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APPROPRIATE TECHNOLOGY FOR THE PRODUCTION OF CEMENT AND BUILDING MATERIALS

STRATEGIES FOR DEVELOPMENT OF CEMENT AND ALLIED INDUSTRIES IN DEVELOPING COUNTRIES

Background Paper

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STRATEGIES FOR THE DEVELOPMENT OF CEMENT AND ALLIED INDUSTRIES IN DEVELOPING COUNTRIES *

by

the Cement Research Institute of India

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INTRODUCTION

ational progress, in today's context, is possible only with industrial progress. The quality and quantity of industrial progress achieved is influenced, in a large measure, by the quality and quantity of technological support the industries are able to progress.

Construction is not only an integral part of human civilization but also an important constituent in national progress. Analysis of expenditure in India under the successive national plans clearly brings out that the expenditure on construction has been of the order of 50 per cent of the total investments. On an overall basis, about 66 per cent of this expenditure on construction is accounted by the cost of materials of construction. In fact, expenditure on materials of construction in the Fifth Five Year Plan of India was estimated to be over Rs 180,000 million - a figure which far exceeded even the total outlay of India in the Third Five Year Plan. In this background, the vital role cement and cement based construction materials play needs no elaboration. The cement industry, cement based industries such as those engaged in concrete construction, manufacture of precast concrete products, and manufacture of asbestos cement products, and the allied industries such as those engaged in the manufacture of plant and machinery thus have a direct and determining impact on the economic development of a country.

A study of the developments in the Indian cement industry since its inception about 64 years ago and those of the allied industries will at once bring out that these industries have endeavoured to use the tools of science and technology as best as possible in tune with the prevalent socio-economic considerations over a period. Whilst a great deal of research and development and other related technical activities are apace, considerable strengthening of the technological base in this field has become imperative. However, with the rapid pace with which science and technology are progressing the world today and with the growing realization of the increasing need for harnessing the fruite of science and technology for industrial progrees, a national strategy for strengthening the technological eupport to these industries has become inevitable.

The basic constituents for successful and meaningful strategy for technological support to the industry are (a) Strategy; (b) Resources Mobilisation; and (c) Direction.

A correlated study of these constituents leads to the following basic characters in the framework of an appropriate developmental plan for technology support:

i/ Updating of the available technological talents to the industries through programmes covering continuing education refresher courses and training

ii/ Generation of new technological talents not only to meet the present shortages of technological talents to the industries but also to cover newer and emerging technologies through regular industry-oriented long-term educational programmes.

iii/ Utilization of available technological talents and infrastructure in various forms in the country - in research institutes, in universities, and in industries - towards solving either parts of or the whole of an identified problem of the industry: this requires a centrally monitored system which should be capable of identifying competence, of evaluation work, of integrating findings, and finally of transleting these into a form which would have a satisfactory interface with the industry.

iv/ Strengthening of available infrastructure to carryout organised, coordinated and intensive R & D in an increased measure.

v/ Creation of systems, means and mechanisms for effective transfer of technology not only with reference to the technologies generated within the country but also technologies which might be generated elsewhere which are considered appropriate for absorption or adoptation and for transfer to the industries in the country.

1 BASIC FRAMEWORK

1.1 Preamble

There is no doubt that in a world where about 20% of the population gets about 80% of the total world product whilst about 80% of the population live on the remaining about 20% of the world product, science and technology have to play a dominant role in correcting this situation. But it has by now become clear that mere copying of what this 20% of the population do will not be a solution to the 80%; adopting the same processes, designs and equipment as the 20% adopt is also not the solution even if one were to adopt the same by reducing the scale. In the name of low, medium or high technology, to adopt a technology which was once prevalent and which has now become absolete amongest the 20% of the population does not appear to provide the solution either.

The Lima Declaration and Plan of Action on Industrial Development and Cooperation adopted by the Second General Conference of UNIDO, proposed that the share of developing countries in total world industrial production should be increased as far as possible to at least 25 per cent by the year 2000. Implied in this statement is a requirement for detailed understanding and intense study of appropriate technologies in all major industrial fields to support this unprecedented growth objective and to correspond to the needs and goals of developing countries.

1.2 True Dimensions of Appropriateness of Technology

If the various aspects of any design of industrial equipment or manufacturing process are examined in depth with a view to finding out as to how these differ from those in another design for similar purpose the following three abstract attributes present themselves prominently:

A The technolggical contents in the design and their orientation, which, for convenience, we may call TECHNOLOGY ORIENTATION.

B The nature of interface envisaged by the technological contents for transfer of technology which we may call TRANSFER INTERFACE, and

C The socio-techro-economic system to which the design belongs which, again for convenience, we may call SYSTEM STATUS.

These attributes may now be examined with a view to understanding their meaning in identifying the various aspects of design and their significance in the processes of evolving what may be called a design standard based on appropriate technology.

1.2.1 Technology Orientation

The technologies deemed to be appropriate are:

a/ Those producing the kind, quality and uniformity appropriate to the needs;

b/ Those producing goods or services at the lowest possible capital investment and skill requirements for a viable enterprise;

c/ Those producing goods or services with optimum degree of employment also consistent with a viable operation; and

d/ Those producing goods and services with the highest utilization of suitable materials available locally.

A technology at a given point of time suitable for India, for example, may be quite different from the technology which is suitable at the same point of time for another country say Japan or USA. The design of industrial equipment and manufacturing processes in these situations for the same purpose could, therefore, turn out to be totally different because of the variation in emphasis in the orientation of technology. The orientation of technology can be classified as:

- materials-saving technology
- labour-saving technology
- time-saving technology
- quality-improving technology
- labour-intensive technology

and so on

These main classifications can be further sub-divided and their permutations and combinations, depending on the degree of emphasis in the orientation, may be representated by points T_1, T_2, T_3, T_4, T_5 ....T_n on the X-axis of the three dimensional space illustrated in Figure 1 for appropriate technology.

1.2.2 Transfer Interface

Technology transfer can be achieved by one or a combination of various ways, such as dissemination of information through published literature, conferences, lectures, various communication media, movement of people, discussions, visits, through licensing know-how, patents and trade marks, through standards, through technical cooperative programmes and so on. One such powerful and effective means is the input of machinery and equipment.

It is well known that for an effective transfer of technology, the transferee should have developed the requisite competence and be equipped enough to receive, assimilate and utilize the new technology, by adapting it to the transferee's own conditions; the transferer should also be willing and cooperative in this process. In any such system of transfer of technology, actual mechanics can considerably vary from situation to situation but it is now well established that the most important single factor which would contribute to the success of transfer is the creation of proper interfaces in the system.

In any given circumstances, every centre of technology has four clear interfaces - two in the vertical direction and two in the horizontal direction as illustrated in Figure 2 of which, from the point of view of design and operation of industrial equipment and processes, the vertical lower interface need only be considered.

Whilst this concept of interfacing is a basic one and the philosophy of interfacing is an essential prerequisite in any effective system for transfer technology, it is not always necessary that the design centre which transfers technology be a separate institution, organization or entity; it is possible to bring about such a transfer even within the framework of a single unit as long as the transfer mechanics is realised as a closed orbital loop in which every link has an interface with the prceeding one and the following one.

These interfaces may be identified and represented by points I_1, I_2, I_3, I_4, I_5......................I_n on the Y-axis of the three-dimensional standardization space illustrated in Figure 1.

1.2.3. System Status

Appropriate Technology at once implies recognition of existance in a total system but it is not uncommon to find a technology and hence the design standard being linked only with aspects which are its neighbours on either side - may be sometimes a little farther - but without an attempt to study the system as a whole. Whilst it is accepted that equipment design and manufacturing processes and therefore the relevant design standards should be related to social, technolggical and economic aspects of a nation, there is presently practically no organized or systematic effort to link them with the socio-techno-economic system to which they really belong.

Those in the field of systems science are well aware that the basis of systems approach is to ask "what are the parts of the forest?" rather than "What do these trees and shrubs constitute?". Though ultimately answers to both these questions are found and matched, the analysis of the total problem must occur before the synthesis of its components is attempted. Similarly, the socio-economic and techno-economic systems are the basic system to which design standards belong and therefore the processes of industrialization should provide for a systematic effort towards improving the efficiency of the total system even if the individual units of industry feel that decisions on technological inputs in their domain responsibility are being compromised.

A system can be defined after establishing parameters of Objectives (O), parameters of Inter-Relationship (R) and parameters of Effectiveness of Measurement (E). Any system "S" may, thus, be represented by a time variable, linear, discrete and/or statistical function.

$$S = f(O, R, E)$$

The parameters will differ from context to context.

Moreover, to correlate a single design standard to a total system with very many complex parameters is not an easy task; these considerations will lead to the concept of limited systems where each limited system could be related to its limited objectives taking into account limited parameters. The status of such a chosen system could thus vary from a very elementary and simple System S_1 to the most complicated and complete system S_n, going through the intermediate systems S_2, S_3, S_4...... $S_{(n-k)}$, $S_{(n-1)}$. The best of these would naturally be that design standard which belongs to system S_n since all the parameters of the total system have been simultaneously taken into account; but, in order to formulate and implement such a design standard, the effort might be collosal and may be out of proportion with the resources available to an industry. One might therefore be satisfied with an intermediate system $S_{(n-k)}$ as the most optimum considering the restraints or limitations; in this case formulating a design standard relating to any system below $S_{(n-k)}$ could mean that the design standard is not optimized with the largest practicable system $S_{(n-k)}$ and formulating a design standard relating to any system above the level $S_{(n-k)}$ would mean that disproportionately large resources are being expended.

To illustrate this principle and concept of limited system in the system approach an example may be taken of formulating a design standard for vertical shaft kiln for a mini cement plant.

In this case of one set of possible parameters for each of the three systems functions would be:

PARAMETERS OF OBJECTIVES

O_1 - Reducing capital outlay in cement industry as a whole by reducing unit cost of plant

O_2 - Utilizing small deposits,

O_3 - Reducing strain on transport system,

O_4 - Reducing time of delivery,

O_5 - Ensuring production of quality cement at minimum cost,

O_6 - Assuring unhindered expansion of cement industry

O_7 - Making it possible to massproduce components

- and so on to O_n

PARAMETERS OF INTER-RELATIONSHIP

R_1 - Specifications for steel sheet

R_2 - Specifications for welding

R_3 - Specifications for rotary grate

R_4 - Specifications for grate drive

R_5 - Specifications for king shaft

R_6 - Specifications of nodule feeder

R_7 - Specifications for blower

R_8 - Specifications for chimney

R_9 - Specifications for refractories

R_{10} - Requirements of vertical shaft kiln for other mineral industries

R_{11} - Transportation restraints

R_{12} - Deposit assessment

R_{13} - Exploitation of deposit

R_{14} - Overburden stripping

R_{15} - Winning

R_{16}	-	Raw material loading
R_{17}	-	Raw material conveying
R_{18}	-	Raw material storage
R_{19}	-	Primary crushing
R_{20}	-	Fuel storage
R_{21}	-	Raw meal grinding
R_{22}	-	Raw meal homogenizing
R_{23}	-	Nodulization
R_{24}	-	Clinker burning
R_{25}	-	Clinker grinding
R_{26}	-	Clinker discharge
	-	end so on to R_n

The nature of Inter-Relationships is illustrated through Figure 3.

PARAMETERS OF EFFECTIVENESS OF MEASUREMENT

E_1	-	Cost of kiln per tonne of clinker produced in a year
E_2	-	Quantity of fuel required for producing a tonne of clinker (Assuming use of a given fuel and given raw materials)
E_3	-	Kwh units of power consumed per tonne of cement
E_4	-	Time for delivery of one unit
E_5	-	Saving in design costs
E_6	-	Manhours required per tonne of clinker produced
	-	and so on to E_n

On this basis a vertical shaft kiln for a mini cement plant may belong to any one of the following systems S_1, S_2............$S_{(n-k)}$ ....S_n

$$S_1 = f(O_1, O_2, O_3, O_5, R_1, R_2, R_3, R_4, R_5, R_{22}, R_{23}, R_{24}, E_1, E_2, E_3)$$

$$S_2 = f(O_1, O_2, O_3, O_5, R_1, R_2, R_3, R_4, R_5, R_6, R_8, R_{22}, R_{23}, R_{24}, R_{25}, E_1, E_2, E_3, E_6)$$

$$S_{(n-k)} \quad f(O_1, O_2, O_3, O_4, O_5 ....O_{(n-a)}, R_1, R_2, R_3, R_4, R_5, R_6, R_7, R_8 ....R_{(n-b)} E_1, E_2, E_3, E_4, E_5, ... E_{(n-c)}$$

Where $O_{(n-a)}$, $R_{(n-b)}$ and $E_{(n-c)}$ are the limiting parameters corresponding to the largest practicable limited system.

and so on with all practicable permutations and combinations; and finally the total systems

$$S_n = f(O_1, O_2, O_3, O_4, O_5 ....O_n, R_1, R_2, R_3, R_4, R_5, R_6, R_7, R_8 ....R_n E_1, E_2, E_3, E_4, E_5, E_6 ......E_n$$

The design standard for vertical shaft cement kiln can be formulated in such a way that it ties up with any of the above systems. Even in selecting a system several difficult questions present themselves; what weightage should be given to the various parameters? How to get at exact correlations or quantitative values? and so on. It is obviously not possible to generalise these parameters or systems behaviour but with the aid and principles of systems science the best possible solutions have to be found.

Thus the status of the contents of a design standard on the basis of the system to which it belongs, can be representated by S_1, S_2, S_3,... ....$S_{(n-k)}$..........S_n on the Z-axis in Figure 1.

A totally mathematical approach is rather complex in indentifying or assessing the appropriateness of technology; such an approach could, howev-ever, be demonstrated in certain specific cases. The above analysis has been given merely to throw light on the true dimensions which have to be taken into account in assessing the appropriateness of technology in any given situation and to direct analysis of issues on this rationale.

