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SOME ASPECTS OF TECHNOLOGICAL PROGRESS IN IRAQ'S CEMENT INDUSTRY*

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Introduction

The present case study will examine the growth of capacity and technological progress in the cement industry in Iraq. After a brief introduction to the historical background of the cement manufacturing industry in Iraq, the progress in technological capabilities of the industry in the various stages of planning and executing industrial projects will be examined.

A. Demand factors affecting the growth of the cement industry

The cement industry in Iraq has made a significant contribution to various aspects of the well-being of the population, particularly in the areas of housing and the construction of roads, bridges, dams, etc.

Cement forms an important material in the construction of urban houses, as well as those in rural settlements, where it is rapidly replacing conventional local materials such as stone or mud. This is illustrated by the growth of the proportion of the cost of cement in the total cost of construction materials in private buildings. This proportion rose from 8 per cent in 1977 to about 12 per cent in 1981. The total cost of construction materials as a percentage of the overall aggregate cost of buildings fell from 68 per cent to 61 per cent over the same period.

It is also interesting to note the increasing use of concrete blocks in the construction of rural dwellings, where they are replacing stones in mountainous areas and mud in the central and southern parts of Iraq. Thus, the use of blocks in private buildings for the whole country rose at an annual rate of about 27 per cent for the period 1977-1981, while that for stones only rose by about 13 per cent.

The increasing tendency to use cement as compared with other building materials such as bricks can be illustrated by the growth in the annual rate of cement tonnage used in private buildings for the period 1977-1981, which amounted to about 13 per cent. This is compared to an annual growth in the use of bricks (a very common building material in most parts of the country) which was only 3.4 per cent for the same period.

The growing use of cement in the non-housing sector such as dams, dykes, roads, bridges, etc. can be gauged by the public sector's consumption of cement. In the absence of detailed statistics, only aggregate figures for the overall consumption of cement by the public sector is given. Thus, for the period 1977-1981, the annual rate of growth in the use of cement by the public sector came to 14 per cent in terms of tonnage and 44 per cent in terms of value. Over the same period, the total value for all types of construction materials only rose by 5 per cent, while the proportion of cement in this total rose from 3.6 per cent in 1977 to 9.4 per cent in 1981.

These figures indicate to the greater use of cement by the public sector to the extent that during the construction boom of the late 1970s and early 1980's, the country had to import cement in order to satisfy its needs. As an indication of the increased demand for cement in the construction industry, it is revealing to observe the steady increase in the import of this material,

beside other building materials, up to 1981. Almost one billion dollars of building materials were imported during the boom period in construction. Since then, there has been a sharp drop, and in 1983 the value of imports was below the level for 1979.

Thus, in spite of the increase in the production of cement by local industry, as shall be pointed out, cement imports increased appreciably and in terms of dollars exceeded the value of imported iron and steel products in 1982, as is shown in table 1.

Table 1. Imports of cement, iron and steel
(Millions of dollars)

Year	Cement	Iron and steel
1979	15.7	451.0
1980	68.8	367.7
1981	290.8	292.5
1982	286.2	238.1
1983	146.6	152.1

Source: F. Jallal and others, "Productivity growth of Iraq's cement industry, 1965-1980", Proceedings of the Second Conference of the Iraqi Economic Association, 1983 (Arabic only).

This has also led to seek greater production capacities and larger plants. However, the slow-down of development plans and the falling demand for cement by the construction and building industry as a whole, reversed the situation in the mid 1980's, to that of excess supply. This situation prompted the industry to seek greater export opportunities than was originally conceived when such capacities were built.

B. Development of capacity in the cement industry

Cement manufacturing in Iraq dates back to the late 1940's. The first plant with 80,000 tons/year capacity became operational in 1949, but did not go into commercial production until 1950 because of technical problems concerning plant operations and product quality. Since then, cement plants have multiplied at a spectacular rate, both in number and in capacity, to reach the present production capacity of over 20 million tons/year. From its inception, cement production in Iraq was developed to satisfy the needs of the local construction industry in the housing and non-housing sector.

However, the glut in the construction industry and the recent war have caused a slow-down in operations to 75 per cent of capacity. It has also forced the cement industry to look for export opportunities at an inappropriate time owing to the general glut in cement production in the ESCWA region.

