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FUNDAMENTALS FOR SUCCESS IN THE ESTABLISHMENT OF CEMENT PROJECTS*

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*The views and opinions expressed in this paper are those of the consultant and do not necessarily reflect the views of the secretariat of UNIDO.

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I. THE CEMENT INDUSTRY AS A FOUNDATION FOR DEVELOPMENT

The need for cementing materials has been emphasized increasingly since the early stages of human history. It started with the natural requirement for lodging with ample protection from the weather and has grown with the development of society and the accompanying improvements in lodging facilities and social services such as schools, hospitals, and electrical and sanitary systems. The consumption of cement increases with the growth of population and of gross national product.

The cement industry is especially important because of its direct relation to all development activities. It is basic to the building and construction industries and is therefore considered the foundation for development plans, involving all aspects of progress in industrialization, housing schemes and the general social infrastructure.

Cement raw materials are simple calcareous and argillaceous deposits that are abundant as natural resources in nearly all countries. The rate of cement consumption and the average per capita consumption reflect the rate of development and progress of a country.

In most developing countries there is a special concern for the improvement of rural facilities. The traditional village huts, which were formerly composed of soil and plant elements, are now being replaced by houses made of cement or durable building materials requiring cementing. This trend entails the establishment of public services including centres of education, security, medical treatment etc. and of small rural industries for processing agricultural products, workshops for the production and maintenance of farming implements and establishments for the utilization of animal resources.

The increasing use of precast concrete elements in industrialized building systems creates a regular demand for cement as a substitute for building bricks and traditional plastering materials. Prestressed and precast concrete elements are also replacing wooden and metallic elements. An example is the prestressed concrete railway sleeper, which is greatly favoured for its strength and durability. Cement products also now include a large number of elements such as asbestos-cement (corrugated and flat sheets); sanitary and sewage water pipes; irrigation and drainage implements; electrical power cables; telecommunication poles; special harbour and canal blocks; and curbings and pavement slabs.

The future prospects of the cement industry are excellent for continuous expansion and progress. Most development programmes call for extensions of existing cement plants or for the installation of new cement production lines, because cement is the basic element in practically all projects, whether in the form of foundations for industrial projects or of infrastructure for agricultural purposes and social schemes.

Research has revealed that various raw-material deposits that were unsuitable for cement production in the past can now be utilised. In addition, a number of improvements have been introduced in traditional cement types already in use. Both trends point to more elaborate cement application and higher consumption. The latest technological developments now favour the dry process for economy and energy preservation and for reduced labour requirements per ton[1] of cement. Today kilns of 3,500 tons/day capacity (1,150,000 tons annually) are replacing previously installed smaller kilns. Bigger kilns capable of producing 6,000 tons/day or more are on the drawing board. Grinding mills are now designed for the 10,000 hp range.

These economical trends towards increased production and larger units increase the availability of cement and give impetus to its wider use in different products.

1/ References to "tons" are to metric tons.

II. REQUIREMENTS FOR A SUCCESSFUL PROJECT

The success of a cement project depends on various technical and economic factors that should be carefully analysed to attain clear and secure results. The basic requirements should be cautiously investigated to secure regular production over the economic age of the project, thus affording the utmost utilisation of the invested capital. This sort of study is no longer as simple as the previous resort to rough estimates or general views. The recent procedure of first making a feasibility study entails an evaluation of each of the technical and economic factors before initiating project activities.

The traditional production of Portland cement is now only economically possible if the cement is manufactured in plants above a certain minimum size, requiring an initial capital investment equivalent to several million United States dollars. The establishment of a new cement plant is therefore a major project, which calls for a thorough investigation of the market, of resources, and of economic conditions before the decision is made to start the construction of the plant.

The necessity for manufacturing cement in large units has developed through economic considerations combined with a steadily increasing demand for cement. The costs of production per ton of cement decreases considerably with increasing plant capacities. This is a well-known pattern within several other industries, and the principle of establishing the minimum economic size of plant is the same as that used in other industries.

Another characteristic of the cement industry is that the capital investment is high compared with the actual costs of production. However, the type of equipment used in a cement plant normally has a long life, about 25 years, and the depreciation of the plant may therefore be distributed over several years.

This means that a new cement plant should preferably operate for a period of at least 25 years in order to render the full return on the capital invested. If the production is discontinued after a few years of operation, the remaining life of the equipment is in most cases completely lost because the resale value of this heavy type of plant equipment is very low owing to the high costs of dismantling and transporting it.

In other words, continuous operation for several years is indispensable for the economic success of a new cement plant. The planning team must therefore take the precaution to ascertain that the surveys on market and resources contain sufficient evidence that the demand for cement and the supplies of raw materials will match the life of the plant.