1.3 Choice of Technology

Many current concepts of appropriate technology centre on the study of existing equipment and their potential for transfer and adaptation to favour conditions in developing countries, particularly on the promotion of low-cost and small-scale village technologies. Related concepts commend the advantages of existing and proven equipment since, according to the argument, such equipment could be most practically adapted to developing countries' needs and would not require a very high investment. While not regarding this approach as a universally accepted advantage, it should be possible in many circumstances to include for consideration equipment and methods for developing countries that do not necessarily represent the latest or most sophisticated technology. On the other hand, the prevailing concept that the introduction of advanced industrial equipment and processes necessarily imply the adoption of capital-intensive and labour saving systems may now be questioned. There are many current experiences that dispel this general assumption and demonstrate instead that the introduction of labour-intensive and capital-saving production systems can incorporate in many cases management methods and control devices that the most advanced technological developments have produced.

Appropriate technology has to be considered in respect of both hardware and software (interpreted in their broadest sense).

The selection and implementation of technologies which are appropriate should relate to three distinct possibilities:

a/ Choosing a technology from among the available alternatives for direct transfer into the design of equipment and production processes;

b/ Adapting an available technology to suit a given condition and transfering it into the design of equipment and production processes;

c/ Generating or developing a new technology appropriate to a given condition and transferring it into the design of equipment and production processes.

2 GENERAL OUTLOOK ON CEMENT AND ALLIED INDUSTRIES IN DEVELOPING COUNTRIES WITH PARTICULAR REFERENCE TO INDIA

2.1 Raw Materials

The inorganic mineral-based cements are produced primarily from natural rocks of suitable compositions. Sometimes a few selected industrial wastes and byproducts find a role to play in the manufacture of cement. In addition to those, a limited number of standard chemical products and reagents are used in extremely small proportions as special additives. The natural raw materials constitute the backbone of cement industry, and the industrial wastes and byproducts, except for granulated blast furnace slags and fly ashes, have found limited application in cement manufacture at the present moment.

Theoretically for one tonne of clinker the quantity of raw mix prepared from natural materials comes to about 1.5 tonnes on dry basis. Limestone constitutes the prime raw material, besides clay, coal and gypsum, in cement manufacture, the actual consumption of different forms of raw materials varying over a wide range. A long term provision of good quality raw materials will not only reduce the cost of production but will also add to the economic viability of plants.

There is strong pressure to optimize the economics of industrial projects and commercial advantages weigh heavily against possible shortcomings of raw materials and plant location. Moreover, ideal raw materials are becoming steadily more scarce. These factors have forced cement producers to consider limestones of inferior quality as raw materials for cement manufacturing. Blending and other quality control/improvement/developments have changed such an outlook. The Cement Research Institute of India (CRI) has done considerable work on issues relating to the utilization of relatively lower grades of limestones in cement manufacture.

The employment of analogue computers to simulate the effects of using raw mixes of different compositions constituted a new approach to raw mix chemistry and has helped to overcome some of the traditional, restrictive tendencies in the industry.

The introduction and refinement of a pre-homogenization process has made it possible to pre-blend raw materials of inferior quality with the necessary corrective additives, before grinding them.

Proper prospecting, exploration and reserve estimation of limestone deposits are essential pre-requisites in decision making for setting up cement plants. It is not uncommon to find both in this country and elsewhere in the world that cement plants have come to grief after their establishment due to inadequate attention paid to prospecting, exploration and reserve estimation. There are also instances where substantial unnecessary resources have been expended just to make sure that the reserve estimation is reliable in quality, quantity and minability; yet there are further instances where substantial resources were invested only to abandon the site ultimately.

These complex and apprently contradictory issues were discussed at a Seminar organized in January 1974 at Bangalore jointly by CRI, the Geological Society of India, the Institution of Engineers (India) and the Indian Standards Institution. The Seminar entrusted CRI with the task of drawing up the 'Norms' for prospecting, exploration, reserve estimation and technological assessment of cement-grade limestone deposits based on the outcome of the Seminar discussions and the available knowledge and experience in this field. Accordingly, CRI prepared the first draft Norms and circulated it to all the organizations and individual expoerts associated with the limestone prospecting and elicited their comments. Deliberations at further Seminars resulted in what is today known as "Guide Norms for Prospecting, Exploration, Reserve Estimation and Technological Assessment of Cement-Grade Limestone Deposits". The experience of use of these norms and the feed back data were further reviewed at yet another Seminar in 1978 as a result of which a revieuwed and updated version of these norms are now in an advanced stage of finalization.

2.1.1. <u>Limestone and Clay Horizon in India</u>

In India the availability position of all the principal raw mix components is, on the whole, encouraging, there is a total reserve of more then 59,600 million tonnes of cement grades limestone, although only a very small quantity (about 7,900 million tonnes) has so far been brought under the proved category of reserve, the rest remaining in the categories of inferred/indicated. The limestone occurrences and distributed throughout the length and breadth of the country. Whilst Table 1, given below, outlines the statewise reserves of cement grade limestone in India, Figure 4 shows locations of limestone horizons and cement plants in India. Also, limestone is available at certain places along the coastline of India in the form of corals, seashells, etc. However, the workable deposits are known to occur roughly in four zones.

1 Northern (the sub_Himalayan region
2 Central (Vindhyan region)
3 South Central (Cuddaph region)
4 South (Madras region)

TABLE 1

STATE WISE RESERVES OF CEMENT-GRADE LIMESTONE IN INDIA

	State	Reserves in Million Tonnes		
		Proved	Inf/Ind	Total
1	Andaman & Nicobar Islands	-	1.0	1.0
2	Andhra Pradesh	3871.8	11663.3	15535.1
3	Assam, Meghalaya, Manipur Nagaland & Tripura	194.3	4087.6	4281.9
4	Bihar	61.4	848.8	910.2
5	Gujarat	215.0	1070.4	1285.4
6	Haryana	40.0	18.5	58.5
7	Himachal Pradesh	537.0	217.8	754.8
8	Jammu & Kashmir	81.4	124.9	206.3
9	Karnataka	157.2	18326.2	18483.4
10	Kerala	25.0	-	25.0
11	Madhya Pradesh	1553.4	572.5	2125.9
12	Maharashtra	87.9	1988.0	2075.9
13	Orissa	162.5	269.0	431.5
14	Rajasthan	693.5	11663.3	12356.8
15	Tamil Nadu	104.2	179.2	283.4
16	Uttar Pradesh	93.0	696.0	789.0
17	West Bengal	1.0	1.5	2.5
	TOTAL	7878.6	51728.0	59606.6

The northern zone deposits are not usually exploited due to their occurrence at high altitudes. The remaining three zones are important from the point of view of cement manufacture. The Vindhyan limestones are specially suitable for cement production both from the point of view of their average composition and mode of occurrence. A massive and continuous exposure of limestone is known for about 160 km from Dehri-on-sone via Rohtas to Rewa.

Although there has not been any systematic delineation of clay horizons in India for cement manufacture, it is generally known that the availability of suitable clay does not pose any problem. However, in tune with the recent trends of raw material technology it is desirable to have well-delineated clay horizons with the appropriate granulometry and composition.

2.1.2. Availability of Gypsum in India

Gypsum is added to the extent of 4 to 5 % to cement clinker during grinding to control the setting properties of the finished cement. At the present level of production of cement, the Indian cement industry consumes about 1 million tonnes of gypsum.

The total reserves of natural gypsum in India are placed at about 1216 million tonnes. The State of Rajasthan accounts for more than 90 per cent of the total reserves. The locations of the sources of gypsum ~~in R~~ Rajasthan are distributed in Jodhpur, Bikaner, Nagpur and Jaisalmer districts mainly. In Tamil Nadu, the mines of natural gypsum are located in Tiruchirapalli and Coimbatore districts. Doda and Barumukla are the districts of Jammu & Kashmir where natural gypsum is available. Some of the small deposits are known at Jamnagar, Junagarh and Kutch districts of Gujarat, at Nellore district of Andhra Pradesh, Tehri Garwal in UP and Sirmur district of Himachal Pradesh. The present total production of natural gypsum in the country is estimated to be of the order of 1.1 million tonne per year. The quality of gypsum varies from 50 - 93% of SO_3 , the average purity being 70-85% of SO_3. The higher grades of gypsum (SO_3 78%) are only suitable for making cement, plaster moulds and ammonium fertilizer.

The total availability of the byproduct gypsum in the country is of the order of 1.5 m tonnes per year. Phosphogypsum, a byproduct from the phosphoric acid industry account for more than 90% of the total production (1.35 m tonnes). Of the remaining, nearly 0.1 m tonne comes from the marine salt industry and the rest from titania, boric acid, citric acid and hydrofluoric acid industries.

2.1.3. Availability of Industrial and Agricultural Wastes

Some of the industrial wastes, which might be of interest to the cement industry, their sources and the estimated annual production are given in Table 2. It is seen from this table that industrial wastes, such as blast furnace slag from the iron and steel industry, fly ash from the thermal power stations, carbonate sludge from the fertilizer industry and lime sludge from the sugar and paper industries are already available in enough quantities to merit serious consideration in regard to their use. Wastes such as chemical gypsum, red mud, and kiln dust, though available in relatively small quantities, are worthy of consideration in terms of their mineral or economic value. The demand of cement is likely to be in excess of the targets of fixed for production, and the utilization of industrial wastes will get a further impetus in a bid to bridge the gap between demand and production.

TABLE 2

AVAILABILITY OF INDUSTRIAL AND AGRICULTURAL WASTES

Sl No	Industrial Waste	Source	Availability (million tonnes)
1	Blast furnace Slag	Iron & Steel industry	6
2	Fly ash	Thermal Power Stations	8

Cont'd...

Table 2 (Contd)...

3	Calcium carbonate sludge	Fertilizer industry	1.2
4	Lime sludge	Paper and sugar industries	2.5
5	Byproduct	Fertilizer, phosphoric acid, hydrofluoric acid industries	1.5
6	Red mud	Aluminium industry	0.6
7	Kiln dust	Cement industry	0.6
8	Rice husk	Agriculture	15

2.2 Status of Cement Production in India

2.2.1 Origin and Early Growth of Indian Cement Industry

Cement was first manufactured in India (near Madras) in 1904 but it was not until 1914 that the foundation of a stable Indian cement industry were really laid. In October 1914, the first bag of cement was packed at Porbandar by the Indian Cement Co Ltd. The First World War gave a fillip to the infant industry and by 1918, there were 3 factories producing some 85,000 tonnes of cement per year. by 1924, six more new factories were installed and the capacities of the 3 older plants were increased, bringing the combined installed capacity to 559, 800 tonnes. Actual production however, was less than half the installed capacity mainly because of severe competition, from foreign countries. By 1936 the annual installed capacity of nine cement factories stood at about a million tonnes producing 968,000 tonnes and by 1938 the number of cement factories rose to 13 with an installed capacity of 1.57 million tonnes and production of 1.16 million tonnes. The rapid increase in the production capacity resulted in a situation in which production outstripped effective demand. During the war years, there was no expansion in the capacity.

2.2.2 Post-Independence Progress

Prior to Independence, there were 23 cement factories in undivided India, and during the partition of the country in 1947, five factories went over to Pakistan bringing down the number of cement factories in India to 18 with an installed capacity of 2.15 million tonnes and production of 1.47 million tonnes. The new Department of Planning which was formed by the Government of India after the attainment of Independence gave the cement industry a fresh impetus.

2.2.3 Progress under the Successive National Plans

During the First Five Year Plan the targets of capacity and production were quite close to the planned targets of 5.3 and 4.8 million tonnes respectively, resulting in an overall increase of over 50 per cent in capacity and giving a growth rate of about 9 per cent. Whilst the rate of growth increased to over 13 per cent per annum during the second plan, the capacity and production targets set at 16 and 13 million tonnes respectively were not achieved. Similarly, the new capacity added and increase in production during the Third Plan were also well below the capacity and production targets estimated at 15 and 13 million tonnes respectively at a growth rate of over 5 per cent. The progress of the industry during the three years of Plan Holiday was slightly better with an addition of 2.96 million tonnes to the capacity in the three years, representing a growth rate of about 7.6 per cent per annum. During the Fourth Plan the targets of both the capacity and production were not achieved, growth rate, however, was 5.7 per cent.

The progress registered by the Indian Cement Industry upto the Fifth Five Year Plan is evident from Table 3.

TABLE 3

GROWTH IN CEMENT CAPACITY

	Plan	Target Capacity in million tonnes	Achievement	Shortfall Tonnes		Annual growth rate
1	First Plan (1951-1956)	5.31	5.02	(-)	0.29	8.9%
2	Second Plan (1956-1961)	16.00	9.30	(-)	6.70	13.1%
3	Third Plan (1961-1966)	15.00	12.00	(-)	3.00	5.2%
4	Annual Plans (1966-1969)	-	14.96		-	7.6%
5	Fourth Plan (1969-1974)	Capcity target not fixed	19.74	capacity target not fixed		5.7%
6	Fifth Plan* (1974-1979)	24.50	22.45@	(-)	1.05	2.6%

Notes:- *The Fifth Plan has been terminated by 1977-78.

@ Anticipated

2.2.4 Present Status and Size of Indian Cement Industry

On the basis of the quantity of cement produced in 1976, India occupies the eleventh place in the world, the first ten, as shown in Table 4, being USSR, Japan, USA, Italy, West Germany, China, France, Spain, Poland and Brazil.