From the wider perspective of the building materials industry, there was a marked increase in capital investment in the period 1968-1984. Investment increased from 84 million Iraqi dinars (ID) in 1968 to ID 1,400 million in 1984, with cement manufacturing claiming more than 60 per cent of capital invested in the 1980s. The growing importance of the construction sector alongside the general growth pattern of the manufacturing sector for the period 1977-1982 is illustrated by their respective shares in gross domestic product (GDP), is shown in table 2.

Table 2. Relative importance of the construction sector
(Percentage of GDP)

Sector	1977	1978	1979	1980	1981	1982
Construction	6.9	7.7	8.7	7.2	10.8	16.2
Manufacturing	8.6	7.5	7.1	17.3	10.2	-

Source: N. al-Dabbagh and others, "Development in the transfer of technology in the cement industry", The Industry, 1985 (Arabic only).

It is interesting to note that the building materials industry accounted for more than 30 per cent of the capital invested in the manufacturing sector. Of this proportion, the cement industry had the lion's share.

In terms of plant production capacities, the cement industry moved towards the construction of ever larger plants from 250 tons/day for the first plants built in the 1950s to 700 tons/day for those built in the 1960s, 1,500 tons/day in the 1970s and 3,200 tons/day for plants built in the 1980s. It was hoped that by installing larger capacities, higher efficiency in production could be achieved.

C. The state of technology in the cement industry

Iraq is endowed with all the necessary resources to support a flourishing building materials industry. All the mineral deposits needed such as clay, limestone, gypsum, marble, sand, gravel, dolomite, etc., are available. Moreover, extraction requires only simple technology. For cement manufacturing, the minerals needed are plentiful and of a very high quality, which allows the production of different types of cement to the highest international standards.

Cement manufacturing technology has reached a mature state, and apart from some minor modifications and improvements, there are two main manufacturing processes: the so-called dry process and the wet process. The former has gained ground over the latter since the early 1960s, mainly because it is an energy-saving process which has a number of design and processing advantages. In both processes the solid materials (cement rocks, limestone, clay and other materials) are dry crushed. In the wet process this is followed by mixing with water and grinding before passing in a finely ground slurry onto further processes. In the dry process, however, fine grinding is carried out in the absence of water. The saving in energy through the use of more advanced versions of the dry process can be as much as 50 per cent.

In Iraq, up to 1979, with only one exception, cement plants based on the wet process were built. However, in the 1980s when total capacity reached 20 million tons, dry processing accounted for more than 70 per cent of this capacity.

Other developments in the 1980s, besides the trend towards the construction of plants with capacities of up to 3,200 tons/day, the industry also adopted more capital-intensive technologies with fully automated and/or computerized operations and control which allowed a wider mix of products.

D. Technological capabilities in the cement industry

In this section, the cement industry in Iraq will be examined from the planning stage to the operation and development stages, with special attention being paid to the role played by indigenous science and technology capabilities in the various stages.

1. Planning

Although the cement manufacturing industry was started in the 1940s by the private sector, it was taken over by the public sector in the 1960s. Since that time planning for the development of the cement industry has been a government responsibility. The growth of the industry has been controlled by the government's five-year development plans which incorporate annual investment programmes. Macro-economic and sectoral planning was carried out by the technical and economic departments of the Ministry of Planning with the participation of the Ministry of Industry and Minerals and the Ministry of Housing and Construction in matters relating to the building materials industry and to the construction industry respectively.

Planning has usually been on a short- or medium-term basis. However, some long-term planning was undertaken by the Ministry of Planning. Teams of foreign experts were employed for this purpose, but for various reasons no conclusive results were forthcoming.

From the beginning the cement industry, together with many other industries, relied almost completely on foreign consultants for project planning and design, including the selection of technology. However, with the development of the public sector and the strengthening of the control of the central governmental bodies responsible for economic planning in the country, especially since 1968, there followed a period of greater reliance on national capabilities and, consequently, the marked development of indigenous capabilities in project planning and general design works in the construction industry.

This period witnessed the strengthening of central institutionalized industrial planning, design and construction activities within the Ministry of Industry, as well as within the Ministry of Housing and Construction, with the full participation of Iraqi engineers.

