CHAPTER - II

ROLE OF CEMENT IN ECONOMIC DEVELOPMENT
Cement which may be described as powdered stone is a generic term used for all powdered materials and it has a plastic form when mixed with water, but it becomes a solid structure within a few hours, the structure gaining strength and binding properties with age. Defined thus, cement is an ancient building material. The principal constituents of cement are lime, silica, alumina and iron. On adding water to it, this mixture forms a paste, which, on setting, becomes as hard as stone.

Since the time immemorial, cement as a building material has been known in one way or the other. It appears to have been in use at the time of the ancient Indus Valley Civilization at Mohenjodaro in India. One of the seven wonders of the world is the Egyptian Pyramid which has endured the ravages of time to become a monument of tribute to the hoary civilization of the Nile. When the ancient Egyptian engineers began constructing the Pyramid out of huge limestone blocks, they realised the need for a building material to hold these blocks intact in their respective places. They
succeeded in solving the problem by burning limestone-chips and improvising a crude but effective form of mortar.\(^2\)

The aqueducts of Carthage in Africa were built with similar aid long before the commencement of the Christian Era.\(^3\) The Greek civilization with its Acropolis and the Parthenon, no doubt, used some form of mortar, but it remained for the Romans to develop and use a counterpart of modern concrete.\(^4\)

Beautiful aqueducts, magnificent amphitheatres, royal roads and unique bathrooms bear testimony to the sophisticated Roman architecture and construction-craftsmanship. Volcanoes like those at Etna and Vesuvious furnished the materials and the Romans used their brains and energy to avail themselves of their utility. They took volcanic ash calcined by the tremendous heat of the crater to form hydraulic mortar. The beautiful and dexterous architectural designs remaining today in the debris of Pompeii and Rome amply invoke the admiration of our renowned modern architects.\(^5\)

The credit for the invention of cement as used now, goes to an Englishman named Joseph Aspdin of Leeds in England. In the year 1824, Joseph Aspdin manufactured cement in a
rudimentary form by burning mixture of limestone and clay. It was termed as 'Portland cement' because of its resemblance to a rock found in the English isle of Portland. This limestone was used for construction in England.

Another quarter of century passed when cement of superior quality came to be produced by another Englishman called Issac Charles Johnson in the year 1850. Later in the year 1875, David Saylor, an American, improved upon the process of limestone and clay resulting in cement of a much more superior quality. He also called his cement by the same name viz. Portland cement.

It was only in the year 1900 that further impetus was given to the development of the cement industry mainly due to two factors. The first factor is that it had become feasible through the research-work done by two French Chemists, Vicat and Le Chatelier and by the German Chemist Michaelis, to produce Portland cement of such a uniform quality that could win the common faith of the building industry. The second factor is that two very important mechanical inventions were made at the turn of the century. The one consisted of use of a rotary kiln for making clinker and the other was the use of
a tube mill for grinding cement. These two machines made manufacture of Portland cement of consistent quality and of high strength in large quantities possible.

Prior to the development of Portland cement, there had been natural cement made from cement rock, a naturally occurring raw-material that needed only to be burnt and pulverised and Puzzolana cement, which was a mixture of slaked lime and granulated blast furnace slag. Today, Portland cement constitutes over 90 per cent of the total world-production of cement. Aspdin's method differed from the earlier processes in that he mixed several ingredients not already combined by nature and burnt them at a very high temperature until they formed a clinker.

Over the years, numerous developments took place in technology, equipment, transportation etc. directed towards reducing the cost of production of cement. The wet kilns slowly began yielding place to dry kilns and reducing fuel cost by about 70 per cent. The improvement in the thermal efficiency was effected by the installation of preheaters and further efficiency was achieved with the use of pre-calcinators. Finally, computerisation and quality-control
of raw-material resulted in optimal utilisation of fuel and power.

Transportation is a major cost factor in cement industry. In the early years with small capacity plants, bagging of cement for despatch by rail and road was possible. But later, when cement plants expanded their capacity for achieving economies of scale, the plants of over one million tonnes capacity became a common feature. Bulk movement of cement by trucks, railway-wagons and also ships was resorted to. This enabled economical and efficient transportation. Split location plants also came into being by the installation of grinding plants near the market centres.

Later, ready mixed concrete was made available at major construction sites in metropolitan cities to speed up construction projects thereby ensuring quality with speed.

