industrialisation des pays africains au Sud-Sahara, op. cit.

India has made considerable efforts to develop cement research. At present each group of cement producers has a well-equipped laboratory and some groups, such as Associated Cement Companies (ACC), Orissa Cement Ltd., KCP Ltd., and some others, have their own research facilities.

The Central Research Station situated at Thane near Bombay, and belonging to ACC, is the largest and most modern research centre in the country. Among the more notable developments are slag cements, bore-hole lining cements, alumina cement and hydrophobic cements. 1/

India also encourages the development of new machinery for cement works. According to the study mentioned above, India is now, thanks to the large number of machinery and equipment builders, in a position to export turn-key units with a capacity of 50 to 150 tonnes/day, and some producers have already embarked on the transfer of their capital goods and know-how. In this connection, ACC has designed and installed a cement works with a capacity of 700 tonnes a day in Iraq and has exported clinker crushers to Kuwait.

Other Indian manufacturers would like to export equipment of the same kind within the framework of a South-South co-operation, but they demand reliable guarantees of payment from customers.

Co-operation among developing countries is of value only if the partners see mutual advantage in it: for the importing country, strengthening of its production capacity and mastery of technology, and the possibility of local production of machines, etc., and for the exporting country, establishment of a network of equipment manufacturers for export, creation of jobs, inflow of foreign currency and beneficial effects on the balance of trade.

The export guarantees requested by producers in developing countries are thus understandable and are in any case the rule in international trade.

Except for the countries in the Middle East and the Maghreb, most African countries have weak financial means at their disposal. Certain development-aid financing agencies could play an important part in supporting this type of transfer. The agencies concerned could on the one hand support transfer projects and on the other assist research on potentially transferable capital goods.

South-South co-operation can cover many fields: transfers of capital goods, training, and research and development. Many countries have acquired experience in the area of industrialization (India, China, Korea, Mexico, Brazil, Algiera, Tunisia and so on) and consequently have a contribution to make.

However, South-South relations are of value only if they are accompanied by a change in the nature of the transfer, i.e., only if the exporting developing countries do not commit the same errors as the industrialized countries.

GENERAL CONCLUSION

This study has attempted to highlight the importance of the cement industry and the buildings and public works sector within an industrial system.

Long neglected by many countries of the South, these industries should now be accorded special attention in view of the many advantages they offer, such as the secondary effects on other industries, the creation of a network of producers and skilled workers, and the creation of employment.

1/ Amandane Baradane: Les mini-cimenteries: la voie indienne, Irbat, Plan Construction (Rexcoop), p. 141, July 1984.

The diagnosis performed on the cement and brick industries in those regions of the world that are most affected by lack of raw materials have shown that practically all large-scale units are faced with technical and organizational problems, such as lack of know-how, missing production organization and absence of efficient management.

There is also a correlation between the complexity of the equipment in use and the inadequate production level and productivity of the units.

However, the small and medium-sized units are not always more efficient. It seems necessary in particular to improve product quality and to reduce the energy consumption of the kilns.

Competence in selecting equipment for cement, brick and plaster production is thus becoming essential. Mastery of the judgement and organizational ability essential to the proper running of the equipment, and also the ability gradually to take over the production of part or all of the capital goods, would enable the countries of the South:

- To increase their national capacity and reduce the gaps between the supply and demand of materials;

- To reduce imports of materials; and

- To generate positive effects on the industrial system, such as better relations among industries, the creation of equipment manufacturers and the emergence of a skilled labour force able to transmit its know-how.

We have seen the place occupied and the part played by project-study and industrial information respectively in the skills required for equipment manufacture and in those needed to make technological choices.

Unquestionably, the mastery of operating equipment, of equipment manufacture, of project study and of technological choices are essential pre-conditions for developing countries wishing to establish a coherent, competent and independent industrial system.

BIBLIOGRAPHY

I. GENERAL WORKS ON THE INDUSTRIALIZATION OF THE BUILDING SECTOR AND ON CAPITAL GOODS

ABDELMALKI (L.) L'Industrie du bâtiment au MAROC : contribution à l'analyse des filières de construction de logements urbains - Thèse de 3ème cycle - Sciences Economiques et de Gestion - Université LYON II - Décembre 1983

BOUBEKEUR Sid Les logements urbains en Algérie : crise et perspectives - Thèse de 3ème cycle. Département de Sciences Economiques et de Gestion - Université LYON II - Décembre 1983

CERNEA-E.C.T. Colloque crise de l'habitat et perspectives de co-développement technologique avec les pays du Maghreb. Economie des changements technologiques - ERA-CNRS 872 - LYON II - 18 mai 1984