TABLE 4

MAJOR PRODUCERS OF CEMENT IN THE WORLD(1976)

	COUNTRY	PRODUCTION (million tonnes)
1	USSR	124.0
2	Japan	68.2
3	USA	61.7
4	Italy	36.6
5	West Germany	33.8
6	China	31 (Estimated)
7	France	30.6
8	Spain	26
9	Poland	19.8
10	Brazil	19.1
11	India	18.6
	WORLD	727.4

The present installed capacity of the cement industry in India, is 21.87 million tonnes. This will become 22.01 million tonnes by the beginning of 1978-79. Excluding the provision for export, the internal demand for cement by 1980-81 has been estimated at 26.13 million tonnes on the basis of the an annual growth rate of 8% and together with the present gap in demand and supply of 2 million tonnes, the total demand for purposes of projection may be taken at 28.13 million tonnes corresponding to a capacity of 33.10 million tonnes on the basis of 85% utilization.

2.2.5 Cement Production in Some Developing Countries

Table 5 gives the production of cement in some developing countries:

TABLE 5

CEMENT PRODUCTION IN SOME DEVELOPING COUNTRIES

Country	Production (million tonnes)	
Bangladesh	0.28	(1977)
Bulgaria	4.67	(1977)
Burma	0.27	(1977)
India	19.19	(1977)
Argentina	5.83	(1977)
Taiwan	8.73	(1976)
Thailand	4.4	(1976)
Korea, Rep of	11.87	(1976)
Turkey	12.39	(1976)

2.2.6 Future Prospects of Indian Cement Industry

The present installed capacity of the industry (1977-78) is 21.87 million tonnes. This capacity is expected to be increased to 23.09 million tonnes at the end of 1978-79 by the completion of some schemes as given in Table 6:

TABLE 6

SCHEMES PROVIDING ADDITIONAL CAPACITY BY 1978-79

Name of Units	Additional capacity (in million tonnes)
Cherrapunji Expansion	0.20
Mandhar Expansion	0.18
Rajban	0.20
Ariyalur - I	0.25
Hemagundam	0.25
Total	1.08

During the three year period from 1978-79 to 1980-81 the expected yearwise materialization of the capacity would be as under:

TABLE 7

SCHEMES PROVIDING ADDITIONAL CAPACITY BY 1980-81

Sl No	Year	Public sector	Capacity	Private Sector	Capacity	Total
1	1978-79	1 Cherapunji(E)	0.20	1 Ramagundam(E)	0.25	
		2 Mandhar (E)	0.18			
		3 Rajban(N)	0.20			
		4 Ariyalur-I(N)	0.25			
			0.83		0.25	1.08
2	1979-80	1 Ariyalur-II(N)	0.25	1 Maihar-I(N)	0.40	
		2 Neemuch(N)	0.40	2 Wadi-I(E)	0.20	
		3 Akaltara(N)	0.40	3 Udaipur(E)	0.20	
		4 Yerraguntla(N)	0.40	4 Nimbahera(E)	0.42	
		5 Chunar-I(N)	0.20	5 Sulurapet(N)	0.05	
		6 Khrew(N)	0.20			
		7 Purulia(N)	0.25			
			3.58		1.27	4.85
3	1980-81	1 Rourkela	2.00	1 Yadiki (N)	0.40	
		2 Bokaro		2 Maihar-II(N)	0.40	
		3 Bhilai		3 Morak (N)	0.40	
				4 Narsinghar(N)	0.40	
				5 Wadi(E)	0.30	
				6 Satna (E)	0.40	
				7 Macherla(E)	0.10	
			2.00		2.40	4.40
GRAND TOTAL			6.41		3.92	10.33

The above capacity build up includes the setting up of a capacity of about 2 million tonnes by the steel plants in a period of 36 months. While the Rourkela Steel Plant is understood to have completed a project report and gone ahead with the project, it is reported that Bokaro and Bhilai Steel Plants are in the process of preparation of feasibility reports for the slag cement projects. Subject to all the above capacity materializing as expected, the capacity by the end of 1980-81 will be of the order of 32.34 million tonnes or only marginally lower by 0.76 million tonnes than the capacity of 33.10 million tonnes required to meet the demand of 28.13 million tonnes mentioned earlier.

If the gap in demand and availability is not to increase further, it would be necessary to materialize additional capacity of about 3 million tonnes every year to meet the annual increase of 8% in the demand. The capacity expected to materialise during the 1981-82 is as under:

TABLE 8

ADDITIONAL CAPACITY EXPECTED IN 1981-82

Year	Public Sector	Capacity	Private Sector	Capacity	Total
1981-82	Palghat	0.42	Jaffrabad	0.7	1.12
			Gagal	0.4	
			Tandur	0.9	
				1.3	1.3
GRAND TOTAL		0.42		2.0	2.42

The setting up of a capacity of 3 million tonnes per annum would mean 7 to 8 plants of standard capacity of 0.4 million tonnes per annum and an investment of about Rs 200 crores on the basis of an investment of Rs 650/- per annual tonne. This would involve corresponding investment in other allied sectors like coal, power and rail transport.

2.3 Cement Consumption and Future Demands in India

The consumption of cement is very closely related to the production of cement and its demand. Several agencies have employed different methodolgies for estimating the future demand for cement. The methodologies employed included projecting actual growth in production, projecting consumption figures, projections based on regression analysis, projections based on input-output balance method etc.

The wide variations in the various demand estimates appear due to lack of adequate and reliable data. In any estimate of demand, the production and despatches for the last few years have to be taken into account. These are as follows:

TABLE 9

PRODUCTION AND DESPATCHES OF CEMENT

Year	Production (in million tonnes)	Despatches	% increase
1973-74	14.60	14.47	1.5
1974-75	14.73	14.69	16.8
1975-76	17.21	17.14	8.9

The fact that emerges is that whatever is being produced is practically consumed and there is no accummulation of stocks. The natural conclusion is that if more had been produced it would have also been consumed and that there is a considerable unsatisfied demand which was estimated in 1961 by the Tariff Commission at about 1.2 million tonnes. Recently, in addition to stopping of exports of cement, Government has also permitted import of about 1 million tonnes of cement to meet the demand. It would, therefore, be not unreasonable to estimate the present unsatisfied demand at about 3.0 million tonnes. The average per capita consumption of cement in India increased from 22 kg in 1967 to 27 kg in 1972 registering an increase of about 4% per annum. The per capita consumption fell during the year 1973 and 1974 and increased again in 1975 registering an increase of about 5.4% over that of 1974. The per capita consumption of cement in the country is nowhere near the per capita consumption in developed countries and is low even as compared to some of the neighbouring countries. As observed by the Estimates Committee of the Parliament, the per capita consumption is dependent on the economic affluence and the easy availability of cement in regard to both of which the average Indian consumer is still at considerable disadvantage as compared to his counterparts elsewhere in the world. Keeping in view the yet largely untapped rural sector, the present accent on rural development and development of backward areas, the potential demand for cement is much greater than is apparent. While various steps are being taken to curb unethical practices arising out of shortages, the only conclusive answer to meet the situation is increased production. It would, therefore, be prudent to plan on the basis of a slightly higher rate of demand. Considered from these points of view, an annual growth rate of 8% has been adopted for projecting future demand.

The next question that would arise is the base figure on which the above growth rate might be projected. As stated earlier, the Study Group appointed by the Planning Commission estimated the domestic demand for cement in 1978-79 in the range of 19.33 to 22.40 million tonnes. It is proposed for reasons discussed above that the higher figure of 22.40 million tonnes may as well be adopted for projection purposes. The yearwise demand on this basis and the capacity required at 85% utilization and actually expected to materialize in the near future would be as given in Table 10.

TABLE 10

DEMAND PROJECTIONS

Year	Projected demand *Internal	Export	Total	Capacity required at 85%	Expected Capacity	Shortfall (-)/ Excess (+)
1978-79	22.40	1.5	23.90	28.12	23.09	(-) 5.03
1979-80	24.19	1.5	24.69	29.05	27.94	(-) 1.11
1980-81	26.13	1.5	27.63	32.52	32.34	(-) 0.18
1981-82	28.22	1.5	29.72	34.96	34.76	(-) 0.20

(Note : *Estimated at 8% growth rate)

CRI had done an independent exercise of estimating the demand for cement in India during Fifth and Sixth Five Year Plans. CRI had expressed that notwithstanding the justifications given or the degree of acceptaibility of the projections of demand made by various agencies, the final targets are to be fixed taking into account the total picture not only as related to the cement industry but also as related to the entire industrial development forming part of the national developmental programme. CRI had estimated through a detailed exercise of Input-Output Balance, the requirement of cement for fulfilling the Fifth Five Year Plan. According to these calculations the demand of cement for the year 1978-79 worked out to 32 million tonnes, including the requirement for non-plan constructional activity.

The anticipated demand of cement for 1978-79, based on different approaches, made by some agencies, is as given below in Table 11.

TABLE 11

DEMAND PROJECTIONS BY DIFFERENT APPROACHES

	Approach/Agency	Demand 1978-79 (million tonnes)
1	Projecting Growth in Capacity	28.9
2	Projecting consumption figures	30.0
3	Estimation by CRI (Based on Input-Output Balance)	32.0
4	Estimation by National Buildings Organization	28.0
5	Estimation by Task Force on Cement of Government of India	28.0
6	Estimation by Cement Corpn of India	33.6

2.4 International Trade in Cement & Cement Machinery

2.4.1 Cement

The most striking feature of world cement trade during the past ten years is the predominant position taken by the developing countries in supplying each other's import requirements.

Export of cement to other countries is being done by several countries which can be grouped into three categories. The developing countries appear in the second and the third category, the first one comprising of mainly the developed countries.

The second category includes the countries which export a substantial proportion of their production : the Bahamas, Kenya, Norway, Iraq, Malaysia, Lebanon, Egypt, Belgium, Romania, Pakistan, the Democratic People's Republic of Korea, Greece (in declining order of exports as a percentage of production).

In the case of the Bahamas, the cement plant was built with a view to exporting to the east coast of the United States of America and to the West Indies.

The Kenyan cement industry is oriented towards export business and supplies a vast area in the Indian Ocean region by means of vessels and cement terminals which it owns.

The location of the Norwegian cement plants near harbour facilities, the existence of very favourable freight rates and the use of special bulk carriers for cement and clinker have encouraged that country's cement exports. The Norweigian cement industry has acquired a large captive market in Ghana by participating in the State-owned company which operates clinker-grinding plants. Furthermore, a Norwegian company has constructed large silos in New York harbour, from which it supplies the surrounding area with imported cement.

Iraq and Lebanon have a long tradition as cement exporters. The expansion of production capacity in these countries during the past ten years was mainly intended for the export market. Iraq's largest customers are Kuwait and the emirates of the Arabian Peninsula. Lebanon has recently found a large market in Algeria, in addition to its west African outlets. Egypt is strongly oriented towards the export of cement, which is an important source of foreign exchange.

The third category consists of the remaining countries in the list : Canada, Republic of Korea, Colombia, Hungary and Venezuela. No generalization can be made concerning their exports of cement.

In addition to several developing countries, some developed countries in Europe and North America are also importing large quantities of cement. This is probably a temporary phenomenon. It may be expected that they are taking (or will take) steps to remedy the situation. This has already been the case with Spain, whose cement imports amounted to 2.5 million tonnes in 1965. A large increase in production capacity enabled Spain to reduce its imports to 406,000 tonnes by 1969.

Some developing countries, such as Algeria, Argentina, Brazil, Ghana, Indonesia, Kuwait and Saudi Arabia, are in a position rather similar to Spain's; they have access to financial and technical resources which will enable them to become self-sufficient in the not too distant future. Others, such as Colombia, India, Mexico and Venezuela are already in a position to satisfy their own cement requirements.

The following trends seem likely to be followed in the developing countries :

The developing countries - especially those that are far from self-sufficient - will increase their production facilities.

Many of these countries will instal larger capacities then are actually needed domestically in order to benefit from the economies of scale. The resulting surplus will be available to other countries, thus offering possibilities of inter-regional cooperation. As a consequence of these trends, the share of the developing countries in world cement trade should continue to grow.

Table 12 gives the international trade of developing countries in cement :

TABLE 12

INTERNATIONAL TRADE IN CEMENT (1975)

Country	Import		Export	
	Quantity (tonnes)	Value (000 US $)	Quantity (tonnes)	Value (000 US $)
Hong Kong	115300	39771	-	-
India*	-	-	338055	12957
Trinidad & Tobago	3138	296	69282	2219
Sri Lanka	-	-	-	558
Nigeria	1738000	115498	-	-
Thailand	-	-	729182	25087
Korea, Rep of	1817	138	2439000	68922
New Zealand	6468	1016	5400	224
Zambia	2159	134	2058	102
Ghana	854157	23078	5988	177
Egypt	104158	5537	86196	3015
Venezuela	18357	1470	35759	1003
Pakistan	-	-	-	18595
Sudan	77107	4679	-	-

*Now importing

2.4.2 Cement Machinery

At present, in India there are 8 units engaged in the production of cement machinery viz the Associated Cement Coe Ltd, ACC-Vickers - Babcock Ltd, Indian Sugar & General Engineering Corporation, The K C P Ltd, Laraen & Toubro Ltd, McNally Bharat Engg Co Ltd, Utkal Machinery Ltd, Walchandnagar Industries Ltd and the total licensed/registered capacity is 14 complete plants of capacity equivalent to 600 tpd or 7 to 8 plants of 1200 tpd. The units have composite workshops wherein they manufacture other items of industrial machinery such as those required for sugar industry, etc. The manufacturere have so far supplied 37 complete plants of various capacities, the majority being of 600 tpd capacity, adding about 8 million tonnes capacity. Capability for manufacture of 1200 tpd plant has also been developed. The cement machinery making capacity is considered to be adequate to meet the anticipated capacity build-up. These manufacturers are further reported to be geared up to manufacture plants upto 3000 tpd with precalcinators etc.

The Heavy Engineering Corporation at Ranchi (a public sector undertaking) is already supplying huge castings etc to the cement industry.