Ever since the dawn of civilisation the world has undergone several stages. History and Anthropology have recorded such stages as stone-age, bronze-age and so on. But, these ages have been successfully succeeded by other ages in due course. The twentieth century marks the invention of a grey-powder which has cemented friendship between man and man.
and nation and nation. It is, in other words, an age of prolific growth or an 'age of cement'.

Cement is a versatile material which helps the growth of the national economy, because it is a commodity that enters into various activities of construction, investment and welfare in almost every segment of economy. Cement is used almost everywhere and is associated with every structure in the world. It is the basis of modern building-industry. It is one of those industrial products whose production and consumption determine the economic development and potentiality of a country. Whatever be the strategy for development that is adopted in the process of planning, the building of key-sectors, providing basic materials and services remain the sheet-anchor. Construction is a vital activity in the progress of any developing country. The content of cement is present in every constructional activity. In a nutshell, cement has become synonymous with construction.

Large-scale construction activity is an essential pre-requisite to progress. Cement being the basic building material, its availability in sufficient quantum plays an important role in the growth process in all sectors of
economy. This product is required by firms, factories, households and for the construction of dams, highways, airfields, bridges etc. So, its contribution to the development of modern civilization is evidenced by the innumerable channels in which this product is being used for structures from massive dams, towering sky-scrapers etc. to dainty garden-walks and springing fountains.

Cement industry is one of the key-industries whose growth sustains the success of investment programmes in the various sectors of economy. Cement being a vital construction-material, its demand primarily depends on the scale of investment undertaken in various sectors of the economy. In the event of dire dearth of cement, it is obvious that construction-activity on a large-scale cannot be sustained. It is thus a vital industry which assumes a crucial role in economic growth and development of a country.

Cement and Industrial Development: Cement industry is an indigenous industry. Limestone the principal raw-material used in the manufacture of cement is indigenously available in plenty. The completion of numerous industrial projects, dams, power-stations as well as defence-constructions require large
quantities of cement. The very process of economic growth, therefore, will inevitably generate an increasing demand for cement, although the actual level of consumption will be governed by the pattern of investment in the development programmes. Industrial development without cement will become just a remote dream.

Cement and Transport: Cement as a builder of infrastructure is of paramount importance to the transport and communication system of a nation. Cement plays a significant role in different types of transport viz. by land, water and air in one way or the other.

Cement for Roads and Runways: Cement concrete is the ideal material for surfacing roads and runways where they are subjected to heavy wheel-loads and exposed to durable and maintenance-free service. In road-construction, it came into vogue late in the last century with the first recorded concrete road construction being made at Bellefontaine, Ohio in the United States of America in the year 1892.

The history of concrete road construction in India dates back to the year 1914 when the first stretch of
concrete-pavement was laid which almost coincided with the establishment of the first cement factory at Porabander in Gujarat. Some concrete roads constructed in India, about six decades back are still in perfect condition. The advantages of concrete roads are numerous. The adoption of concrete-pavement as surfacing material for road-construction to cater to the exacting demands of modern vehicular traffic is due to some of its intrinsic qualities.

1) **High rigidity and beam-action**: High strength and resistance to wear are the twin qualities of concrete-pavement. The reason for this remarkable resistance to heavy and repetitive loading is that with a concrete slab the load is distributed over a wide area of subgrade due to its high rigidity and is not concentrated on the point of impact. The pressure in any part of the foundation is never great. In the case of other types of surfacing, pressure is ten to twenty times as high as concrete slab. Concrete, therefore, can be laid on a properly prepared and compacted subgrade with minimum of foundation. In other words, the performance of concrete-pavement will be far better on weak subgrade than on any other type of surfacing. This would considerably
reduce the cost of subgrade preparation and sub base/base construction.

2) **Riding quality** : Concrete-pavement maintains its riding quality throughout its life as compared to other pavements where it deteriorates fast with use. The effect of the roughness of road on vehicle operating cost particularly in respect of spare parts and tyre life is enormous. The roughness of black-top road may be comparable to that of concrete-pavement when the surface is new. However, there is rapid deterioration in surface evenness and riding quality in the case of black-top roads.

3) **Skid-resistance** : There are other ways in which concrete gives safer driving, skid resistance under rain or shine. The characteristic gritty sand paper like texture of concrete, grips the tyre, holding it on to its course and allowing any surface water to drain away. Tests have shown that concrete road has skid-resistance as good as that of the best newly constructed black-top road, but with a difference that concrete maintains its skid-resistance throughout its long life, in all weather-conditions while the other one does not.
Deficiencies in skid-resistance, if any, can be rectified by mechanical retexturing of concrete-surface. However, in the case of black-top road, it is not possible to retexture the surface to improve skid-resistance except by expensive surface-dressing or renewal of wearing course.