In addition to surveys on market and resources, the planning team will have to find answers to a number of other questions, namely:

Plant location
Size of plant
Manufacturing process
Plant equipment and layout
Financing and cash-flow profiles

All these questions are important and should be evaluated in detail before the decision is made on the implementation of the project.

A comprehensive study, as outlined above, is costly. It is advisable that the work be divided into a preliminary feasibility study, which is based mainly on existing information and which may thus be made at a fairly low cost, and a more comprehensive study which would follow if the outcome of the preliminary study were encouraging.

Market survey

Portland cement is one of the most widely used commodities in the world. Owing to the rather low price per weight unit, it is manufactured locally in practically all countries in which suitable raw materials (limestone and shale or clay) are available.

The consumption *per capita* varies from about 50 kg/year in many developing countries to about 500 kg/year in industrialised countries. The average growth rate of cement consumption is about 5-6 per cent per year, but the growth rate varies considerably from place to place. In the industrialised countries the growth rate is normally below the world average, thus indicating that the market is approaching its saturation point. In the developing countries the growth rate is usually higher than 6 per cent and in some countries considerably higher.

In all countries the demand for cement fluctuates with the activities within the building sector, thus also reflecting the present economic situation in the country. Large construction schemes such as dams for hydroelectric plants, airports or highways, may change the demand pattern significantly.

In some areas the demand for cement may be low because of normally high prices of imported cement or cement from existing uneconomical plants. The potential markets of such areas may be evaluated by studying the procedures within the building industry and the costs of alternative construction materials.

The competitors' activities should be watched as closely as possible. A potential market may easily attract several groups of cement manufacturers. It often happens that new plants or expansions are constructed simultaneously within the same area, with the result that both works run at reduced outputs for several years.

<u>Raw materials investigations</u>

The raw materials for the manufacture of Portland cement are normally limestone and shale or clay. Deposits of these materials are found in most countries, but the quality and quantity are not always satisfactory for the requirements of a cement plant. In fact, only relatively few cement plants are so fortunate as to have supplies of high-quality raw materials available within the vicinity of the plant.

In areas with small or inferior quality limestone deposits, the prospecting for useable reserves becomes the most important part of the feasibility study. Even when raw materials seem to be available, however, a survey should be carried out to ascertain that the quantity and quality are adequate.

For a new plant the proved reserves of raw materials should cover at least 25 years of operation and preferably a longer period to allow for possible expansions.

The limestone should contain a minimum of about 76 per cent calcium carbonate and only small amounts of magnesia, phosphate, alkalies, chloride and sulphur. The shale or clay should preferably have low contents of alkalies and chloride and suitable ratios between the oxides of silica, aluminium and iron. Apart from the chemical composition, the raw materials should preferably have physical properties that make them easy to quarry and handle.

Geological investigations, including bore-hole sampling, are normally required for the assessment of the deposits. For these studies expert assistance may often be needed in order to ensure that the necessary evidence shall be obtained at a minimum cost of bore-hole drilling. In special cases low carbonate limestone may be upgraded by different types of processes, of which selective grinding and flotation are good examples.

Preliminary feasibility study

As soon as it has been established that the market for cement is large enough to justify constructing a new cement plant and that raw materials are available, a preliminary feasibility study should be made to determine whether the project deserves further consideration. If the results are affirmative, more detailed investigations should be carried out to provide the basic data for a final feasibility study.

The main objective of a preliminary feasibility study, as mentioned above, is to determine whether the project is promising enough to justify a detailed study and further planning work, which are usually quite expensive. Other objectives are to provide the basis for a plan of action and a time schedule for the execution of the comprehensive study and to obtain preliminary information about the project which may be required to calculate the initial capital investment and to secure financing for the detailed study.

If the preliminary survey indicates that the market for a new cement plant exists and that sufficient quantities of suitable raw materials are available, the preliminary feasibility study should contain an over-all estimate of the initial capital requirement, the estimated costs of production, estimates of gross and net earnings, a preliminary financing programme and the estimated profitability.

All estimates should be based on information that is readily available or that may be obtained at small cost and without delay. For example, the estimate of the capital requirement may be based on typical cost figures for standard cement plants, after these have been adjusted to the required plant size and updated in accordance with actual rates of inflation.

The profitability is expressed as the pay-back time or the rate of return on invested capital. The pay-back time is the number of years that it takes the plant to earn back the initial capital, disregarding interest, amortization and taxes.

The gross rate of return is the yearly earnings expressed as the percentage of the initial capital, again disregarding interest, amortization and taxes.

Both methods of evaluating the profitability are crude, but they are often used because they are simple to work out and readily understandable. If a more accurate picture is required, the profitability may be calculated by the internal rate of return method, which takes into account all expenditure and income during the estimated life of the plant and considers interest, amortization and taxes. This method will be discussed later in this report in relation with the final feasibility study.