However, this was short lived, for with the advent of the so-called "explosive development" period of the late 1970s and the early 1980s, when "turnkey" projects were the usual way of implementing projects. There was a

marked regression of indigenous capacities. Foreign consultancy firms took over most of the work, especially for the major high-cost projects. For the cement industry, this coincided with the construction of modern large-capacity plants of 3,200 tons/day using the dry-process, completely automated and computer-controlled. In the construction industry, the participation of foreign firms in planning and design is usually hidden by the fact that most projects were contracted on turnkey basis.

However, in 1981, of the 63 major development projects valued at more than 11,000 million dollars (\$), only four projects were contracted to Arab firms and of these, only one was Iraqi. These four projects amounted to only 3.7 per cent of the total value. Further, during the same year, six cement plants to the value of \$1,078 million, i.e. about 10 per cent of the total value, were under contract. The construction industry as a whole formed 57 per cent of the value of the 63 major development projects.

2. Industrial construction

It is difficult to separate industrial construction from consultancy and design work, since for most of the period under consideration (the mid-1970s to the mid-1980s), the majority of the projects were turnkey contracts. But, as with other major factories, the construction of cement plants was completely executed by foreign contractors. The role of national bodies was limited to supervision and a "resident engineer" role.

Although the National Company for the Construction of Industrial Plants was established in the late 1970s, it was mainly involved in small and medium-sized projects in the civil engineering field. And, as was mentioned previously, only one of the 63 projects contracted in 1981 was given to this company. Table 3 shows the type of civil engineering work contracted in 1981.

Table 3. Distribution of civil engineering works according to type (1981)

<u>Type</u>	<u>No. of projects</u>	<u>Value</u> (thousands of US dollars)	<u>Percentage</u>
Housing	13	1 160	18
Ports and airports	6	2 317	36
Dams	2	1 555	24
Roads and bridges	2	646	10
Agricultural	8	562	9
Monuments	1	136	2

Source: A. Zahlan, The Arab Construction Industry (Beirut, Centre for Arab Unity Studies, 1985).

3. Operation and capacity utilization

Plant and factory operations are usually carried out by a well-trained Iraqi work force (engineers, chemists, technicians, etc.). The structure of the work force relates directly to the type of technology used in the plant and also to its capacity and age. Thus, the proportion of technical staff for the newer large-capacity 3200 tons/day cement plants amounts to 10 per cent of the work force, while skilled labourers represent 50 per cent and the semi-skilled and unskilled 40 per cent. In the older, small-capacity plants of 250-700 tons/day the corresponding figures are 3 per cent, 27 per cent and 70 per cent respectively. The structure of the mid-capacity plants of 700-1,500 tons/day falls between these two ranges where the corresponding figures are 5 per cent, 33 per cent and 62 per cent, respectively. The structure, specialization and training of the labour force affects the quality of decisions regarding the choice of technology, technology development, and capacity utilization. For example, the management of the Baghdad Cement Factory opted to retain the technology with which their labour force was familiar. This was in spite of the fact that the wet process was somewhat inefficient by world standards at the time of the expansion in capacity. However, bureaucratic delays and inexperience could help to explain the unwillingness to harness the newly introduced dry-process technology which was installed in the Kufa Cement Plant in 1978. Table 4 shows the utilization ratio of the dry-process plant in Kufa with a 1,800,000 tons/yr capacity.

Table 4. Production capacity utilization of the 'new' Kufa Cement Plant

<u>Year</u>	<u>Percentage utilization</u>
1978	70
1979	81
1980	79

Source: F. Jallal and others, "Productivity growth of Iraq's cement industry 1965-1980", Proceedings of the Conference of the Iraqi Economic Association, (Baghdad 1983)(Arabic only).

With regard to the utilization of plant capacity, the development of production at the Baghdad Cement Factory may serve as an example. This is the oldest plant in the country, having commenced production in 1950 with one furnace using the wet-type technology; it had a rated capacity of 82,000 tons/yr. The capacity of the plant was upgraded to 400,000 tons/yr with the addition of 3 more furnaces of the same type by 1955.

Table 5 shows the development of the utilization ratio (based on design a capacity of 400,000 tons/yr) over the years.

Table 5. Production capacity utilization of the Baghdad cement factory

<u>Year</u>	<u>Percentage utilization</u>
1955-1960	83 (average)
1961-1965	84 (average)
1966-1970	114 (average)
1971-1975	113 (average)
1976	129
1977	153
1978	129
1979	121
1980	118

Source: F. Jallal, "Productivity growth of Iraq's cement industry 1965-1980", Proceedings of the Conference of the Iraqi Economic Association, (Baghdad 1983)(Arabic only).