As regards the international trade of India in cement machinery, one of the cement manufacturers succeeded in securing orders for export of cement machinery; one clinker grinding and packing plant and one 700 tpd wet process plant have been supplied to Kuwait and Kufa (Iraq) respectively.

2.5 Modern Developments in Cement Technology

2.5.1 Developments in Crushing and Grinding

In recent years there have been very significant developments in the design of different types of crushing equipment like jaw, gyratory, impact and roll crushers to crush raw materials which are usually considered suitable to cement industry. Single-stage crushing of medium hard limestone with large throughputs have already made their appearance in cement industry in Europe. The cost of crushing in case of single-stage crusher was considerably less than in two or three-stage crushing plant. Single-stage crusher can reduce large blocks measuring even more than 1 m to minus 25 mm size at one stroke. Noteworthy development in this field is 'Hezemag Compound Crusher' with capacities greater than 1000 tonnes/hour.

The adoption of closed-circuit grinding in raw materials processing, however, has paid dividends not only by way of reduction in power consumption, but also in improved performance of rotary kilns and quality of cement.

Another important development in size reduction operation is autogenous grinding, that is 'Rock grind itself' though this has not been very much used in cement industry. These mills generally consume more power, but this is offset by the saving on expensive grinding media and elimination of metallic contamination.

Roller Mills operating in conjunction with large preheater kilns are also of interest to cement industry. In fact roller mills are hailed as the mills of the future in dry process cement plants. With high efficiency and good capacity, they also combine drying, grinding and classification. Their potential power saving is 20 to 30%. They can cope with increased moisture conditions and are extremely suitable for automatic operation. They have added advantage of lower noise level. Roller mills for kilns upto 3000 TPD are already in operation. It is felt that these mills may not be readily suitable for limestones which are generally hard and have high silica content; these may cause high rate of wear to the grinding elements. The capacity of VR mill is particularly sensitive to the wear of grinding rollers. According to one manufacturer of roller mill, the limit for its use is the content of 8 to 10% free silica sand in raw materials as only free silica sand is decisive with respect to wear of grinding mill elements and hardness of the material also does not play essential part there. In India, M/s Bharat Heavy Electricals Ltd are making efforts to develop VR mills for limestone; they have already supplied such mills for coal grinding. However, the use of such roller mills with the consequent possibility of frequently having to change the mill linings and leading thereby to increased downtime, has to be resorted to with proper care specially in many situations in India.

To decrease power consumption and increase efficiency of grinding one of the latest methods in grinding to fine stages is by introducing grinding aids during grinding operation. The grinding aid are mainly surface active chemicals which reduce the agglomeration of fine cement particles, sticking of particles to the mill lining and grinding media and thus increase the overall grinding efficiency.

Any development aimed towards reducing the consumption of power in a cement plant will be of considerable interest to the developing countries. In this field also useful work is being done in evaluating indigenous grinding aids for improved clinker grinding and evaluation of mineralizers, additives and corrective materials used in the manufacture of cement.

2.5.2 Suspension Preheater Kilns

The process of cement manufacture by dry process has the twin advantage of economy and reduced volume of exit gases to be cleaned for dust control. Today amongst all the dry process, the most prevalent kiln is the short dry process kiln with a four-stage cyclone suspension preheater (SP). The four cyclone stages increase raw meal feed temperature from about 70°C to 750°C and bring about an apparent calcination of about 40% when feed enters the kiln.

Although the different esuspension preheaters of four-stage cyclones shaft type, such as of Humboldt, Polysius, Krupps FLS, FCB Wedag, etc have got little variations in the designs for which they claim different advantages, basic principle of operation of suspension preheaters supplied by all remains almost the same.

2.5.3 Developments in Precalcination

Calcination reaction in cement clinker burning process is a highly endothermic reaction and the amount of heat required for normal raw materials and mixing proportions is about 500-520 kcal/kg of clinker. If the calcining could be accomplished before the materials enter the kiln, the rotary kiln size could be reduced for the same capacity, because then the kiln could be used mostly for sintering process.

The precalcination system offers a number of advantages e.g.

i/ A precalcination system increases the kiln production 2 to 2.5 times without enlarging the kiln size.

ii/ The reduced size of kiln and reduction in heat loads, resulting from the introduction of precalcinators, improves the life of refractory brick and reduces downtime and operational costs.

Several attempts to achieve precalcination have been made in recent years; these include Mitsubishi Fluidized Bed Calcinator (MFC) system, Suspension Preheater with Flash Furnace (SF) and Reinforced Suspension Preheater (RSP) system, F L Smidth precalcining system and precalcining process of Polysius (PREPOL) and a number of others. Precalcinator system suitable for coal, small size and partial precalcination to suit the Indian conditions is being implemented by CRI in collaboration with an Indian cement producer.

There have been some other developments also in such systems but these are only at experimental stage. Fuller have been developing Pyzell fluid-bed type kiln but have not yet got much commercial success. The Thermo Electron Corporation (TECO) have developed a trough shaped stationary kiln in which burners are fired while submerged in raw mix in the calcining zone. Clinkering is done by a short conventional rotary kiln which consumes 20 percent of the total process fuel input. And in the new Harrop Osciplate Calciner (HOC), the material bed moves over a cascade of stationary, overlapping hearths. The HOC can take feed in the slurry, powder or granular form. The stationary furnace can be fired directly or indirectly with gaseous, liquid and solid fuels and can also be heated electrically.

2.5.4 Developments in Clinker Coolers

Wellknown among the coolers are grate coolers, planetary coolers, rotary coolers and shaft coolers. Recently, a tubular cooler, in which dust removal of exhaust air is also not necessary, has been constructed in Austria with a capacity of 2000 tpd; clinker exit temperature of 160°C have been reported for this cooler. The Walker-Beratherm shaft clinker cooler with few moving parts and good overall thermal recovery is also worthy of notice; an additional advantage with this cooler is that no excess cooling air is required to be vented.

2.5.5 Developments in Dust Collectors

The dust collectors commonly used in cement plants include electro-static precipitators, multicyclones, bags, etc. Electrostatic precipitator (ESP) requires least energy of all the high efficiency collectors; its maintenance cost is low because it is constructed of steel and operates dry, above the dew point. Its major disadvantages, however, are the high installation cost, impredictable collection efficiency on certain high resistivity dusts and the expensive nature of supporting instruments. However the installation of such expensive systems involving heavy capital outlay without commensurate enhancement of production is a situation which developing countries can illafford.

2.5.6 Developments in Instrumentation

Instrumentation and control systems in large size cement plants are now well developed to record and control the operating conditions. On line X-ray analysers for quick analysis of raw materials are used in the cement industry. Systems for automatic centralized process control comprising control panel equipment, analogue controllers, television, computers and mini computers are also being employed increasingly in modern cement works.

In the Indian context, perhaps off-line X-ray analyzer may be more appropriate as this would be adequate for keeping track of the raw material composition without being as expensive as the on-line arrangement while at the same time permitting a good part of the work to be done manually.

2.5.7 Other Developments

There have been various other developments in the overall process of cement manufacture such as cold process of cement manufacture, laying the refractory lining without stopping the kiln, gearless drive for cement mills, manufacture of cement and sulphuric acid together, fluidized bed sintering based on total energy concept. However, there is an imperative need for evolving more ingeneous methods of packing cement where one totally disposes with the packing machines and bagged supply of cement. Homogenizing techniques for raw meal suitable to Indian materials and situations such as continuous homogenization are also a subject under in-depth study.

3 TECHNO-SOCIO-ECONOMIC BASE IN DEVELOPING COUNTRIES AS RELEVANT TO CEMENT AND ALLIED INDUSTRIES

3.1 The GNP and Cement Consumption

Regression analysis confirms that the relationship between cement consumption (in kilograms per capita) and the GNP (in dollars per capita) in 1965 was non-linear; the GNP elasticity of cement consumption decreases with an increasing GNP. It was unity when at a GNP of approximately $ 390 per capita and cement consumption 148 kg per capita. Below this, cement consumption increased faster, and above this, slower than the GNP.

When cement consumption is compared with expenditure on construction, one or two countries show pronounced departures from the general trend, that might be explained by a significant change in the nature of construction output, as for ample a large increase in the proportion of civil engineering works. New building constructions carried out in some developing countries in the year 1976 are as per Table 13 given below :

TABLE 13

NEW BUILDING CONSTRUCTIONS IN SOME DEVELOPING COUNTRIES (1976)

Sl No	Country	Dwellings (1000 nos)	Residential (1000 m^2)	Non-residential
1	Brazil	200.4	22800	8700
2	Chile	11.5	868	374
3	Guatemala	-	142	-
4	Hong Kong	-	1306	-
5	Iran	-	14436	1680
6	Israel	54.9	5208	1656
7	Kenya	-	96	156
8	Korea, Rep of	-	9492	8496
9	New Zealand	30	3389	2628
10	Senegal	-	74	9.6
11	South Africa	11.8	162228	55812
12	Syria	29.8	3296	458
13	Trinidad & Tobago	-	368	73

3.2 Availability of Manpower

Well equipped building contractors and a qualified labour force are normally available in developed countries, although some of them (for example, Switzerland) depend on a large quota of foreign workers in order to keep their construction industry going. Without these resources, cement cannot be used effectively; their absence may cause in a developing country.

In the first case, the problem may be evolved by making it attractive to local or foreign firms (by means of credit facilities, loans, reduced import duties on equipment) to engage in the contracting business; the establishment of

State-owned building companies is another measure which can help to develop the industry.

In the second case, the problem must be solved through training of labour. As the cement manufacturers and building contractors reap the advantages, such training should be their responsibility.

Cement is a manufacturing industry and in so far as developing countries are concerned, mostly they have to utilize labour intensive technology for cement. So availability of manpower i.e. giving employment to people in developing countries, is of utmost interest. The following table gives the progress that some of the developing countries have made in giving employment to people, in manufacturing industries :

TABLE 14

INDEX NUMBERS OF EMPLOYMENT IN MANUFACTURING INDUSTRIES (1976)
Base 1970 = 100

Sl No	Country	Index
1	India	113.4
2	Israel	117.5
3	Korea, Rep of	233.5
4	Malawi	171.5
5	Mauritius	338.2
6	New Zealand	108.1
7	Spain	115.8
8	Venezuela	133.9
9	Bulgaria	111.2

3.3 Technological Base for Indian Cement Industry

Whilst a great deal of research of different kinds is already going on in the field of cement and concrete technology and valuable work is being done by the various laboratories spread all over the country covering manufacturers and users, private entrepreneurs and the governments at the centre and the states alike, the need for considerably strengthening the R&D effort in this field becomes obvious when the potential of the industries involved is considered.

Whilst undoubtedly, research in various other fields is as essential for human progress as research in cement and concrete the diversified effort has resulted in a positive and conspicuous absence of an intensive, well coordinated and planned effort at the national level on an institutional basis towards reaching the desired goals in the technological fields of cement and allied industries.

It is exactly to fill this gap that the Cement Research Institute of India has been established. The principal objective of CRI is to give increasingly better technology support to the cement and related building materials, cement machinery, construction, and allied industries for which purpose it provides the base necessary for a planned and intensive R&D effort as well as proper coordination and utilization of competencies wherever they may be available in the country and in whatever form for achieving the set objectives.

The R&D activities of this Institute cover the entire spectrum, starting from the chemical elements available in nature and their exploitation towards making cement through the manufacturing processes, engineering design and development of cement plant and machinery - to cement technology and concrete technology-ending in concrete structures where cement finds its final place of rest. Thus CRI's R&D

is essentially a multi-disciplinary endeavour, the service and assistance of which, as a national asset, are also available to industries dealing with other related building materials.

Realising the importance of such intensive and coordinated research, and in keeping with the broadest conception of public service, similar efforts have been put in many other countries of the world and the cement industries in almost all the advanced countries of the world have established research institutes which are some of the finest of their kind. Work done in these institutes has been responsible for many notable advances in cement and concrete technology which have taken place in recent years; but for the programme of continuing scientific research in these institutes, as well as in the field, many applications of cement and concrete which are considered today as common would have been totally unknown or prohibitive in cost. In today's context, inter-disciplinary approach is an inescapable necessity if any real progress and break-through have to be obtained.

4 ALTERNATIVE TECHNOLOGIES AVAILABLE

4.1 Process of Manufacture

The process of manufacturing portland cement consists in the incorporation of the raw materials, one of which is composed mainly of calcium carbonate (as limestone) and the other of aluminium silicate (as clay or shale), to form a homogeneous mixture; the burning of the mix in a kiln to form clinker; and the grinding of the clinker with the addition of a small proportion of gypsum to a fine powder. Two processes, known as the wet and dry process according as to whether the raw materials are ground and mixed in a wet or dry condition, are used. In a variant of these processes, the semi-dry processes, the raw materials are ground dry and then mixed with 10-14 per cent water and formed into nodules.

The wet process was originally used for very friable materials such as chalk and clay and later extended to the harder limestones and shales. For many years the wet process was preferred because of the more accurete control of raw mix which was possible with it. With improved control, there has been a swing back to the dry process, for less fuel is required for burning than in the wet process. Modern developments in the dry mixing of powdered materials have, moreover, now removed the disadvantage of the dry process.

In the dry process the raw materials are crushed, dried in rotary driers, proportioned, and then ground in tube mills consisting of rotating steel cylinders containing a charge of steel balls or other grinding media. The mills are continuous in operation, being fed at one end and discharging the ground material at the other. Two mixes, one high and one low in lime, are often prepared and blended in the required proportions in a silo with vigorous air circulation. The dry powder is fed to the kiln.

In the manufacture by the wet process the method differs somewhat with the nature of the raw materials. When chalks and marls are used the raw materials are broken up and incorporated in wash mills. The chalk and clay are fed in the required proportions to the wash mill together with sufficient water to form a liquid of creamy consistencies. The finished slurry does not usually contain more than a few per cent of material remaining on a 170 mesh, and its water content varies from 35 to 45 per cent with different raw materials. The slurry is pumped to slurry tanks or basins.