Plant location

The choice of the plant location is important because the costs of transportation of raw materials and cement are high in relation to the costs of production, and because the location must be right for the total life of the plant since the equipment can be moved only at a cost that is normally prohibitive. The plant site should be near the raw materials, the market and the means of transportation such as a shipping port, railway and good roads. The availability of electric power, fuel, water and manpower should also be considered.

Some of the factors influencing the choice of the plant location may conflict. For example, it will often be desirable to have the plant placed in the vicinity of a big city with a dense market, but, on the other hand, the plant should not be too close to a residential area where complaints about dust or noise nuisance are likely to cause difficulties, for example, later when the company asks permission to expand. In general, the vicinity of raw materials is more important than the nearness of the market, mainly because raw materials are about 60 per cent heavier than the cement.

The ideal location of a contemplated plant may be calculated from details on the distribution of the market and the location of raw materials and other resources by use of linear programming. In many cases, however, the choice is simplified because one or a few sites have obvious advantages, and sophisticated calculations are therefore not required.

Some rules of thumb may be quite useful, such as that a plant should be located near the centre of the market, but such rules should be used with caution, because they may not apply. If, for example, the market is divided mainly between two centres with little sales possibility in between, the ideal location is not necessarily the point of gravity between the two centres but rather the larger of the two centres.

The position of possible competitors may also influence the choice of the plant site. In general, the location of a new plant should be closer to the expected market than any competitor. The distance should then be measured in unit costs of transportation rather than in miles or kilometres.

As the cost of transportation by waterway using barges or ocean-going bulk carriers is considerably lower than the costs of rail or road transport, it is obvious that a location at the waterfront places the plant in a strong position in relation to all competitors within the areas near the waterway.

The relation between the costs of road and ship transport may be illustiated by the fact that the radius of the distribution of cement by road in a competitive market is usually limited to about 100 to 150 miles from the plant, whereas cement is often shipped several thousands of miles by sea carrier. Owing to the low cost of shipment by sea, it is in many cases economical to operate one large-capacity plant with a waterway distribution system rather than a number of smaller plants. The trend towards concentrating production in a few large plants and distributing the cement by ships or barges to a number of distribution silos has become more and more pronounced in recent years. All existing and new cement plants therefore face the threat of new competition from distant larger producers who may decide to extend their sphere of operation by building new distribution silos.

Optimum size of plant

The consumption of cement is in most countries steadily increasing. A new cement plant should therefore have some excess capacity to cover the demand not only for the year after its commissioning, but also for a few years ahead. On the other hand, the plant must not be too big because its operation is only profitable when it is working at almost full capacity. The break-even point often corresponds to about 70 per cent of utilisation. In a market with competition the optimum size of a new plant will depend greatly on the relative merits of the new plant and of the existing competitors. If the new plant is designed to produce cement at lower costs than the existing plants, it may be able to take over a considerable portion of the market, and building a big plant may be justified on this basis. However, this means hard competition with the existing producers, who may decide to lower their prices and take other actions to keep their share of the market.

The optimum plant size can be calculated from the market survey data and the basic unit prices of cement and transport as well as by the calculated cost figures for the construction and operation of plants of different sizes. Such calculations are based on assumed market volumes and prices, and sensitivity tests are recommended in order to evaluate the effect of possible deviations from the estimated basic figures.

The final decision regarding the size of a new plant is often influenced by the optimism or pessimism of the planning group. Some executives may wish to be on the safe side and not build the plant any larger than necessary. Other decision makers may feel that the plant must first of all be large enough to meet the challenge of the future.

Both types of planners may claim that they were right in the light of actual later developments. The plant that was intended to be small will be less competitive because of the higher production costs of small plants, and it will be unable to capture its share of the market. The owners may therefore conclude that they were right in being prudent in gauging the plant size. The larger plant may prove to be highly competive and take over a larger share of the market, making the owners happy that they decided on the bigger plant.

The influence of decreasing production costs with increasing plant capacity may, of course, be included in the calculations. If, however, the profitability curve develops a "flat" maximum with almost the same value for a wide range of plant sizes, the calculation may be of little help to the planning group.

Although the calculation of the optimum plant size is often complicated, the principle is in fact simple. The unit cost of production decreases with the increasing size of the plant, but at the same time the unit cost of transportation of cement increases because normally the marginal market can be gained only by increasing the radius of the market area. The theoretical optimum plant size is then determined by minimising the combined cost of production and of transportation.

This simple model may, of course, be modified to suit the special characteristics of the market, the means of transportation and the type of plant.