4) **Good visibility/Reduced temperature surfaces**: The other safety feature of the concrete road is its good visibility especially at night. The National Safety Council of the United States has ascertained that the death-rate per vehicle-mile at night-time is nearly three times as much as that of the day time. Temperature-stresses in bridge deck structures with concrete surfacings are substantially reduced as compared to black-topped surfacings which absorb heat.

5) **Economy in street-lighting**: It costs less to light concrete roads than dark coloured ones. Concrete has reflectance values ranging from 5 to 8 per cent.\(^\text{18}\)

6) **Railway sleepers**: Cement concrete, in its two important structural forms reinforced concrete and prestressed concrete sleepers, is more suitable and economical in the long run. Installation of heavy concrete sleepers along
with long-welded rails ensures the stability of track and helps speeding up trains. 19

7) Navigation: In the construction of dams and harbours, most of the works are under water and cement is largely used for such marine structure. In artificial harbours, break-waters are to be constructed for protecting ships against the direct shock of the sea. Mass concrete blocks of three to five tonnes are used in such works. 20

8) Tetrapods: Tetrapods made of cement concrete are used to prevent sea-erosion. By virtue of its shape like a central core with four arms, it can dissipate the energy of the waves completely. Besides, it helps to minimise the quantity of concrete used, at the same time giving the best results. These tetrapods were used in Bombay to protect the sea-wall on the Marine Drive and are used in Madras harbour also.

9) Concrete Boats: Concrete boats made out of seacrete or ferrocement, a special mixture of sand and cement reinforced with steel-wiremesh, are used for navigation and fishing in countries like Canada, Italy, Australia, Saudi Arabia, Guyana and Nigeria. The main advantage of
the concrete boats over those of timber and steel is that the former requires no maintenance during its entire life and is not vulnerable to the attack by borers, while the latter requires maintenance and is vulnerable to the attack of borers.

Cement and Agriculture: Cement is a versatile building material and is required in large quantities to the agricultural development also.

1) Concrete cultivation: The expression 'concrete cultivation' may sound queer. The versatility of this magic powder makes cultivation possible even in sandy sea-shores. Due to its porous nature, the sandy soil in sea-shore areas is unsuitable for cultivation, but it can be made to retain water and manure by excavating sand to a depth of 18" and then laying a flooring of lean cement concrete. The sides are then built with soil cement or concrete blocks and the whole area is filled with fertile soil carted from nearby tank-bed. In this way, it is possible to grow two or three crops of paddy or other corn annually in such reclaimed plots.
2) **Segmental hollow blocks and well rings**: Pre-cast well rings can be economically used for lining the wells up to a diameter of 6'. Segmental hollow blocks can be adopted for wells of larger diameter. In addition to economy, these types of linings will not allow the growth of vegetation or moss which tends to pollute the water in due course of time.\(^{23}\)

3) **Concrete channel and pump-house**: The pump-house for installing motor and pumps and concrete channels for irrigation etc. are some more essential items made up of cement concrete. The advantages of these pre-cast channels are that the farmer can re-arrange them as and when required to facilitate irrigation in different parts of his field.\(^{24}\)

4) **Bins and Silos**: Lack of proper facilities for storage of foodgrains causes to the nation a loss of grains which may represent nearly ten per cent of the total annual produce. Since substantial portion of total produce is retained by the cultivators, scientific design and construction of small capacity grain storage structures would be considerably beneficial to the farmers. Several agencies
projects have unlined canals in India and nearly half of their storage is lost due to leakage, evaporation, seepage in the distribution system etc. This is a matter of great concern so far as the irrigational projects go. Earlier, scant attention was paid to minimise water loss in canals, as the available water was adequate to meet the requirements. Things have changed at present and there is a need for bringing as much land as possible under cultivation. Thus, a situation has now arisen when the lining of canals should be deemed absolutely essential to minimise the loss of water due to seepage and to bring more area under irrigation. Lining is also necessary for safety to avert breaches in canals. The limited availability of cement in the past was one of the factors which dictated the type and the extent of lining in India. Cement is now openly available and this is the opportune time when cement concrete can be used extensively for canal lining, particularly in new projects. The cement scenario has now changed radically due to the increased production of cement.
CEMENT AND HOUSING

Housing being next in importance to food and clothing has been recognised as a key-factor in any social upliftment programme. The traditional mud and thatched houses in the villages in less developed countries deteriorate quickly and are susceptible to attack by termites, rodents etc. They are also easily affected by rain, floods and fire. The cost of effecting improvement in these structures is not always commensurate with the gain achieved. The increasing maintenance-cost of rural houses indicates that the main problem is to make houses more durable through the use of innovative techniques and durable materials.