The rotary kiln in which the cement is burnt at 1300-1500°C is a long cylinder rotating on its axis and inclined so that the materials fed in at the upper end travel slowly to the lower end. Here the fuel, pulverized coal, oil or natural gas, is blown in by an air blast and ignited. In the upper part of the kilns chains are fixed to assist in the transfer of heat from the kiln gases to the raw materials. The slurry is dried in the upper part of the kiln and the water driven off as steam, and then as it descends the kiln, the dried slurry undergoes a series of reactions, forming what is known as clinker.

4.2 Size of Plants

In countries where there is little or no production of cement, an annual capacity of 1,00,000 tonnes by the rotary kiln process is considered to be the economic size whereas the corresponding figure for countries where the cement industry has developed is 4,00,000 tonnes or more. The cement industry in India, having been established on a firm footing with an installed capacity of 21.87 million tonnes, falls under the latter category. The capital required at today's price level is of the order of Rs 650 to Rs 7-0 per tonne of cement produced annually.

Considering the advantages of the influence of scale of operation on total investment cost and production cost - the world trend today is to go in for larger and larger single unit cement plants. Now-a-days a number of 3000 to 4000 tpd rotary kilns are already in operation in many parts of the world, such as those in USA, USSR, Germany and Japan. A suspension preheater kiln of 4800 tonnes per day capacity at Karita Cement Plant and an 'SF' kiln (based on newly developed 'SF' process) of 7200 tonnes per day capacity at Kumagaya work of Chichibu Cement Co Ltd in Japan need special mention in this context.

The Indian cement industry is a mixture of small and large capacity plants ranging from 20 tpd (CRI Tamilnadu) at one extreme to 3000 tpd (Jaipur Udyog Swaimadhopur) - though based on multiple kilns.

The economic unit capacity for cement plants in India was standardized at 600 tpd, in the beginning of 1960. However, the present day trend is towards going in for larger size units in view of their economics, both on the fixed investment and the cost of production. In view of the above savings and taking into consideration the increases in labour wages, railway freight, and price of coal and electricity, it appears necessary for the cement industry to go in for larger sizes of the order of 2000 tpd single unit plant or even 3000 tpd. A curve depicting influence of size of plant on capital investment cost is given in Figure 5.

In India, there are seven cement plants having capacities more than 2000 tpd (ACC - Chaibasa, Saurashtra Cement - Ranavav, Shree Digvijay, ACC - Jamul, ACC - Kymore, Jaipur Udyog - Sewaimadhopur, and India Cements, Talaiyuthu) - though based on multiple kilns rather than single-unit plants.

Mini cement plants are essentially those in which cement is produced in quantities much less than in the conventional process. However, what precisely demarcates a mini cement plant from a conventional plant, is the techno-socio-economic approach and content. Accordingly, the question is not one of mere scaling down or scaling up, but one of determining the appropriate technology under a given socio-economic situation to make it techno-economically viable within the given situation.

The mini cement plants can alternatively be based on the following processes :

a) Vertical Shaft Kiln
b) Small Rotary Kiln
c) Sinter Bed - Straight (like Lurgi) or inverted (like Reba)
d) Belt kiln or Mechanical Grill

Of the four systems mentioned above, the commercial exploitation of the last two processes is rather limited. The experience of the one sinter bed plant established in India has not been very encouraging. That is why it may be appropriate for the time being to consider establishing mini cement plants based on the first two processes, the brief descriptions of which are given below :

Vertical Shaft Kiln - The use of vertical shaft kiln process for cement manufacture dates back to the year 1824, when portland cement was invented. However, because of its labour intensive operations, this process was found uneconomical, apart from the fact that it produced non-uniform quality clinker, consequently restricting its growth.

It was only after the development of a pan-type nodulizer, that a significant advance could be achieved and the shaft kiln performance improved considerably this permitting automation and production of a uniform quality of clinker.

Based on the recent developments, a vertical shaft kiln process is a semi-dry process and essentially comprises the following :

i/ Crushing of limestone and additives (if necessary) in a crusher to minus 15-20 mm size.

ii/ Proportioning of raw materials and fuel (coke breeze) based on raw mix design, grinding to desired fineness and blending of finally ground raw mix to obtain raw meal of desired homogeneity.

iii/ Preparation of nodules by addition of water to raw meal in a pan-type nodulizer.

iv/ Feeding nodules to VSK where drying, calcining, sintering and cooling take place as the nodules travel down the VSK and ultimately get converted into clinker.

v/ Grinding of clinker and gypsum (4-5%) in a mill to obtain ordinary portland cement.

The VSK process can adapt itself for full automation or part automation. The necessary simple instruments help in controlling the kiln operation.

Small Rotary Kiln - The use of rotary kilns for cement manufacture is well established. The conventional plants are essentially based on rotary kiln technology. However, a small rotary kiln can be adopted to produce cement on a small scale in a mini plant. A small rotary kiln process could either be dry, semi-dry or wet. The rotary kiln process essentially comprises the following :

i/ Crushing of limestone and additives (if necessary) in a crusher

ii/ Proportioning of raw materials, grinding (dry or wet) to desired characteristics and blending of finally ground raw mix/slurry to obtain homogenized raw meal

iii/ Coal crushing, grinding, storage, and feed control arrangement to the kiln for firing

iv/ Passing the homogenized raw meal through a shaft/ cyclone preheater (if required as per process selected) and feeding to kiln

v/ Cooling of clinker in cooler

vi/ Grinding of clinker and gypsum in a mill to obtain portland cement.

The process is quite simple to operate and results in uniform quality clinker.

Small scale cement plants began to be built in China in 1958. At this time, in other parts of the world, large rotary kilns with internal heat recouperating devices and external suspension preheaters were being installed.

China has not chosen to take the same steps in increasing its cement producing capacity as the rest of the world. In China there have been additions of large rotary kilns near large cities where transportation is better developed, but a major capacity increase also has taken place from small 'egg-shaped' and shaft kilns. The 'egg-shaped' kilns are built below ground level and are lined with brick. They are very small in size. They must be charged, and the material removed manually and are what is known in chemical processing as "batch" type operation. The shaft kiln is an old technology that has been used to heat many types of minerals and is a type of kiln used in the manufacture of the first portland cement.

4.3 Manpower in Indian Cement Plants

The cement industry employs about 80,000 people, i.e. about one worker per tonne of daily production. It has considerable capacity for generating indirect employment in the form of construction labour, quarry labour, transport, etc. The additional direct employment likely to be generated would be as follows :

TABLE 15

ADDITIONAL EMPLOYMENT IN CEMENT INDUSTRY

Year	Cement Production (in million tonnes)	Direct Labour
1977-78	19.00	80,000
1982-83	32.00	1,35,000
Additional employment		55,000

The trend in respect of number of plants and sizes of plants in relation to employment potential is regulated from the following table :

TABLE 16

MANPOWER EMPLOYMENT IN INDIAN CEMENT INDUSTRY

Size of Plants (tpd)	No of Plants	Manpower per tonne of cement
Mini (upto 100)	3	4 - 5.5
Small (101-300)	5	1 - 4.5
Medium (301 - 1090)	16	0.29 - 2.32
Large (above 1000)	32	0.18 - 2.26

As should be expected, the manpower consumption per tonne of cement is highest for small size cement plants. Interestingly, all the three mini plants are based on three different processes, namely, vertical shaft kiln, sinter grate and dry rotary kiln. It may be noted that the range of manpower consumption shown in the table is not of the average figures but indicates the lowest and highest figures for cement plants in India.

5 RELATIVE ADVANTAGES AND DISADVANTAGES OF THE ALTERNATIVES COVERED UNDER SECTION 4

5.1 Wet and Dry Process Plants

Till recently cement was being manufactured throughout the world mostly by wet process in spite of fuel consumption being greater than that for the dry process which was being adopted wherever nature of raw materials permitted and consumption of fuel was a critical parameter. Today the trend is towards dry process all over the world.

Amongst all the factors to be considered while selecting the manufacturing process, the most important decisive factors are the fuel and power consumption which, together, account for about 40 per cent of the cost of production. Fuel consumption depends on the process used and, the power mainly depends upon whether the raw material is soft or hard.

Though development of long wet process kilns with internal heat exchanger system brought down the fuel consumption to as low a value as 1300 k cal per kg of clinker, the more recent developments in dry process kiln on the other hand have reduced the fuel consumption to as low values as about 700 kcal per kg of clinker and this appears to have tilted the balance in favour of dry process. The power requirement in terms of kwh/tonne of cement is around 110-120 for wet process and about 130-140 for the dry process. Water requirements depend mainly on the process used. A dry process plant uses up to approximately 810 litres of water and an average wet process plant requires approximately 1620 litres of water per tonne of finished cement.

The lower consumption of fuel in the dry process than in the wet process makes the former preferable if the material components are not too wet or sticky. As a fundamental rule, the dry process is to be recommended for reasons of heat economy, particularly in cases where the raw materials contain less than 15 to 18 per cent of water. The earlier view that in the dry process of preparation, the raw mix is more likely to vary in composition than it is in the wet process, no longer holds true with regard to modern mixing plant. In the dry process, there is usually sufficient heat in the kiln exit gases to dry the raw material.

The wet process is preferable for dealing with moist raw materials, such as chalk or plastic clay, as the dry preparation of such materials presents difficulties. This process will always have to be employed in cases where the raw material contain deleterious admixtures which have to be removed by washing.

Adoption of dry process can save as much as ₨ 8.80 per tonne of clinker on account of fuel, assuming that dry process requires 0.18 tonnes of coal (of 5000 k cal/kg coal) per tonne of clinker as against 0.29 tonnes for the wet process; the cost of coal taken as ₨ 80/- per tonne.

Although power consumption in dry process is more by about 20 units per tonne of cement costing approximately ₨ 2.00 per tonne, the latter can possibly be balanced by utilizing exit gases in drying raw materials while grinding. In addition to this, adoption of dry process saves about 810 litres of water per tonne of cement produced. In other words, there is a strong case for adoption of dry process wherever possible and when raw materials quality is not a problem.

5.2 Small Vs Large Cement Plants

Mini cement plants will, because of their following advantages, have a role to play in the developmental programme in the country and will come to be established wherever the circumstances are such that these advantages can be secured :

i/ Cement industry is brought within the financial access of smaller entrepreneurs

ii/ A sense of ownership is invested in men with relatively smaller means

iii/ Creation of increased employment opportunities in rural areas on a well dispersed basis

iv/ Contribution to uplifting the local economy and development

v/ Realization of quicker returns on capital invested because of low gestation period

vi/ Exploitation of small deposits of limestone scattered all over the country

vii/ Development of cement industry in terrains where movement of machinery and cement are difficult

viii/ Reduction of strain on country's transportation infrastructure

ix/ Avoidance of wasteful movement of materials and thus bringing down the average unit cost of transportation of cement in the country

x/ Elimination of packing charges where the utilization point is localized xi/ Reduction in multi-handling and intermediaries between the manufacturing point and the consuming point

Table 17 projects the capital investment and investment per tonne of installed capacity for a 1200 tpd and a 50 tpd plant.

TABLE 17

INVESTMENT FOR 1200 AND 500 TPD PLANTS

Type of investment	Size	
	1200 tpd	50 tpd
1 Capital investment (Rs in lakhs)		
a/ Fixed capital	2840.00	94.90
b/ Working capital	125.00	6.61
c/ Total capital	2965.00	101.51
2 Investment per tonne of installed capacity (Rs)		
a/ Fixed capital	710.00	558.40
b/ Working capital	31.25	38.89
c/ Total capital	741.25	597.29

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6 CASE STUDIES IN CEMENT PRODUCTION

6.1 Mini Cement Plants

6.1.1 Background for Developmental Work on Mini Cement Plant

In general, in industrial practice, the sizes in which industrial processes and operations are being carried out are being continually increased in most industries with a view to reaping the benefits of scaling up. The scaling up approach has, however, led to certain drawbacks which vary from industry to industry and country to country. In the case of the cement industry, in India the problems faced with large plants are :

i/ the capital cost of a viable size of cement plant is very high (of the order of Rs 250 million for 1200 tpd plant and Rs 500 million for 2500 tpd plant) and is quite beyond the means of an average entrepreneur;

ii/ the movement of population from their natural locations to big industrial centres causes social problems;

iii/ large plants require relatively longer time (of the order of 3 to 5 years) for machinery fabrication and plant establishment

iv/ difficulties in transportation and other infrastructural facilities for transporting large size machinery is a situation obtaining in many developing countries ;

v/ limited infrastructural services such as power and water in certain areas; interruptions in the required inputs cause interruptions in the operation of the plant with consequent large losses ;

vi/ limitations in the availability of raw materials in sufficient quantity. In fact, many small deposits of limestone spread all over the country have remained unutilized because they are not large enough to establish a viable large size or even medium size plant.

If appropriate technologies are developed to make them techno-economically feasible, small size plants would not only overcome the above limitations and drawbacks of large plants but would in addition offer the advantages outlines in section 5.2.

6.1.2 Progress of Work on the Developmental Project - The imperative need for developing and structuring a viable indigenous technology for mini cement plants with vertical shaft kiln (VSK) or small rotary kiln and the intensive and coordinated efforts carried out in CRI culminated into the development of basic designs of mini cement plants based on VSK technology sometime in late 1973; this was essentially based on laboratory investigations of raw materials and fuel involved along with the analysis of process design data collected from numerous sources. In the meantime a non-working vertical shaft kiln mini cement plant (unable to produce quality cement on account of its faulty design), situated at Muduvathur (Tamil Nadu in South India) was gifted to CRI by the Government of Tamil Nadu in June 1974 for R&D purposes. CRI then took up the task of super-imposing the already available basic design on the VSK plant at Muduvathur. Consequently, the redesigning and restructuring work on VSK plant started in August 1974. As VSK technology requires specialized manpower, CRI also took this opportunity to train the operating personnel simultaneously.