Choice of technological process

The manufacture of Portland cement entails the following three processes:

Preparation of a raw mix

Burning of the raw mix to cement clinker

Grinding of clinker and gypsum to cement

Before the year 1900, Portland cement was burnt in small shaft kilns, but today about 9[illegible] per cent of all cement is manufactured in rotary-kiln plants. Shaft kilns are used only in special cases and are normally not competitive with rotary-kiln installations because of higher labour costs and because it is difficult to manufacture cement of a satisfactory, consistent quality by means of shaft kilns.

The manufacture of cement in rotary-kiln plants may be carried out by different types of processes, the most common being the dry and the wet methods.

A more comprehensive list of the different processes used today is shown in the following table. In the dry process the raw materials are dried in a separate dryer or in a dryer crusher or dryer mill and ground to the fineness required for clinkering. The dry raw meal from the raw mills is homogenized in special silos before it is fed to the dry-process kiln.

The wet process is characterized by the wet grinding of the raw materials into a thick slurry, which is homogenized in slurry silos or basins and pumped to the wet-process kiln. One important advantage of the wet process is the simplicity of operation, which should be taken into consideration when selecting the type of process for a new plant in an area where highly qualified labour may be difficult to obtain.

Apart from the different types of equipment in the raw-grinding department, the kilns used for the two types of processes are also different. The initial costs of the dry- and wet-process plants may differ somewhat, and the costs of operation may also differ mainly owing to the higher fuel consumption of the wet-process plant. The relative merits of the two methods, however, depend on the local conditions, which may favour one or the other. The main factor to consider when deciding about the type of process is the moisture content of the raw materials. In general, the dry process is preferred for all raw materials with less than 10 per cent moisture <u>in situ</u> (as quarried), whereas the wet process is preferred for very wet raw materials with 15 to 20 per cent moisture content <u>in situ</u>.

For raw materials with 10 to 15 per cent moisture it is often difficult to tell offhand which of the two methods is the more advantageous. It is usually necessary to carry out detailed calculations in order to ensure that the right decision shall be made.

The merits of the dry and the wet processes are summarized below.

Table. Portland cement manufacturing processes

Name of process	Raw mix preparation	Clinker burning
Shaft kiln	Dry grinding, pelletizing	Shaft kiln
Dry long kiln	Dry grinding, with or without pelletizing	Long rotary kiln with internal fittings
Dry 1-stage preheater	Dry grinding	Medium-long kiln with crosses and a 1-stage cyclone preheater
Dry 2-stage preheater	Dry grinding	Medium-long kiln with or without crosses and a 2-stage cyclone preheater
Dry 4-stage preheater	Dry grinding	Short kiln without internal fittings and a 4-stage cyclone preheater
Dry shaft preheater	Dry grinding	Short kiln without internal fittings and a vertical-shaft preheater
Dry, grate preheater (Lepol grate)	Dry grinding, pelletizing	Grate preheater and short kiln
Wet kiln with waste-heat boiler	Wet grinding	Short kiln, waste-heat boiler
Long wet kiln	Wet grinding	Long kiln with internal fittings
Slurry filter	Wet grinding, pressure filtering	Long dry kiln or grate preheater kiln
Spray dryer	Wet grinding, drying in spray tower	Long dry kiln with or without cyclones
Fluidised bed	Dry grinding	Special reactors for burning raw mix in a fluidized bed
Sintering grate	Dry grinding, pelletizing	Travelling grate kiln
Cement/sulphuric acid	Dry grinding	Special process using gypsum or anhydrite for production of clinker and sulphuric acid

Condition	Dry	Wet
Initial costs of equipment	Depend on raw materials	Depend on raw materials
Fuel consumption	800-900 kcal/kg clinker	1,100-1,500 kcal/kg clinker
Power consumption	Average	Average
Manpower requirements	Average	Low
Alkalis, chloride, sulphur	May cause problems of operation; difficult to manufacture low-alkali cement of many raw materials	Does normally not hamper Possible to manufacture low-alkali cement of most raw materials
Costs of maintenance	Average to high	Low to average
Quality of cement	Satisfactory	Satisfactory

The initial costs of the plants depend on the properties of the raw materials. For example, a deposit of inhomogeneous limestone may require the installation of an expensive pre-homogenizing store for a dry-process plant, whereas the same limestone may be fed direct to the raw mill in a wet-process plant in which homogenization can easily be achieved after the mill in a less expensive slurry basin. Inhomogeneous raw materials are therefore a factor that may favour the wet process.

The fuel consumption is in general higher for the wet-process than for the dry-process plant, but the actual fuel consumption figures vary considerably from plant to plant, depending on the moisture content of the raw materials. A dry-process plant may use, say, 800 kcal/kg of clinker when the raw materials are all dry or contain only a low percentage of moisture, but if the raw materials contain, say, 15 per cent of moisture, the fuel consumption will be about 1,100 kcal/kg of clinker.