Indeed delays, bureacratic inertia and failure to prepare for the introduction of the new technology may be the main reason behind the poor showing of the utilization ratio in the entire cement industry in Iraq, as is shown in table 6.

Table 6. Production capacity utilization in the cement industry in Iraq

<u>Year</u>	<u>Percentage utilization</u>
1978	79
1979	75
1980	74

Source: F. Jallal, "Productivity growth of Iraq's cement industry 1965-1980", Proceedings of the Conference of the Iraqi Economic Association, (Baghdad 1983) (Arabic only).

Table 7 gives further details of the productivity, utilization and operation efficiency of the various plants with different technologies.

Table 7. Technology of cement plants and various efficiency criteria

	Period of construction		
	1949-1972	1973-1979	1979-1984
No. of plants	12	15	14
Type of process	Wet process	Only 2 using dry process	Dry process
Designed capacity (tons/day/furnace)	250-700	700-1500	3,200
Percentage utilization	90-100	70-80	95-100
Productivity (tons/year/worker)	600-650	2,000	3,000
Fuel consumption (tons/100 tons of cement)	15-18	10-11	8-9

Source: N. al-Dabbagh and others. "Development in the transfer of technology in the cement industry", The Industry, No. 2, 1985 (Arabic only).

Because of the war, greater use was made of foreign workers in most industries. In six cement plants, the number of expatriates formed about 71 per cent of the work force in 1985. The percentage of foreign workers for the whole building materials industry in the public sector was about 35 per cent.

It is clear that there has been a modest increase in the total factor productivity (TFP) change. Most of this growth came about as a result of the adoption of best practice technology (the dry process); some, undoubtedly, may be owing to an increase in the level of technical efficiency.^{1/} This can be seen by examining the growth in output over time in both traditional and best practice technologies. This distinction between the two elements of technological progress is intended to show the increasing level of technical efficiency, an important element in the industry's capacity to run, maintain and operate plants efficiently. Without such efficiency there is no capacity to innovate at the level of product and process design.

4. Management

Industrial management is an issue of great concern in Iraq as well as in most developing countries. The cement industry provides a case in point. The increase in demand for cement in the second half of the 1970s and the subsequent increase in imports focused attention on the efficiency of cement production in the country. The figures presented in the previous section have touched on this area. However, it may be added that the newer plants that

^{1/} N. H. Al-Adhadh "On the concept and measurement of scientific and technological capacity for development and some tentative conclusions for developing countries" ESCWA working paper series No.2, 1989.

came into operation during the first half of the 1980s which used the dry-process with the latest technology in operation and control, showed a 95-100 per cent utilization. Two points may be made in this regard: the first in connection with the structure of the work force and the second with that of management.

The structure of the work force has changed remarkably. The older plants were labour-intensive and relied heavily on semi-skilled and unskilled labour, which formed 70 per cent of the work force, with only 3 per cent technical staff. The changes brought about by the introduction of the dry process technology resulted in figures of 40 per cent and 10 per cent for the two respective categories.

For plants with the same capacity, the total number of workers required in the newer plants is only 70 per cent of those needed in the older ones. This economisation in labour input becomes even clearer when the marked decrease in the proportion of personnel engaged in operation vis-a-vis those in maintenance is considered. The modern plants with their fully automated and computerized control systems engage a larger proportion of workers in maintenance, some 40 per cent as compared with 15 per cent in the older plants.

The second point to be considered, is that of management which has been identified as a major problem in the industrial structure of developing countries. This could hardly be disputed when cement production declines to 70-80 per cent of capacity at the time when demand reaches its highest level. The situation has been aggravated by the shortage of skilled labour in the civilian sector as a result of the war.

This led the industry to use a greater proportion of expatriates in their work force, and to turn to specialized foreign industrial management firms to run a number of cement plants in the country.

Table 8 shows the comparative performance of two groups of cement plants with equal capacities. In the first group, A is under local management and B is under foreign management. In the second group, C is under local management and D under foreign management.

Table 8. Comparative performance of plants' foreign and local management

Elements of performance	Group 1		Group 2	
	A	B	C	D
Number of plants with capacity of 10 ⁶ tons/yr	2	2	1	1
percentage utilization	88	93	67	106
No. of workers	1 000	696	307	302
Productivity (tons/yr/worker)	1 800	2 672	2 182	3 590

Source: N. al-Dabbagh and others. "Development in the transfer of technology in the cement industry", The Industry, No. 2, 1985 (Arabic only).