The redesigned and restructured vertical shaft kiln had a capacity of 20 tpd. First trial runs and proving runs of CRI designed VSK plant at Muduvathur were carried out from 1 June 1975 to 5 June 1975 and 28 February 1976 to 15 March 1976 respectively, establishing that the satisfactory quality clinker can be produced on a sustained basis under Indian conditions. A typical cross section of the designed vertical shaft kiln is shown in Fig 6. Encouraged by the above findings, the Committee of Direction for Cement Research (CDCR), set up by the Ministry of Industry Government of India, sponsored a project to CRI in March 1976 with an objective of running the mini cement plant for six months for periods varying from 2 days to 15 days on continuous basis and to collect the data relating to output performance, consumption factors, process parameters, clinker and cement quality and the related economics.

The commercial operation of 20 tpd mini cement plant under the above approved project started on 19 July 1976. During 1976-77, the plant has operated for a total of 178 days on 1 shift, 2 shifts and 3 shifts basis; producing cement conforming to Indian Standards Specifications, the longest continuous run on 3 shift basis being for 45 days.

After ascertaining the possibility of obtaining good quality clinker and cement, as confirmed from the results of the commercialized runs of VSK plant during 1976-77, CDCR approved another project during 1977-78 for running of mini cement plant at CRI Tamil Nadu Centre. During 1977-78, the mini cement plant has run continuously for 171 days on 3 shift basis in two stages.

The plant is again in continuous operation from 9 April 1978.

6.1.3 Techno-Economic Studies

Projection of the economic viability of 50 tpd mini cement plants of CRI-type named "VISVAKARMA" in three different situations A, B and C has been chosen from out of the actual field projects CRI is presently handling. Situation A represents a favourable location comparable to those of the existing conventional working plants and situation C represents conditions which are extreme in certain respects; Situation B represents a midway situation between the two. It is possible that in reality there could be situations more favourable than situation A and worse than Situation C; these have to be carefully studied with reference to individual cases.

Table 18 projects the capital investment requirement for a mini cement plant in the three situations referred to above, the production cost and the respective profitability. In working out the profitability, revision in the retention price from ₨ 161.12 to ₨ 296.00 and continuance of the existing 25% rebate on excise duty applicable to new cement units, have been assumed. Impact of additional incentives or concessions are also brought out in the statements in this table.

The following Annexures to the table relate to the mini plants in Situation B :

Annexure I - Estimates of Capital Cost

Annexure II - Estimates of Working Capital

TABLE 18

INVESTMENT PRODUCTION COST AND PROFITABILITY

Sl No	ITEMS	50-TPD Mini Cement Plant (CRI-Type)		
		Situation A	Situation B	Situation C
1	Capital investment (Rs/Lakhs)			
	a/ Fixed capital	93.43	94.90	101.40
	b/ Working capital	5.61	6.61	7.81
	c/ Total capital	99.04	101.51	109.21
2	Investment per tonne of installed capacity (Rs)			
	a/ Fixed capital	549.75	558.40	596.65
	b/ Working capital	33.01	38.89	45.95
	c/ Total capital	582.76	597.29	642.60
3	Cost of production of naked cement (Rs/tonne)	234.35	251.33	262.04
4	Retention price for cement on which profitability is based (Rs/tonne)	296.00	296.00	296.00
5	Radius of supply on which profitability is based			
	a/ Maximum (Km)	100	100	100
	b/ Average (Km)	50	50	50

Sl No	ITEMS	50-TPD Mini Cement Plant (CRI-Type)		
		Situation A	Situation B	Situation C
6	Profitability based on 4th year of operation without any concessions as compared to conventional large plants and with wages as per Cement Wage Board			
6.1	Net profit per tonne with sales and distribution being an integral part of the mini plant (incurring only part of the conventional intermediary expenses)	95.87	78.80	68.08
6.1.1	Percentage return on equity capital (Debt-Equity Ratio - 65 : 35)			
	a/ Pre-Tax	42.0%	33.6%	26.9%
	b/ Post-Tax	17.7%	14.2%	11.4%
6.2.	Net profit per tonne with sales and distribution being separate as for conventional large plants	80.90	63.92	53.21
6.2.1	Percentage return on equity capital			
	a/ Pre-Tax	35.4%	27.3%	21.0%
	b/ Post-Tax	15.0%	11.5%	8.9%

Sl No	ITEMS	50-TPD Mini Cement Plant (CRI-Type)		
		Situation A	Situation B	Situation C
6.3	Increase in profitability resulting from the following concessions			
	a/ Freight differential being retained by the Mini Cement Plant (Rs/tonne)	44.74	46.76	46.54
	b/ Use of 100% second hand gunny bags (because of short distance transportation and less handling) (Rs/tonne)	9.83	9.83	9.83
	Total of 6.3:	54.57	56.59	56.37
6.3.1	Net profit per tonne as per 6.1 adjusted for 6.3 above (6.1 + 6.3)	150.44	135.39	124.45
6.3.2	Percentage return on equity capital			
	a/ Pre-Tax	65.9%	57.8%	49.1%
	b/ Post-Tax	27.8%	24.4%	20.7%
6.3.3	Net profit per tonne as per 6.2 adjusted for 6.3 above (6.2 + 6.3)	135.47	120.51	109.55
6.3.4	Percentage return on equity capital			
	a/ Pre-Tax	59.3%	51.4%	43.2%
	b/ Post-Tax	25.1%	21.7%	18.3%

Sl No	ITEMS	50-TPD Mini Cement Plant (CRI-Type)		
		Situation A	Situation B	Situation C
6.4	Decrease in profitability resulting from withdrawal of the existing rebate on excise duty (25%)(Rs/tonne)	16.25	16.25	16.25
6.4.1	Net profit per tonne as per 6.1 adjusted for 6.4 above (6.1 - 6.4)	79.62	62.55	51.83
6.4.2	Percentage return on equity capital			
	a/ Pre-Tax	34.9%	26.7%	20.5%
	b/ Post-Tax	14.7%	11.3%	8.7%
6.4.3	Net profit per tonne as per 6.2, adjusted for 6.4 above (6.2 - 6.4)	64.65	47.67	36.96
6.4.4	Percentage return on equity capital			
	a/ Pre-Tax	28.3%	20.3%	14.6%
	b/ Post-Tax	12.0%	8.6%	6.2%
6.5	Increase in profitability resulting from additional excise duty rebate of 75% (Rs/tonne)	48.75	48.75	48.75
6.5.1	Net profit as per 6.1 adjusted for 6.5 above (6.1 + 6.5)	144.62	127.55	116.83

Sl No	ITEMS	50-TPD Mini Cement Plant (CRI-Type)		
		Situation A	Situation B	Situation C
6.5.2	Percentage return on equity capital			
	a/ Pre-Tax	63.3%	54.4%	46.1%
	b/ Post-Tax	26.7%	23.0%	19.5%
6.5.3	Net profit as per 6.3 adjusted for 6.5 above (6.2 + 6.5)	129.65	112.67	101.96
6.5.4	Percentage return on equity capital			
	a/ Pre-Tax	56.0%	48.1%	40.2%
	b/ Post-Tax	2[illegible].0%	20.3%	17.0%
6.6	Increase in profitability due to exemption from Wage Board application (Rs/tonne)	18.11	18.96	19.54
6.6.1	Net profit per tonne as per 6.1, adjusted for 6.6 above (6.1 + 6.6)	113.98	97.76	87.62
6.6.2	Percentage return on equity capital			
	a/ Pre-Tax	4[illegible].9%	41.70%	34.6%
	b/ Post-Tax	21.1%	17.6%	14.6%
6.6.3	Net profit per tonne as per 6.2 adjusted for 6.6 above (6.2 + 6.6)	99.01	82.88	72.75

Sl No	ITEMS	50-TPD Mini Cement Plant (CRI-Type)		
		Situation A	Situation B	Situation C
6.6.4	Percentage return on equity capital			
	a/ Pre-Tax	43.3%	35.4%	28.7%
	b/ Post-Tax	18.3%	15.0%	12.1%
6.7	Decrease in profitability resulting from 10% increase in capital cost (Rs/tonne)	6.78	6.88	7.35
6.7.1	Net profit per tonne as per 6.1 adjusted for 6.7 above (6.1 - 6.7)	89.09	71.92	60.73
6.7.2	Percentage return on equity capital			
	a/ Pre-Tax	35.7%	28.1%	22.0%
	b/ Post-Tax	15.1%	11.9%	9.3%
6.7.3	Net profit per tonne as per 6.2 adjusted for 6.7 above (6.2 - 6.7)	74.12	57.04	45.86
6.7.4	Percentage return on equity capital			
	a/ Pre-Tax	29.7%	22.3%	16.6%
	b/ Post-Tax	12.5%	9.4%	7.0%

Sl No	I T E M S	50-TPD Mini Cement Plant (CRI-Type)		
		Situation A	Situation B	Situation C
6.8	Increase in profitability resulting from 10% decrease in capital cost (Rs/tonne)	6.78	6.88	7.35
6.8.1	Net profit as per 6.1 adjusted for 6.8 above (6.1 + 6.8)	102.65	85.68	75.43
6.8.2	Percentage Return on Equity Capital			
	a/ Pre-Tax	49.6%	40.3%	32.8%
	b/ Post-Tax	21.0%	17.0%	13.9%
6.8.3	Net Profit as per 6.2 adjusted for 6.3 above (6.2 + 6.8)	87.68	70.80	60.56
6.8.4	Percentage return on equity capital			
	a/ Pre-Tax	42.3%	33.3%	26.3%
	b/ Post-Tax	17.9%	14.1%	11.1%

Annexure III	-	Ectimates of Annual Cost of production
Annexure IV	-	Break-even Analysis
Annexure V	-	Estimates of production cost and profitability for the first ten years of operation
Annexure VI	-	Cash Flow Statement for the first ten years of operation
Annexure VII	-	Expected Benefits/Costs of the projects based on the 4th year of operation.

6.2 Indigenous Precalcinators

6.2.1 Relation to Plant Size and CRI Precalcinator

In any discussion on precalcination technology, it is important to remember that this technology was the answer conceived essentially for very large size cement plants since even with the preheater, the kiln tended to be rather big for larger capacities with high thermal loading. Thus, even after four years of its advent, the precalcinator remains an expedient purely for very large capacity plants, upwards of 2000 tpd. The largest kiln yet in the country being of 1200 tpd capacity (3 more under planning) it is open to question whether the precalcinator technology can benefit the existing plants.

CRI has taken on hand an R&D project for commissioning a precalcinator in an Indian cement plant (300 tpd capacity kiln); some of the important characteristics envisaged are :

i/ at least 30% increase over the rated capacity of the kiln in clinker production ii/ the precalcinator suits Indian coals as available to cement industry

iii/ 20% increase in the life of refractory lining in the burning zone of kiln

iv/ heat saving, to the tune of 30 ± 5 kcal/kg of clinkers compared with the existing preheater kiln

The project covers design of process parameters and economic evaluation in terms of investment, operational costs etc.

The development of CRI precalcinator is in advance stage of development having completed the necessary experimentation, design followed by capacity evaluation for the ancillary equipment, instrumentation details and assembly drawings. Presently fabrication is in progress. The Indian precalcinator is expected to be commissioned by Dec 1978.

6.2.2. <u>Relation to Manufacturing Process</u>

6.2.2.1 <u>Wet Process</u>

With 103 kilns based on wet process for cement manufacture, the first step towards incorporation of a precalcination system would be to change the plant, equipment and machinery to dry process with suspension preheater. In order to adopt to the new precalcination process in wet process plants, to cope with the anticipated capacity increase which could be threefold, the capacity of various unit operations will have to be accordingly increased in addition to the incorporation of the following process changes :

i/ wet raw meal grinding to dry raw meal grinding

ii/ wet slurry mixing to dry raw meal homogenizing

iii/ wet material handling to dry material handling

These various changes and modifications will mean altogether new installation and scrapping of most of the existing unit operations. The total downtime necessary for such conversion may range from 6 - 8 months. Considering the totality of such project involving modifications, the economics may or may not work out to be favourable.

6.2.2.2 Dry process

A two-fold increase in the capacity of a dry process plant is possible either by :

i/ Installing a parallel stream of a completely new kiln unit with all unit operation facilities of its own in an existing plant, which evidently takes no recourse to a precalcinator, or

ii/ Installing a precalcination system and doubling the capacity of the other unit operations.

Yet another approach, which may not be quite convenient could be installing a parallel stream of SP in combination with the existing one. However, this would require, complete restructuring of the preheater tower, etc and involve considerable downtime, all of which could cost as much as an SP of twice the capacity.

There are only 18 dry process kilns having suspension preheater, it will not be possible in all of them to incorporate a precalcination system since hardly 4 - 5 cement plants may command reserve to sustain a two-fold increase. Another limiting factor could be plant lay-out which may not have the necessary flexibility. Therefore, within the next three years the capacity can be expanded only upto 0.8 million tonnes per annum, on the assumptions that the capacity of these plants (4 to 5 in no) is doubled.

Where the circumstances may not favour two-fold increase in capacity, a 20 to 30 percent increase could be achieved by installing a precalcination system assuming that all other unit operations have extra inbuilt capacity to cope with the increase in capacity. In this case, all that is required may be the modification in fan capacities, kiln drive, preheater ducting, and addition of some material handling equipment as well as installation of secondary air ducting from cooler.