For a wet-process plant the fuel consumption depends on the moisture content of the kiln slurry. Some unplastic raw materials may be ground wet into a pumpable slurry with only 28 to 30 per cent of moisture, and the fuel consumption of the wet kiln is then only 1,100 to 1,200 kcal/kg of clinker. Other types of raw materials, usually recognized as plastic materials, will require about 40 to 42 per cent of moisture to produce a slurry that can be handled in centrifugal pumps, and for such slurries the fuel consumption is about 1,400 to 1,500 kcal/kg of clinker.

Owing to these differences in conditions the fuel saving of the dry process in relation to the wet process may be anything from nil to 700 kcal/kg of clinker. This illustrates how difficult it is to arrive at the right decision regarding the type of process. It is strongly recommended that the final choice be based on careful examination of the raw materials and of all other factors involved. Detailed calculations of the initial costs and of the operational costs should be carried out for each alternative solution considered. These calculations are normally made as part of the final feasibility study.

If the dry process is chosen, the next step is to select the best suitable dry-kiln system among the various alternatives. The 4-stage cyclone preheater kiln is often preferred because it usually is the cheapest installation. For raw materials with high contents of alkalis (more than about 1 per cent as sodium oxide) or chlorides (more than 0.0% per cent Cl), however, it is advisable to consider other solutions such as, for example, a 1-stage preheater kiln in which the internal circulation of the volatile matter does not hamper the operation as much as in a 4-stage preheater installation.

The grate preheater kiln is fed with nodules of the raw meal prepared on a disc pelletizer; the dust emission from the kiln system is therefore low. However, the performance of the grate preheater depends very much on the physical properties of the raw materials; it is essential that the nodules should have high strength and porosity allowing them to pass through the preheater with a minimum of breakage.

Slurry filtration has been used in a few cases to combine the advantages of wet raw-mix preparation and the burning of a kiln feed with a low moisture content. This method offers a substantial fuel saving as compared with the wet process, but operating the slurry filters will usually cost as much as the fuel saved, and the over-all efficiency of a plant with slurry filters is therefore not necessarily superior to that of a conventional plant. The cost of installation and operation of slurry filters depends on the filtering properties of the slurry.

Spray drying of cement raw slurry is a relatively new method, which may be advantageous in special cases, for example when the raw materials have a high moisture content in situ but produce a slurry that is not entirely suitable for burning in a kiln.

Other types of less commonly used processes are the fluid-bed, the sintering-grate and the shaft-kiln methods. Normally, these processes are not competitive in relation to the conventional rotary-kiln installations. The shaft kiln is still used at some small plants, but when these plants are expanded, such kilns are usually replaced by rotary kilns, partly because shaft kilns become less competitive with increasing plant capacities, and partly because the rotary kiln produces a more consistent quality of cement clinker. In some developing countries in which suitable raw materials ("natural cement" limestone) are available and the market is small, starting a new plant with a shaft-kiln installation may be justified.

Plant equipment and layout

The selection of equipment and the type of layout involves a detailed planning of the plant contemplated. The equipment should be selected to suit the raw materials, the process and the site. In addition, the different items of equipment should be properly matched.

Quarry equipment, crushers and raw-grinding mills are selected on the basis of field and laboratory examinations of the raw materials. Most types of limestone require blasting in the quarry, but some types may be quarried by ripping with a heavy-duty tractor. Soft chalks may be excavated direct from the quarry face. These different methods of exploitation call for entirely different equipment.

The loading equipment in the quarry preferably should match the primary crusher so that the quarry excavator does not pick up any pieces of rock that are bigger than what the primary crusher will be able to handle.

Some raw materials may require pre-blending (pre-homogenizing) of the pre-crushed rock before it is ground in the raw mill. Such raw material stores take up fairly large areas and cannot therefore always be fitted into a site of limited dimensions. Alternative solutions may be to place raw material stores in the quarry or to store the crushed raw materials in silos.

The plant layout should provide sufficient space and access to the equipment and at the lowest possible cost of internal handling of materials. Very often the layout is planned with a view to expansions of the plant by a second or future unit.

Some plants are designed as "compact plants" with the emphasis on short distances between the main production equipment, i.e. the kilns and the grinding mills. This type of layout has the advantage of short conveyors, power cables and walking distances within the plant, but the layout is not suitable for future expansions beyond the second unit. When the plant is to be expanded, it is therefore often the best solution to build the third unit next to the existing plant as a separate new plant.

A different type of layout has the grinding mills and the kilns arranged with sufficient space for several expansions. The provision of space for future expansions normally increases the cost of the first unit and is therefore only justified when the expansions are expected within a few years after the commissioning of the first unit.