CSORBA (E.) Le rôle de l'ONUDI dans les projects d'habitat pour le Tiers Monde - Conférence "Economie des changements technologiques" - Université LYON II - 15 décembre 1983

CSORBA (E.) Tendances récentes dans le secteur de bâtiment - Colloque - Crise de l'habitat et perspectives de co-developpement technologique avec les pays du Maghreb - CERNEA ECT LYON - 18 mai 1984

GONOD (P.F.) Un outil : L'ouvrage de la complexité technologique in Revue de l'Economie industrielle N° 20 - 2ème trimestre 1982

Transferts et ordre technologique - Institut International d'Etudes Sociales - Genève - Août 1983

UNIDO
- Seminar on Strategies and Instruments to Promote the Development of Capital Goods Industries in Developing Countries. Introductory document prepared by the International Centre for Industrial Studies. Algiers, 7-11 December 1979
- Technology in the service of development. Prepared by the Division for Industrial Studies. Warsaw, 24-28 November 1980. (ID/WG.324/4)

STRASSMANN (W.P.) Housing and building technology in developing countries. M.S.U. International business and economics studies 1978. Employment in construction: Multi-country estimates of costs and substitution elasticities for small dwellings. Working paper No. 3 - M.S.U. International development papers 1982

YAHIAOUI (S.) Le changement technologique dans la construction - le cas du logement urbain en Algérie : thèse de 3ème cycle - Université LYON II - Avril 1984

II. DOCUMENTS ON THE INDUSTRIALIZATION OF THE BUILDING MATERIALS SECTOR

BIERING (N.G.) Recent trends in the development of building materials and construction industries. Paper presented at the Meeting of African Experts on Building Materials, UNIDO, Addis Ababa, Ethiopia, 17-21 July 1978. (UNIDO/IOD.246)

BOUBEKEUR (S.) Remarks and suggestions concerning the background paper of Dr. Fred MOAVENZADEH and J.M.STARR: Measures and actions to increase the production of indigenous building materials in the context of enhanced import substitution, UNIDO, Vienna, 12-15 June 1984

CABANNES (Y.) BOUBEKEUR (S.) Innovation et adaptation de technologies pour l'industrialisation des pays africains au Sud Sahara - le cas des matériaux de construction alternatifs au ciment - GRET - Octobre 1982

MOAVENZADEH (F.) STARR (J.M.) Measures and actions to increase the production of indigenous building materials in the context of enhanced import substitution - background paper prepared for UNIDO April 1984

PLAN CONSTRUCTION CSTB ENPC L'habitat économique dans les pays en développement: matériaux, techniques de construction, composants - colloque - Paris, 25-27 Janvier 1983

PROVISOR (H.) Contribution à l'inventaire et à l'évaluation critique des matériaux et techniques de construction spécifiques aux PVD - Plan Construction - Juin 1982

UNIDO
- 1er rapport sur le programme de développement des industries du bâtiment et des matériaux de construction - Nigéria 1977
- Report of the Meeting of African Experts on Building Materials organized by the Economic Commission for Africa, Addis Ababa, Ethiopia, 17-21 July 1978.

RIEDEL (J.) Construction and building materials industries in Turkey - Draft report - Munich - July 1983

III. DOCUMENTS SPECIFIC TO THE CEMENT INDUSTRY

ADDA (S.) La filière ciment: données et reflexions sur l'industrie du ciment dans le monde arabe - Plan Construction - Décembre 1982

AMBROISE (J.) Elaboration de liants hydrauliques à moyenne température et étude de leurs propriétés physico-chimiques et mécaniques - thèse de Doctorat d'Etat ès sciences - Institut National des Sciences Appliquées - LYON Juillet 1984

ANANDANE (B.) Les mini-cimenteries: la voie indienne - IRBAT - Plan Construction - Juillet 1984

BANQUE SUDAMERIS Le marché mondial du ciment et l'Amérique Latine - Etudes économiques No. 5 1983

CHAPONNIERE (R.) Ciment et cimenteries en Afrique - Les mini-cimenteries: une alternative? Ministère de la Coopération et du Développement - IREP - Janvier 1982

INDUSTRIES ET TRAVAUX D'OUTRE MER Ciment et chaux dans le monde - Evolution des technologies et des marchés - perspectives d'avenir dans les pays en développement - N° 350 - Janvier 1983

RYDENG (C.) Programme for UNIDO industrial safeguarding of factory establishment and operation - UNIDO Division of Industrial Operations - 10 February 1984

SPENCE (R.J.S.) Appropriate technologies for small-scale production of cement and cementitious materials - Intermediate Technology Development Group - September 1979