It is alarming to note the increasing shortage of housing in both urban and rural areas in population-pressed countries. The cost of construction is mounting day by day, since people stick to conventional methods and materials of construction. The application of new techniques can bring about considerable reduction in construction cost which, in turn, will help to give a spurt to the tempo of construction. The cement industry, which is one of the key-industries, can play a significant role in this respect.
The use of cement can foster economy in the following few items:

1) **Concrete hollow block and soil cement block** : These can be used for wall-construction instead of bricks. In addition to economy and higher strength, the hollow block has got the additional merit of ensuring a cool atmosphere inside the room due to its air cavities. Ordinary soil mixed with four to six per cent of cement can also be moulded into compact blocks and used in place of burnt bricks with substantial economy.

2) **Door-frame, Window-frame and Jallies** : The timber frames for doors and windows are too dear to possess now-a-days. It is economical to use pre-cast concrete frames for doors and windows. Provision can be made for fixing shutter by embedding wooden pieces at the places where hinges are to be fixed. In the case of windows, the cross bars or iron grills are fixed to the frame at the time of casting itself. Attractively designed jallies can gracefully replace ventilators and other similar fixtures.

3) **"T" beam or Ribbed slab** : For roofs, pre-cast "T" beams or ribbed slabs are preferable to ordinary cast in-site
slabs to minimise the time, energy and expenditure. It is not only economical but it also saves time to execute the work.

4) **Lintels and Sunshades**: Pre-cast units of these can be used in house construction separately or as composite lintel cum sunshade units.

5) **Roof trusses and Purlins**: For industrial buildings asbestos cement roofing can be adopted and the trusses, purline etc. can also be made of concrete so as to achieve the intended purpose and protect them from fire-hazard.

6) **Septic tank pipes and Water tank**: A house can be complete only if due sanitary and water-supply arrangements are made. Pipes, septic tank and water-tanks are some of the items that can be made up of cement concrete.

7) **Manufacture of concrete blocks for construction**: The methods used in the construction of housing in India have not changed over the last several decades. The main reason for this condition has been the paucity of cement that existed until the year 1985 and an era of control of
distribution until the year 1982, when cement was made available only to the actual user. One saw a system of issue of cement by the client to the contractor. In this scenario, the contractor had difficulty in construction since the availability of cement was not guaranteed. Often, the labour had to be shifted from site to site, depending upon the availability of cement. Factories to make pre-cast cement products were not set up as they were the ultimate consumers of the product.

The advancement in technology has reduced the cost of construction in many ways viz.

a) Factory-made components would be of a higher quality than the site-made components. This would mean that product specification can be met with greater uniformity and reliability.

b) Factory-made components would involve lesser wants of materials, thus increasing the quantity produced.

c) Factory-made components could be designed using the scientific mix design, rather than the normal mix. This mix design itself could be of an optimal nature
and need not involve any security factor to be applied to take into account poor practices at the site.

d) Factory-made components would be lighter and as such they would reduce the cost of foundation, columns and beams.

8) Rising cost of bricks: In the recent past, the cost of bricks has increased enormously. The main reason is the non-availability of good quality clay near urban centres and the high price of coal. It is expected that this trend will continue in future. The use of clay to make blocks takes away valuable agricultural land. The manufacturing process also is inefficient in terms of energy consumption. Hence, it is necessary to find a worthy substitute for burnt bricks.

Concrete blocks made in a controlled environment offer an economic solution to the problem. The cost of the blocks should be close to the bricks they replace. The saving due to thinner plaster, lesser mortar, lesser foundation, lighter column and beams and speedier construction will be the additional benefits that the user will have.
There are two types of concrete blocks—hollow and solid. A solid concrete block can be less in width than hollow block. This will mean that for a given built-up area, the solid block will offer a larger floor space. A hollow block will be lighter and hence cheaper. In some cases, the width of wall has to be a minimum specified one and as such the hollow block will be more advantageous. In the case of partition or filler walls, the hollow blocks have an edge over solid blocks in terms of economy.

Hollow blocks are also of two types—hollow and cavity. A hollow concrete block has two opposite sides open, while the cavity block has only one side open.

Concrete blocks are better than burnt bricks for many reasons. They are:

1) The traditional method of manufacturing bricks may be wanting in dimensional accuracy. So, there is a wastage of plaster that is applied.