6.3 Rapid Quality Control Systems with Simple Facilities

In relation to manufacturing process an important consideration is that the quality of the product produced should not be lower than that aimed to meet the specified requirements; the quality should also be as uniform as practicable consistent with the product if the potential of a product is to be fully utilized. In order, therefore, to achieve these, considerable attention is required towards quality control in the manufacturing process. In advanced countries high degree of instrumentation, controls and automation have come into play, one of the governing parameters of which is quality control. Expensive on-line instrumentation have come in many modern manufacturing processes; a developing country finds it too hard to have such expensive on-line instrumentation controls but nevertheless they need to have some alternative system of quality control. In this area, therefore, appropriate technology aims at having rapid methods of testing and control as that on the one hand there is a timely feed-back for the process control and on the other it makes it possible to have data relating to a relatively large number of samples which is pre-requisite for reliable assumptions on several aspects in modern manufacturing processes. Appropriate technologies therefore cannot ignore the quality control aspects. Cement Research Institute of India has been giving attention to this subject for the last several years and has worked on rapid methods of testing.- both chemical methods as well as simple instrumental methods. A comparative study of the various instrumental analytical studies in CRI is given in Table 19 which is self explanatory. Against this background, a summary of savings in direct costs for the rapid methods (i) with conventional analytical chemistry laboratory facilities, (ii) with colorimetric instrumentation facility which is included in Table 19 and (iii) with EDTA is reproduced in another Table 20.

7 CASE STUDIES IN PACKING CEMENT

7.1 Improved Packing for Cement

7.1.1 Background for Development

On a conservative basis, India presently needs over 350 million bags per year (new and used both inclusive) and this figure may go up to as much as 600 million bags per year by 1980. In addition bags are also required for export. Many developing countries face similar problems though their magnitudes differ.

Quite often attention has been drawn to the loss of cement due to seepage from the plain jute bags generally used in India. This seepage not only causes a loss of cement but also causes nuisance of dust. It was estimated that by avoiding this loss there may be a gain of as much as Rs 100 million every year to the nation as a whole. These problems were worrying equally to the manufacturers of cement, the consumers of cement and the Government. CRI was therefore asked jointly by the interests representing manufacturers, the consumers and the Government to study those problems indepth and arrive at a solution which would be appropriate to the country. The R&D project was thus taken up by CRI in early 1971.

7.1.2 Identifying Basic Requirements for Packaging Cement

In the joint exercise of all those interested, the basic requirements for packaging of cement were first formulated as follows:

i/ The bag should be sufficiently proofed against ingress of water or dampness on the one hand and leakage or seepage of cement on the other,

ii/ The bag should be strong enough to withstand the

TABLE 19

COMPARATIVE STUDY OF THE VARIOUS INSTRUMENTAL ANALYTICAL TECHNIQUES IN CRI

Technique	Instruments	Capital investment (order of the amount in Rs ' 000)	Servicing and Maintenance cost (Relative)	Type of Specialized personnel	Availability of personnel
Electron Microscopy	Electron Microscope	1800	High	Specially trained physicist/chemist	Very difficult
Electron probe study	Electron probe Micro-analyser	800	High	Specially trained physicist/chemist	Very difficult
Infrared studies	IR Spectro-photometer	800	High	-do-	Not difficult
X-ray techniques	X-ray Fluorescence Spectrometer	400	High	X-ray mineralogist	Difficult
Petrographic analysis	Transmitted-cum-reflected light microscope Microhardness Tester Reflectivity Measurement device Point counter U-stage	150	Low	Geologist petrographer	Easy
Thermal analysis	DTA apparatus TGA apparatus	120	Moderate	Specially trained chemist	Easy
Colorimetry	Colorimeter	20	Low	Specially trained chemist	Easy

TABLE 20

SAVINGS IN DIRECT COSTS FOR ANALYSIS BY ADOPTION OF COLORIMETRIC AND EDTA METHODS

(Basis of Comparison: Gravimetric Method as per IS:4032-1968)

Component of cost	Direct Cost in Rupees														Total Direct Cost in Rupees		
	Gravimetric					Colorimetric					EDTA						
	SiO_2	CaO	MgO	Fe_2O_3	Al_2O_3	SiO_2	CaO	MgO	Fe_2O_3	Al_2O_3	CaO	MgO	Fe_2O_3	Al_2O_3	Grav.	Color.	EDTA
Consumable	5.90	4.90	2.90	2.50	4.30	1.00	0.35	0.40	0.40	0.35	1.95	1.40	0.34	1.51	20.50	2.50	5.20
Power/Gas	1.50	1.50	1.50	0.20	1.50	0.05	0.05	0.05	0.05	0.05	-	-	-	0.10	6.20	0.25	0.10
Manpower	8.50	14.25	7.15	2.40	4.75	2.40	0.60	0.60	0.70	1.90	2.40	2.40	2.40	2.40	37.10	6.20	5.60
														Total	63.80	8.95	10.90

COMPARISON OF MANHOURS & TIME

	Gravimetric	Colorimetric	EDTA
Manhours per sample	8	1.5	2

stresses and strains of handling under the prevalent conditions in the country. Either provision should exist for hooking or it should be possible to eliminate hooking in industrial practice with no adverse effects on productivity.

iii/ The bag should not present difficulties in filling, either qualitatively or quantitatively especially with the existing expensive packing machines.

iv/ The material of the bag should be such as to withstand the high temperature of coment - which could be of the order of 90°C - 100°C at the time of packing.

v/ The total cost of the bag should prove sufficiently economical taking into account reusages, if any.

vi/ The material used and the processes adopted for the manufacture of the bags should be such as to ensure continuity in the supply of bags, and

vii/ The material used should have good frictional characteristics to avoid slippage on the conveyors.

7.1.3 Progress of Work on the Developmental Project

After reviewing the work done earlier, the investigations started with a study of the relative properties, availability and techno-economics of the three packaging materials widely in use in different parts of the world, that is, jute, paper and plastics. An analysis of the available information and data indicated that as a first step towards evolving a suitable bag for cement packaging, bags from each of these as well as composite constructions should be studied further. As a result it was overhelmingly clear that any large scale usage in India would require it to be jute based and therefore the technology has to be jute based; this was in fact an important component in determining the appropriateness of technology. Indepth technical studies were then started. As a result of these studies certain systems and designs including special air valves were evolved and some of them patented.

After the laboratory tests were completed successfully, CRI scientists were sent to three cement works to test the bags under the conditions obtaining in the plants. After these tests were satisfactorily completed CRI made out a plan of testing the bags by the cement works themselves; a bundle of 41 bags was sent to each cement manufacturer in the country, covering some 58 cement plants, with detailed guidelines and instructions for testing. On the basis of the results thus received, and a study of the bags tested and returned to CRI, the technical feasibility of the improved bags and their meeting the required performance criteria were proved.

The above research work and industrial trials led to the development of such a composite material for packing cement which could be designed and modified to cater to specific needs.

7.1.4 Techno-economic Studies

Whilst a few of the bags were manufactured in the laboratory itself by hand most of the bags were manufactured in the premises of a laminator-cum-bag manufacturer whose co-operation was enlisted in the early stages of the project itself. Once the feasibility having been proved beyond dubt, date and parameters were collected to enable a techno-economic assessment of the improved performance vis-a-vis the additional cost involved in the packaging. This was studied in the context of overall savings that would accrue with references to conventional heavy cee jute bags as well as with reference to kraft paper bags used in many other countries. A typical summary is given in Fig 7 and Table 21 as an example and a comparative statement of manpower content is illustrated in Table 22.

TABLE 21

A COMPARATIVE SUMMARY

CRI Bags Vis-a-Vis Convential Heavy Cee Jute Bags

1	Improvement in strength	55% More
2	Seepage loss	94% Less
3	Loss due to ingress of moisture	83% Less
4	Possible number of reusages	33% More
5	Initial cost of bag	28% More
6	Equivalent cost of bag	47% Less

TABLE 22

Comparative Table of Manpower Content

Item	Kraft Paper bags	Heavy Cee Conventional bags	CRI Type bags
Manhour per 1000 bags	½	12	16
Manhour cost per 1000 bags (Rs)	2	30	40

Having thus established the techno-economic aspects of the project and the appropriateness of the technology developed, the first pre-commercialization stage discussions were held with the industry, the industry was convinced that the proposition was worth industrial trials and as a part of this about 35,000 bags were supplied to five cement companies for regular commercial use. In this industrial usage, data was collected from both the cement plants where the bags were used as well as from the consumers who received the bags. Industrial usage is now picking up and increasing day by day.

8 CASE STUDIES IN UTILIZATION OF CEMENT

8.1 CRI Type Ready-mix Concrete without using Agitators or Truck Mixers

Ready-mixed concrete as a technology has been well known since a long time and is widely adopted in most of the developed countries, so much so, that nearly two thirds or more of the concrete produced in most of the developed countries is ready-mixed. While the advantages of ready-mixed concrete are well known, its adoption in developing countries has not been to such a large extent. Appropriate technology of ready-mixed concrete for developing countries with particular reference to India was thus taken up for study.

Concrete and construction industry is quite well established in India. Nearly 120 million tonnes of concrete made annually in India and the necessary infrastructure to innovate or develop new technologies in this field is available within the country. If, some or all of the recent developments in construction technology, as practised in developed countries, have not yet been adopted in India it is because of the techno-socio-economic considerations which has led to the adoption of appropriate technology in each case. Ready-mixed concrete is a case in point.

The two modes of transporting ready-mixed concrete envisaged in Indian Standard IS : 4926 - 1968 involve either truck mixers or agitators. Transporting concrete in truck mixers without agitation is sometimes practised for smaller distances of haul and need not be a technology in itself. This is being pointed out in order to contrast this mode of transportation with the one introduced later in this section.

Ready-mixed concrete, although having been talked about for quite sometime in the past, has not yet made any ground in India. The necessary knowledge and expertise in the successful operation of a ready-mixed concrete plant and its fruitful use in the construction sites are available within the country. Central batching and mixing plants of sufficiently large sizes incorporating considerable sophistication are manufactured in the country and widely used in large construction projects. There are manufacturers of agitators/truck-mixers in the country whose products are finding market in the neighbouring countries. Why then, ready-mixed concrete is not yet established as an industry in India? The answers to the question are mainly two-fold and perhaps common to most of the developing countries.

The first reason is the fact that ready-mixed concrete is capital-intensive and a major portion of the capital outlay is for the transportation fleet. A recent study conducted by CRI shows that nearly 62 to 70% of the fixed capital cost for a 125 to 250 cubic metre per day capacity RMC plant goes towards the cost of truck-mixers/agitators.

The second reason has been the absence of matching infrastructure for proper handling, placing and compaction at the site of placement. As it is well known, ready-mixed concrete becomes compitative with site-mixed concrete only when the demand of concrete to be poured per day exceeds a certain level; in the context of European countries, this is perhaps of the order of 500 cu m per week. The study in CRI shows that optimum size of a ready-mixed plant in India should be, more or less, of the same order. However, in India and in most of the other developing countries, the placement of concrete is mostly done manually. Placers or pumps are used in large construction projects only who may also afford to have a central batching and mixing plant near the site of construction itself. For an average construction job in most of the developing countries handling 3 cu m of concrete per trip of the truck-mixer/agitator may indeed pose some problems.

From the above, the strategy to make ready-mixed concrete an attractive proposition in developing countries, points to two considerations :

a/ that concrete be transported in ordinary, non-agitating vehicles, without loss of quality and any other desirable advantages of ready-mixed concrete ; and

b/ the size of the ready-mixed plant and the transport fleet be chosen keeping the constraints of placement at the receiving end.

8.1.1 The Appropriate Technology

With the above considerations in view, an appropriate technology for ready-mixed concrete to be adopted in developing countries like India has been evolved by CRI whose main feature is that it enables concrete from the central batching/mixing plant to be transported without agitation. This technology comprises a central batching/mixing plant, a transportation fleet of non-agitating vehicles like trucks etc of appropriate sizes and a concrete mixer at the site for re-mixing. As it is well known, a high slump (50-100 mm) concrete from the central batching/mixing plant, if delivered without agitation, will pose problems of serious loss of workability and even 'stiffening' of concrete duing transportation which will call for re-tempering at the site. Depending upon the climatic condition and transport bottlenecks, the distance of haul in such cases will be severely restricted. If, on the other hand, only dry concrete materials after batching were to be transported in open trucks etc, most of the cement and other fine particles will be blewn away. Between these two extremes, the choice will obviously lie in transporting concrete in a 'semi-dry' state from the batching/mixing plant, with only sufficient water added initially, to render the concrete into a cohesive mass, and the balance of water added in the second stage before final placing. Although the solution may sound to be simple, it really calls for a thorough study of all aspects of the choice of materials, particularly the grading of aggregates and the percentage of fines, proper mix designs, study of tendency to segregate during transport, loss of water due to evaporation during transport, the state of hydration of cement during transport and its effect on the resultant workability of concrete. CRI has carried out extensive research and trails on these aspects and have come out with a technology which has enabled concrete to be transported in non-agitating vehicles over 1 to 1/2 hours and have indeed successfully adopted this technology in some of its own constructions. Extended application of this technology in some large projects involving construction of concrete dams, canal linings and barrages are being arranged.

8.1.2 Techno-economics

In so far as the economics of this technology is concerned the details are being worked out but at this stage itself it has become clear that the transport fleet should consist of a larger number of ordinary, non-agitating vehicles of smaller capacity (0.5 to 1 cu m) rather than less number of larger capacity vehicles, Generally, overall transport cost will be lower with increase in the unit size of the pay-load. It must be kept in mind that the ultimate advantage of ready-mixed concrete is to be derived in ensuring 'quality' concrete for both big and small jobs alike. While in large construction projects adequate infrastructures to produce quality concrete may be provided economially, it is in the small construction projects that ready-mixed concrete has to serve its purpose where even minimum facilities for testing concrete materials, mix designs and proper batching and mixing to produce 'quality' concrete entails uneconomical overhead costs and where 'nominal' concrete mixes are widely used rather than 'controlled' concrete. Keeping such small jobs in view, smaller size of transportation vehicles may ensure full utilization of its transport capacity, and from an overall consideration may indeed be more economical.