Precautions for plant expansions

The expansion of a cement plant by a new kiln and mills calls for nearly the same amount of planning as that required for a new plant. The experience from the operation of the existing plant may be useful for selecting the equipment for the expansion, provided the reserves of raw materials for the expansion are of the same type as the materials from the existing quarries.

In some cases the expansion is made with equipment identical to that of the existing installation, but often it is decided to alter the specifications, either because a unit with large capacity is required or because new methods or equipment have become available.

The cost of the second unit is usually smaller than the cost of the first unit (when prices are corrected for the effect of inflation). The main reason is that the storage capacity for raw materials, raw mix, clinker and cement may not necessarily need to be extended since the operation of a two-unit plant requires a relatively smaller buffer storage capacity.

Final feasibility study

After selecting the process, plant size and location, the total cost of the project may be estimated from quotations for the main equipment and estimates of costs of construction, erection etc. The cost of operation and the profitability of the plant may be calculated from the estimated requirements of fuel, power, manpower and other resources and from the estimated market price of cement.

The final feasibility report should contain the calculations of the profitability of the projects that have been selected on the basis of the preliminary study. The main purpose of the report is to enable the planning group to decide which of the alternative projects offers the best solution, and if the profitability of this project is high enough to justify its implementation.

For the project preferred the report should contain a financing plan comprising the capital requirements, conditions of credit, cash-flow profile as well as the estimated gross and net earnings and the estimated dividends to the investors. It is advisable to recalculate the return on investment by means of the discounted cash-flow method.

As the cement plant is a long-lasting installation, the return on the invested capital is distributed over, say, 20 to 25 years. The equipment and the construction of the plant, however, should usually be paid for within a few years after the commissioning of the plant. The initial capital requirments are therefore high in relation to the yearly earnings. When the financing plan is based on balancing a substantial portion of the initial cost against credits and loans, it is important to check the cash flow carefully since the yearly earnings are usually not enough to pay off large short-term liabilities.

In many countries the government aids new cement plants by loans, cash grants or tax exemptions during the first few years of operation.

With the comprehensive feasibility report the planning phase is completed. The planning group is then able to decide about the possible implementation of the project and, if the decision is affirmative, to go ahead with the formation of the company or the organisation that will be responsible for the purchase of equipment and for ordering engineering and construction work.

The planning procedure, as outlined above, involves a considerable amount of work as well as the expenditure of capital on commercial and technical investigations. However, considering the high costs of a cement plant project and the difficulties of correcting possible errors that may be introduced during the planning stage, the efforts and the time spent are well justified.

III. CONSEQUENCES OF FAULTY DECISIONS

The preliminary planning should be precisely worked out on the basis of well-established experience. In most cases investors employ a consultant for the duration of a project. There are many capable technical advisers with comprehensive experience in cement manufacture. Some have contributed substantially to recent technological progress in the field. There are investors, however, who prefer to spare consulting fees and rely on local technical personnel to run old cement plants previously installed in a country. Some have even depended mainly on the limited technical advice of machine suppliers. However, faulty decisions may occur if the consultant is not specialized in cement manufacture and does not have sufficient background experience. The risk is greater in the case of local cement-making personnel if they are not aware of the latest technological trends in process techniques. Risks are greater still if reliance is placed only on the technical advice of machine suppliers, since such instruction may be limited to specific types of machinery and may not cover local factors that may have a vital effect on the project in later stages.

It is normal practice to include the guarantee stipulations in the supply contract; these may not necessarily cover all eventualities, however. The suppliers usually give limited guarantees for material and performance in the form of figures for the installed capacity and energy consumption of the main producing units as well as for the efficiency of the whole production line when fully operated. Such guarantees are normally considered as fulfilled when the guaranteed levels are attained in individual and integrated performance tests, for which the procedures are negotiated beforehand. On the satisfactory completion of such acceptance tests, the machinery and equipment are considered to be turned over by the supplier, notwithstanding long-term factors that may interfere with the regularity of production or that may upset its economic efficiency immediately after the issue of the final test certificate.

The mechanical and electrical performance of machinery and equipment is normally guaranteed for a fixed period which is usually one year starting from the date of operation. Any mechanical or electrical defects that may develop later may be partially or completely solved only through co-operation and good-will between the client and the supplier. Deviations from the guaranteed standards, however, should be covered by penalties which are normally represented by the percentage values of the defective parts. Normally the penalty stipulations are so bound together with strict conditions of quality of raw materials and regularity of operations that they are difficult to apply. If penalties are justified, they are usually limited to a specified maximum which, in most cases, never exceeds 5 per cent of the contractual value. Penalty values should in any case be taken only as moral incentives for the fulfilment of guarantees and should not be considered compensation for defects, since production losses and economic discrepancies increase in the long run.