2) Bricks of special quality are essential to load-bearing walls. Otherwise a frame-structure has to be applied. The bricks are used as a filler. Concrete blocks are
load-bearing and can be used for ground plus two construction without columns and beams.

3) The size of one concrete block is equivalent to about eight bricks. So, it is easier to place a concrete block which reduces the man-power required. For the same reason the amount of mortar required is remarkably reduced.

4) A wall made up of concrete blocks will be lighter than a wall made up of bricks. This will reduce the dead load and will entail lesser expenditure on foundations. In the case of frame-constructions the columns and beams can be made lighter. The thickness of the wall can be less, a point which increases the carpet-area.

5) Concrete blocks are manufactured in machines which have facilities for vibration and compagination. They are then cured, either in a steam-chamber or in the atmosphere with a regular spray of water. All these and the proper selection of raw-materials render good strength to the block leading to the proper maintenance of moulds to achieve dimensional accuracy. In the case of hollow blocks, additional benefits of thermal insulation and sound insulation can be achieved.
CEMENT AND RURAL DEVELOPMENT

In many under-developed countries a bulk of population resides in semi-urban and rural areas.

The problem of rural development is the problem of the upliftment and the welfare of this vast segment of the population. The importance of and urgent need for rural development, therefore, cannot be over-evaluated.

FERROCEMENT FOR RURAL DEVELOPMENT

Ferrocement or reinforced cement mortar made up of cement, sand, water and wiremesh can be used to build several types of structures for rural development such as seed and grain storage bins, sewage troughs, septic and biogas tanks, pipes and irrigation conduits, cattle feeders and water troughs, grain dryers, water storage, low-cost roofing etc. Ferrocement constructions do not require heavy plant or machinery and are labour-intensive. It is claimed that ferrocement is particularly suited to developing countries. The Structural Engineering Research Centre, Roorkee has carried out extensive studies on the development of ferrocement structures for rural applications. These studies have resulted in the development of ferrocement bins...
of 1/2 t, 1 t, 2 t and 3 t capacities. The skill needed for casting the bins is simple and can easily be followed by the villagers. The bins are strong, light and durable and in addition are proof against fire, dampness etc. They are suitable for both underground and overground usage and can be cast in the form of pre-cast units such as, reinforced concrete base units, ferrocement inlet and outlet lids etc. These bins are light and can be conveniently transported from one village to another.

In addition, the Structural Engineering Research Centre, Roorkee has also developed ferrocement water-tanks and ferrocement biogas holders. These biogas holders are a suitable substitute for the metallic holders, which are prone to corrosion. The process used in the fabrication of ferrocement biogas holders is similar to that used for the construction of grain storage bins. It is claimed that these gas-holders are about 50 per cent cheaper than the conventional metallic biogas holders. The use of ferrocement biogas holders is likely to reduce the cost of biogas plant by about 20 to 25 per cent and thus it helps popularise the gober gas plants in the villages. It also saves the non-conventional energy forms like coal, wood etc.
The pre-fabricated R.C.C. trusses have the following features:

1) Use of minimum number of standard components.
2) Simplified casting technique to minimize the use of skilled labour.
3) Bullock-carts to transport the components in rural areas at the minimum possible expenditure.
4) Lightweight of individual components so as to make use of manual labour for handling and hoisting.
5) Simplified joint details and erection methods.
6) Economical construction as against the traditional expensive technique.
7) Time required for construction is reduced to its minimum.

The concrete trusses are either of scissor type with all pre-cast components or of composite type with part in pre-cast concrete and part in steel. These have been designed for 6.56 and 5.37 metre effective spans for Mangalore pattern tiles and for corrugated sheet roofings.

Yet another sphere of social welfare programme where cement concrete can be effectively used is in mass-construction of rural health centres. To provide a more
comprehensive health and family welfare programme covering the entire rural area of the country calls for a systematic approach to the design and construction of a large number of standard types of buildings for various types of health-centres. The use of pre-fabricated channel units can help considerably to speed up the mass construction programme.

Thus it would be clear that cement concrete has much to contribute to the sphere of rural development. If a part of the cement produced in the country is reserved for use in rural areas particularly for mass construction of houses, schools, health-centres, feeder roads, irrigation etc. it would go a long way to improve the rural economy.

Cement, therefore, forms the core of industrial, constructional and developmental activities of every nation in the present age and has, thus, become an important parameter in the progress of human civilization. Hence, cement can be called 'growth-promoting commodity'.
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