The results clearly show the greater efficiency of the plants under management contracts. In each case the foreign contractor is obliged to give full training to the Iraqi personnel to ensure a smooth change-over at the end of the contract and continuation in the level of running efficiency.

5. Marketing

As with most public sector industries in developing countries, marketing is seldom given the attention it deserves. This is best illustrated by the presence of almost continuous bottle-necks in the markets of the goods marketed by the public sector. The cement industry in Iraq carries the burden of 25 per cent under-utilization, with no breakthrough in export opportunities in sight. Because of this situation, some plants are threatened with closure.

6. Research and development

For years research and development (R and D) activities have been completely neglected. A newly established industry seldom incorporates such activities within its organization. However, research on building materials and construction has long been pursued in the scientific departments of most Iraqi universities. Research on cement and cement-related materials is also taking place at the Building Research Centre of the Scientific Research Council, as well as at the National Centre for Construction Laboratories of the Ministry of Housing and Construction. This Ministry also runs the National Centre for Engineering and Architectural Consultancy. As for the cement industry itself, until recently, a number of R and D units were operating at some plants. However, these units appear to have been abolished in the course of the reorganization of the industrial sector. There is also a central laboratory that serves the industry directly by providing quality control services and undertaking some trouble-shooting. National specifications and standards for building materials are the concern of the Central Organization for Standardization and Quality Control.

The General Establishment for Geological Survey and Mineral Investigation of the Ministry of Industry and Minerals is concerned with the task of searching for new sources of building materials.

However, collaborative R and D efforts between these centres are limited. There is even less collaboration between independent R and D centres and industry. Nevertheless, wherever collaboration has taken place, the outcome has been successful. A case in point is the successful development and subsequent implementation of expandable cement. This product was developed at the Building Research Centre of the Scientific Research Council, and implemented jointly with the General Establishment of Cement in the central region. It has saved the General Establishment for Industrial Construction, the main user of this kind of cement, millions of dollars annually. The cost of one ton of this cement, produced using this innovation, is only \$50 compared with the imported price of \$1,900.

The unimpressive achievements in what are termed "white collar" R and D of the non-integrated and quasi-independent centres, however, should not obscure some of the notable achievements of the so-called "blue colour R and D" activities on the factory and quality control laboratory level. Several

cost-saving developments have been reported including the use of local iron ore to produce reinforced concrete, the replacement of organic glue by cecotine, the use of corn starch and other additives in place of glue, the production of smoothness and purifying metal etc.

Behind the modest progress in the technological capabilities of the cement industry in Iraq there has been a reasonable, although insufficient, human resource development programme.

E. Human resources development in the cement industry

Manpower development for industry, and cement manufacturing in particular, offers a good example of the efforts expended in building an indigenous technological capability. This is owing to the variety of skills, knowledge and experience needed.

At the national level, these needs are catered for by different educational establishments, namely: (a) vocational education; (b) technical education; and (c) university education.

It has been calculated that for the efficient running of the building materials industry in Iraq, 26,500 persons are needed. Of these, 11 per cent are required in management, 56 per cent in production and the remainder in ancillary services. In 1986, there were only 16,500 Iraqis; the other were expatriates. Of the Iraqis, the greatest shortage is in production, where the present manning level constitutes only 56 per cent of the number required to work in production. The shortage in management amounts to 27 per cent. The situation in the industrial sector in general is rather similar, and was further accentuated by the war.

The main channels for the provision of technicians for industry are vocational schools (open to the age group 16-21) and technical educational institutes (open to secondary school leavers). Industry has its own training centres, but their capacity is limited.

The situation regarding engineers and the other university graduates needed for industry is slowly improving. At present, there are six engineering colleges and six colleges of science. Another three of each type may be opened in the very near future.

To develop skills and personnel capabilities in matters of importance to the industry, a viable training programme is carried out both at the factory level and at the sectoral level. In addition, for projects under construction, the contractor is obliged to provide hands-on training for Iraqi personnel at similar factories abroad as well as to run training programmes at the work site. This has helped some personnel to master the technologies adopted in new projects. Scientific societies, in co-operation with the universities and industrial establishments through continued education programmes have played an important role in technical manpower development.