In sum, the consequences of defects are mainly borne by production economics. Sometimes the defects last throughout the life of the project. Many of the necessary precautions may be taken through appropriate consulting or engineering work in preliminary studies and in the planning and execution of projects. Faulty decisions in these initial stages may bring about one or more of the following consequences.

Problems with raw materials

The preliminary survey of raw materials may indicate an ample supply. This study should not be taken as the basis for the final decision for starting a project, however, but should be followed by detailed investigations which reveal the particular characteristics of the raw materials. The detailed work of prospecting is done at considerable cost and effort, including the use of suitable boring machines, portable compressors and the employment of experienced personnel capable of hard work in open areas that are subject to severe weather conditions. Water may have to be transported to prospecting sites along difficult, uneven terrain.

Some investors may be inclined to spare these troubles by reducing or eliminating the detailed raw materials prospection. The consequences may be detrimental if undesirable impurities create obstacles to production processes or have deleterious effects on the cement produced.

Misunderstanding of the economics of cement production

Incomplete studies of the economics of production may lead to various difficulties. The expected capital investment may be underestimated. Operational charges may be erroneously forecast, and consequently the cost price may be predicted at lower, impracticable levels. This may occur through an attempt to encourage investors to expect an exaggerated profit. In some cases miscalculations may result from the application of foreign standards of material and labour costs, which may be different locally. For instance, the average pay may be normal but less technical skill and lower productivity may result in a high labour cost. In the same sense the material cost per unit weight may be near to normal, but the limited process and possibilities of workmanship may double the final costs. The unfavourable economic consequences of such miscalculations are normally felt at later stages when rectification is no longer possible, whereas an early precise forecast will indicate improvements, such as bigger plant size with more economical technical process. In developing countries it is essential to analyse the capital investment particulars in terms of foreign payment and local expenditure; otherwise miscalculations may lead to serious financial complications.

Unsuitable technological processes

The choice of technological process may at times be based on an incomplete picture of circumstances, or some of the main elements relating to the nature or composition of raw materials may not be taken properly into account. In such cases operational inconveniences are incurred which may hamper production and even affect the cement quality. For instance, operational troubles were extreme in one case where the alkali content of the raw materials was not adequately taken into consideration. The rotary-cement kiln had to be completely stopped and converted into a lime-burning kiln.

The erroneous choice of a technological process is further aggravated when the basis of the choice is not purely technological. In some cases complications arise when the project is financed through commercial agreements or assistance or credit facilities granted by an industrially developed country. The choice may then be limited to the industrial range of cement-making machinery available in the financing country.

Erroneous site location

The wrong site may be selected because of lack of information about local conditions. Normally the market conditions, raw material deposits and means of transport are the first factors to be considered. Sometimes such factors are carefully taken into consideration and the factory site is fixed accordingly, but information may be incomplete about detailed programmes planned for future development. One of the development features will most probably be the expansion of housing schemes. Housing may therefore approach the factory site and thus create pollution hazards. Environmental concerns are now especially important and must be thoroughly examined. Moreover, the expansion of agricultural projects and land reform may encroach on the areas reckoned as raw materials reserves for future expansions.

In other cases market studies may be based on optimistic export prospects; whereas a more reflective survey of international trade and the projected cement-industry expansion in traditional and planned export markets may give a different prognosis for the near future. Erroneous decisions in this regard may lead to the location of a factory site nearest to the export habour, thus imposing a permanent burden on raw materials transport. In one case the factory site was located 60 kilometres from the limestone quarry, and lorry transport was arranged across a rough, unpaved road which was washed out during the rainy season, thus causing a complete stoppage in the work for several months with consequent serious production losses.

Short-sighted extension forecasts

In planning the general layout of the project ample consideration should be given the possibilities for future extensions. The natural development of and requirements for cement render the expansion of the industry a necessity; constructing extensions is a matter of time and the precaution should therefore be taken to have ample area and facilities. The reserve extension areas invariably require longer conveyors and passways. The extension may require some additional preparatory measures for linking or adjoining the original plant with the future machinery and equipment. Moreover, the extension requirements favour bigger storage capacities to suit the final plant size.

Precautionary measures naturally entail increased investment, which will bring in no revenue during the early stages of the project, but spare time and expenditure in making extensions. An erroneous decision to forego these initial precautions may cause much waste of money and time in the future. In some cases a short-sighted decision may cause not only extra investment, but it may also lead to production losses. Original production units may have to be stopped for considerable periods to arrange for their junction with newly erected machinery whether in civic construction work or mechanical and electrical facilities.