SAMIRI (M.) Transfert entre systèmes techniques d'inégal développement et maîtrise de la technologie cimentière : le cas du Maroc - Thèse de 3ème cycle - Département de Sciences Economiques et de Gestion - Université LYON II - Décembre 1983

IV. DOCUMENTS SPECIFIC TO THE BRICK AND PLASTER INDUSTRY

BOUBEKEUR (S.) La filière brique - GRET - Janvier 1982

Centre CACAVELLI La terre cuite au Togo - rapport préparé par DANSOU pour les journées d'étude sur les industries des matériaux de construction à base d'argile en Afrique - Tunis - Décembre 1970

DES LAURIERS (T.) Approche énergétique de la fabrication de la brique cuite dans les pays en voie de développement - le cas d'Addis Abeba, Ethiopie - GRET - Juin 1983

HIEBEL (H.) Pourquoi et comment créer une briqueterie dans un pays en voie de développement - Centre Technique des Tuiles et Briques - Novembre 1981

PARRY (J.) Better brickmaking for developing countries - ITDG - Appropriate technology - Vol. 5 No 1, May 1978

PARRY (J.) Small-scale brickmaking. Technology series No. 6. UNIDO, International Labour Office, Geneva, March 1983

RONALD P. BLACK Malaysia: Small scale brick manufacturing - Appropriate technology for development - 1979

SATYA PRAKASH Use of renewable source of energy for burning building bricks in bull's trench kiln - Central Building Research Institute, Roorkee, New Delhi, 15-16 April 1982

THOMAS (D.W.) La fabrication à une faible échelle des briques cuites pour la construction - VITA - Août 1976

SYNDICAT NATIONAL des INDUSTRIES DU PLATRE : Le Plâtre, physico-chimie, fabrication et emploi - PARIS - EYROLLES - 1982

F. BARDIN Le plâtre : production et utilisation dans l'habitat - PARIS - GRET - 1982

NOLHIER - DIALLO Construire en plâtre - Colloque "l'habitat économique dans les P.E.D. - PARIS - 25-27 janvier 1983 - op.cit.

V. DOCUMENTS ON: TECHNOLOGICAL CHOICE AND ADAPTATION; INDUSTRIAL INFORMATION; CO-OPERATION AMONG DEVELOPING COUNTRIES

BOUBEKEUR (S.) Ce que pourrait être une politique de co-développement technologique dans le secteur de l'habitat - Colloque CERNEA ECT. Crise de l'habitat et perspectives de co-développement technologique avec les pays du MAGHREB - Lyon le 18 mai 1984

UNCTAD Handbook on the acquisition of technology by developing countries. United Nations Conference on Trade and Development, New York, 1978

QUASMI (L.) Le processus d'acquisition de la maîtrise technologique dans le bâtiment: le cas du Maroc - Colloque CERNEA ECT Lyon - 18 mai 1984

UNIDO - Renforcement du potentiel technologique dans les pays en développement: cadre général d'une action au niveau national - Vienne - Juillet 1979

- Manual for the preparation of industrial feasibility studies. New York, 1979. (United Nations publication, Sales No. E.78.II.B.5)

- Development and transfer of technology. Report of the Secretariat. Fourteenth session. Vienna, 9-19 May 1980. (ID/B/252)

- Mesures à prendre dans le domaine de l'information industrielle et technique en Afrique - Vienne, 7 octobre 1980

- Institutions et technologies industrielles - Vienne, 15 octobre 1980

- The role of external assistance in African technological development: Potential and limitations. Khartoum, Sudan, 5-11 November 1980. (ID/WG.332/8)

- The role of UNIDO in industrial technology. Khartoum, 5-11 November 1980. (ID/WG.332/3)

- South-South and North-South co-operation on energy for industrialization of the South. Division for Industrial Studies, 7 February 1983. (UNIDO/IS.369)

- Industrial Development Strategies and Policies for Developing Countries. World industrial development: Dynamics of growth through co-operation. High-level expert group meetings. Lima, Peru, 12-22 April 1983. (ID/WG.391/9)

- Industrial technology in Africa: towards an integrated approach, Joint OAU/UNIDO Symposium, Khartoum, Sudan, 11 November 1980

- Industrial Development Decade for Africa: review of progress, and proposals on ways and means to attain its objectives - draft programme for the implementation phase 1985-1990, Vienna, 2-18 August 1984

SAMIRI (A.)
BOUJIDA (B.) Maîtrise de la technologie et co-développement Nord-Sud - Colloque CERNEA ECT - 18 mai 1984

SEBESTYEN (G.) Research priorities for building materials industries in developing countries, CIB, Rotterdam, June 1984

YAHYA (S.S.) Training for human settlements in east and southern Africa. Paper presented at the training seminar organised by center for human settlements - University of British Columbia - 24-26 October 1983