Defective contractual stipulations

The conditions of the agreement between the supplier and the investor should be fair to both sides and should be clearly set out, especially contractual stipulations concerning the efficiency of production units. Articles should cover guarantees for production capacities of the main units, whether separately or collectively, in a complete production line. Comprehensive data should also be given for efficiency and should cover the main economic aspects of heat energy and electrical power consumption at optimal operational conditions.

All particulars for handing over after running tests should be explained in respect of procedure, timing and general circumstances. The mechanical and electrical performance should also be clarified in terms of material, design and time limits for the agreed guarantees. Defective or vague agreements may lead to endless disputes which may require arbitration. Tension and unpleasant disputes are always harmful to the interests of both parties, whereas comprehensive contractual stipulations may eliminate unnecessary debate.

Inadequate estimates of spare parts

Regular, uninterrupted operation is necessary to attain the installed capacity. Such regularity requires an ample stock of spare parts to replace parts subject to normal wear and tear such as friction and other mechanical stress. The problem of the availability of spare parts is less acute in industrially developed countries since they are easily manufactured with the availability of advanced workshop equipment, or they may be readily procured from original suppliers. Manufacturerr maintain stores of standardised spare parts as a safeguard for consumers. Consequently, the stock of spare parts in cement factories of industrially developed countries are comprised mostly of spares of a special nature and unique design. In developing countries, on the other hand, complicated import procedures and special financial problems hamper the procurement of required spares. Special allowance has to be made for long delivery time and shipment risks. A stock of spare parts should be procured for a sufficiently long period to cover all exigencies. In developing countries this period is normally from one to two years depending on special local circumstances. The characteristic features of each spare part should be carefully studied and a check list of spare parts should be drawn up with a precise indication of the minimum amount that should be kept in stock and with the time to order new stock clearly marked on cards for guidance. Workshop drawings should also be on hand to cover the possibility of local manufacture as a safeguard.

Deficient estimates of the need for spare parts or defective forecasts may lead to the stoppage of a production unit which can possibly stop the related stages of operation. In extreme cases, the whole production line may come to a complete standstill for considerable periods.

Lack of trained technical personnel

A complete team of technical personnel should be well trained and ready by the time the project starts. Proper training should be organized during the initial stages of execution. The best practical experience for the mechanical and electrical maintenance group can be gained through participation in the building and running-in phase. This may easily be arranged through mutual co-operation and strict supervision even with turnkey contracts. Trainees would thus be provided with full details and would be kept in close contact with machinery and equipment that they were to maintain. The operational and quality control personnel should have sufficient in-plant training, whether in the same plant to be extended or in a process similar to the new production line. They should be ready to participate during the period of start-up and of testing the guarantees of the equipment to ensure maximum transfer of know-how from the suppliers to the local technicians. One of the best procedures is to include a training programme in the supply contract. The supplier will then undertake the training in similar production processes according to well-established programmes.

Overlooking the training process may lead to major troubles. Deficient experience may cause serious damage that may certainly not be considered a liability of the supplier; it may even obviate all contractual rights of the investor from the supplier. In the long term, the lack of technical experience causes production losses owing to faulty operation. Further, it reduces the lifetime of machinery and equipment as a result of improper maintenance.

IV. UNIDO ASSISTANCE TO THE CEMENT INDUSTRY IN DEVELOPING COUNTRIES

Experience demonstrates that a well-planned and organized cement industry is not easily realized in any country. Its accomplishment is often made more difficult by an underestimation of the importance of preliminary studies, testing and branch knowledge. Governments interested in establishing a sound and well-consolidated industry may ask for assistance from UNIDO. The first step is to contact the local United Nations Development Programme (UNDP) resident representative, who will be prepared to discuss, on an informal basis, the type of help available. Services can be provided by individual experts, teams of experts or consulting firms in the special area concerned.

Specialists with long experience in the cement industry are available to advise and assist local officials in the practical establishment of their industry by helping to prepare tenders for international bidding, to evaluate the bids and to negotiate with suppliers. They may also participate in an early survey of the market and raw materials, advise and arbitrate during the period of plant erection and running-in, and ensure that international standards and guarantees shall be respected.

UNIDO has helped to improve the performance and economy of many existing plants and to plan new ones. This assistance is being expanded to include the training of local engineers through in-plant courses and fellowships.

In general, for the construction and building materials industries, UNIDO carries out a large number of active assistance projects all over the world. The Organisation is engaged in continuous endeavours to broaden its range of assistance and to improve joint achievements in the field.

UNIDO experts or consultants undertake exploratory missions in developing countries or provide technical assistance under the Special Industrial Services (SIS) programme. They can, according to the specific needs of the country, assist the government in formulating requests for further UNIDO assistance, which may lead to operations of a longer duration. Requests for more regular assistance of, say, one year or more, fall under the technical assistance component of the UNDP and the Regular Programme for Technical Assistance.

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