The size of the central batching/mixing plant has also to match the capacity of the transportation fleet. There is a need, therefore, of going for smaller size batching plants (may be 10 to 30 cu m per hour). Such batching plants need not have the finest levels of sophistication and complete automation; indeed many or most of the controls may be done manually.

8.1.3 Advantages

At this point of time, a few advantages become apparent which are common to most of the developing countries. These are :

i/ Such a technology will enable the use of controlled concrete for small or medium construction jobs also. In most of the developing countries, for small or medium size construction jobs, the cost of necessary infrastructure for producing controlled concrete has been known to be disproportionately and uneconomically high. Yet, on a national level, when the available excessive use of scare concreting material like cement which results from the use of 'nominal' mixes is considered, the advantage of using 'controlled' concrete which ensures rational use of materials and proper performance and durability of the structure at the same time, cannot be denied.

ii/ This technology will enable the use of industrial wastes like flyash in construction industry, in a larger scale.

iii/ In a conventional ready-mixed concrete plant truck-mixers/agitators always return empty. Compared to this, non-agitating, ordinary vehicles like trucks can be gainfully utilized in many developing countries for carrying materials etc. in return trips and need not return empty.

iv/ Employment-generation is an important consideration in most of the developing countries and a technology which is fully mechanised may not always meet the social obligations and needs. The proposed technology strikes a harmonious balance between utilization of manpower and mechanisation is an appropriate dose in the relevant areas.

8.2 CRI Design of Concrete Poles for Rural Electrification

8.2.1 Background for Development

Presently, the demand for line supports required for rural electrification in India is estimated at over 4 million poles per annum. A large portion of this demand may be met by prestressed concrete poles, and therefore economical designs which are consistent with functional requirements, may result in considerable savings. Though the absolute value of cost reduction per pole may seem inconsiderable, the savings, when expressed as a fraction of the cost of pole, will be substantial and therefore, additional efforts to arrive at the economical designs become worthwhile.

8.2.2 Scope of Work

With the above background CRI under took an R&D project towards evolving economical design of rectangular prestressed concrete transmission line poles for use in rural areas. The functional requirements of these poles are strength and durability. In the design, both mild steel and high strength deformed bar reinforcements were considered. Working loads taken were 140 kg and 200 kg and factors of safety of 2.0 and 2.5. The R&D work also included, inter alia, determination of the influence of transverse reinforcements and influence of geometrical parameters on the behaviour of a vierendeel pole; elastic stress problem in Vierendeel poles was studied by photoelastic methods.

8.2.3 Developmental Work at CRI

Full scale specimens of prestressed concrete poles of rectangular and vierendeel types were cast and tested to investigate the different aspects of the behaviour of poles.

The specimens were cast in a long time pretensioning bed. The concrete was made from granite aggregates, pits and cement. The transfer of prestress was effected by a slow detensioning of the wires. The poles were tested as per Indian Standard Specification IS : 1678 - 1960.

After studying the results of the preliminary tests for assessing the performance of poles, eighteen specimens in one series were cast and tested to assess the performance of six types of prestressed concrete poles recommended for use. The six types of poles made from concrete of grade M-420 were of rectangular cross-section having a factor of safety of 2.5 against ultimate failure. These poles also showed sufficient resistance to cracking and ultimate failure.

8.2.4 Techno-Economics

Two sets of design parameters, one corresponding to the design practice adopted now and the other corresponding to the specifications from a few codes were listed out and the change in cost, when the design parameters were modified, was worked out. To compare the cost of the alternatives, the "relative cost" of a pole was used as an indicator rather than absolute cost, as the latter may vary with time and from place to place.

The relative cost was definud as follows :

$$C = Q_c + KQ_s,$$

Where C = relative cost of pole

Q_c = volume of concrete, m^3

Q_s = weight of prestressing steel

$$K = \frac{\text{Cost of one tonne of prestressing steel}}{\text{Cost of one } m^3 \text{ of concrete}}$$

For the materials used K was found to br approximately 11. Table 23 indicates the percentage savings in costs of six CRI designed poles (Group C) against those in use by a State Electricity Board (Group A) and those as per Indian Standard Specifications (Group B); parameters are same for all the three groups.

TABLE 23

Cost Savings in CRI Designed Poles

Sl No	Relative Cost			Cost Saving in C %	
	A	B	C	$\frac{B-C}{B} \times 100$	$\frac{A-C}{A} \times 100$
1	0.216	0.237	0.186	21.5	13.9
2	0.278	0.299	0.241	11.2	16.7
3	0.235	0.261	0.203	21.3	7.43
4	0.303	0.321	0.270	14.88	21.10
5	-	0.314	0.255	25.9	-
6	-	0.381	0.314	18.25	-

8.2.5 Implementation of CRI Design

The Indian Standard on prestressed concrete transmission line poles IS : 1678 - 1960 has now been revised on the basis of the suggestions made through CRI; the revised standard will to be released soon.

Also, the Rural Electrification Corporation are going to bring out a manual for production of transmission line poles incorporating CRI's design and development work.

8.3 CRI Design of Low Cost Materials for Low Cost Houses

The demand for building materials required for the construction of dwelling units and grainries is enormous especially in rural India where these advanced materials are not available hence the transportation of these materials to the consumers centre involve high costs and with the present problem related to the fuel shortage every effort should be made to minimise cost on this account by exploiting local material for construction purposes.

Keeping in view the availability of local materials and paying capacity of economically weaker sections, CRI developed a design for a rural house and small capacity storage bin wherein the use of costly conventional construction materials was eliminated. The design emphasizes carting of only small quantity of advanced material to the rural areas for materials like natural soils. It further exploits other locally available materials, such as rice husk, secondary spices of timber and sand stone slabs.

The soil stabilization technique is the solution to most of the problems faced in rural areas. The soil is available everywhere. It requires only a small quantity of cement, which is used as a stabilising agent. Since the quantity to be transported is very small the cost of construction is not adversely affected. The process of blockmaking is very simple and the services of skilled labourers are not required. This is not only cuts down the cost by minimising the use of skilled labour but encourages the self help concept also.

For the roof of the house, sandstone tiles are used which are locally available. Broken tiles are made use of for floor for the house; which gives a very good irregular pattern. For window and door panels the locally available variety of wood is used. In foundations the lime and surkhi are made use of. Thus most of the materials used in the construction are available locally and only a small quantity of cement need be transported.

If required inside of walls can be plastered with 15 mm thick layer of clay bhusa putty. The ratio of the mix is normally 12 : 1.

The external joints of block masonry are pointed with cement sand mortar (1:4) to protect the mortar from weathering away. A plan of the house is given in Figure 8 and perspective view in Figure 9.

8.3.1 Analysis of Cost

Inputs for a building consist of two major items normally materials and labour cost of which differ widely in different regions of the country. Hence the cost of the house of the same design built to similar specifications will tend to vary from region to region.

The material cost of the house constructed within the campus during current financial year works out to be Rs 1700.00. In addition to that total cost of skilled and unskilled labour is about Rs 1000/- which may be taken as self help of the occupant or it may be added to the cost of the unit if the construction is through organized agency. These cost estimates are based upon the CPWD schedule of rates for the year 1974 + 15 percent. Whenever the rates are not available in the schedule, item rate analysis has been done. Total cost quoted of the unit does not include charges for any kind of service like electricity, water supply and sewage disposal.

Due to the concept of self help and use of local material rural housing scheme will act as a countermagnet to migration of rural population to urban areas which are already under much housing pressures, lacking housing accommodation and prevent emerging of slums & squatters. Another important factor of housing is that it would provide the necessary incentive and inculcate the desire in rural poor to save for the hope of having a roof of his own over his head.

The house is well within reach of rural poor. The self help construction can be done and the cost of materials alone come to Rs 70/sq m. With limitation of the funds allocated for housing, this low cost will help in advancing towards achieving the ratio of number of dwellings 1000 inhabitants of about 8 achieved by the developed countries of the world.

9 IMPACT OF NATIONAL POLICIES AND PLANNING OF STRATEGY FOR DEVELOPMENT

9.1 Policies Relating to Limestone Quarry Leases

The sanction of prospecting licences and mining leases as also acquisition of land fell within the purview of the State Governments. To encourage new industries in its own State, promises are made for immediate allotment of land and sanction or prospecting licences and mining leases. It has, however, been pointed out that the actual sanction/execution of mining leases and land acquisition proceedings take quite a long time and this requires improvement.

9.2 Norms for Prospecting and Exploration of Limestone

Prospecting and exploration of limestone deposits can yield fruitful data required for entreprenal use and assistance if proper norms such as CRI's "Guide Norms for Prospecting, Exploration, Reserve Estimation and Technological Assessment of Cement Grade Limestone Deposits" are followed.

9.3 Policies Relating to Limestone Availability to Mini Cement Plants

Geological prospecting, exploration etc required for a mini cement plant are such that the small entrepreneurs may find it difficult to get these done by geological consultants as the cost of such investigation may be proportionately large. Therefore for mini cement plant entrepreneurs, the State Governments might consider possibility of making available the required exploration data as a service.

9.4 Policies Relating to Coal Movement and Quality

Coal has been in short supply to cement industry for quite some time; the situation improved in the year 1976 when the loss of production owing to shortage of coal was only 5000 tonnes. Recently the situation has again deteriorated in some quarters for various reasons.

The Government of India constituted a Standing Linkage Committee for coal movement in January 1973. As a result of the discussions between the Committee and cement manufacturers, the cement plants have been linked up with specific sources of coal supply, the linkage committee allocates the quota of coal for each cement plant, the fixed quota is sufficient, by and large, for each cement plant. However, actual supplies usually fall short of the allocations. The linkage Committee also decided to maintain coal stocks at cement factories to the extent of 21 days' consumption. As regards the actual movement of coal, Indian Railways are responsible for providing adequate wagons.

Transportation in areas involves multiple handling and transhipment; a unified policy for handling and transhipment will help smoother supply of coal to some of the cement plants.

9.5 Policies Relating to Supply of Coke Breeze and Low Volatile Fuels for Mini Cement Plants

For Vertical Shaft Kiln, the fuel used is coke breeze, which is available mainly from steel plants and other coke oven batteries or low volatile coals available only in certain parts. Though the present production of coke is nearly 21 million tonnes, the availability of coke breeze has become less because of recycling of coke breeze within the steel plant mainly for sintering process. In some plants, there is surplus of coke breeze and in some others it balances. Though the initial mini plants can be well sustained by the coke breeze that will be available, a clear-cut policy has to be arrived at to ensure that mini cement plants do get assured supply of coke breeze or alternative low volatile fuels.

9.6 Policies Relating to Utilization of Industrial Wastes

Blast furnace slag and fly ash are two important industrial wastes which are utilized in the manufacture of cement with advantage.

The Government of India had decided to reimburse the cost of transport of slag provided it was moved from sources approved by the Cement Controller and was in the logical forward direction as for cement and to the extent of savings accruing to Cement Regulation Account of the Government of India. This however did not result in any increased utilization of slag, as the condition for reimbursement proved rather restrictive. This position has since considerably improved with the announcement of incentives for utilization of industrial wastes.

Since the freight cost is also a cost to the economy, the relevant consideration should be to minimise the total cost including the production cost and the freight cost. The need for increased use of slag with the reimbursement of the transport cost has, therefore, to be balanced against the cost to the economy.

Substantial slag cement production could be achieved with least cost to the economy if cement plants using slag are established at or near the steel plants subject to availability of raw materials also close to the steel plants.

Fly ash is a waste product of the thermal plants using coal. The basic problems in the way of greater use of flyash are the inadequate availability of dry fly ash and lack of consistency in its quality. These problems could be satisfactorily overcome if, as in the case of steel plants, a directive is given to the thermal plants to establish the necessary arrangements at each plant for certifying the quality of the fly ash according to prescribed specifications and making it available to the industry in a proper framework. The additional expenditure involved on these arrangements could be met out of the sale proceeds of the fly ash.

Other industrial wastes like calcium bearing sludges from paper and sugar industries, by-product gypsum from fertilizer industries are similarly to be encouraged.

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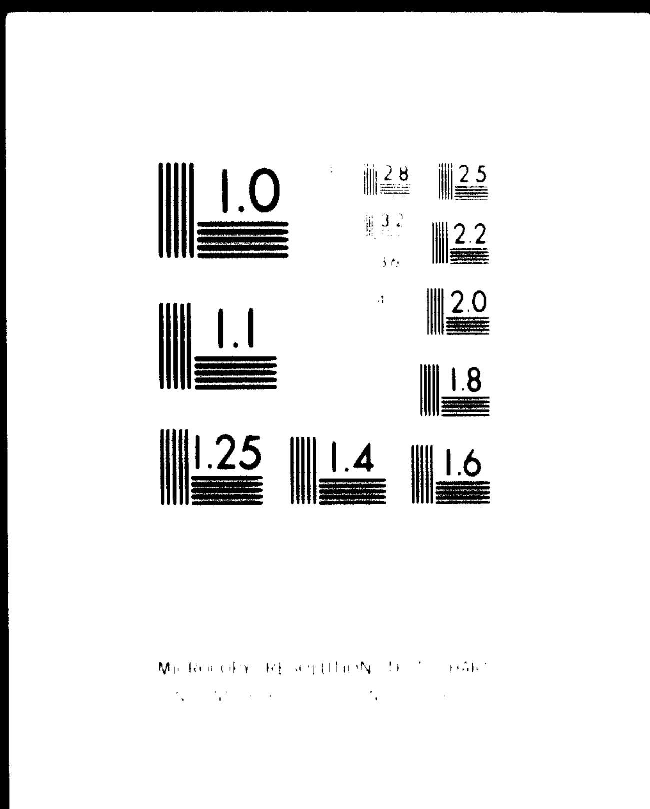

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9.7 Policies Relating to Split Location

The normal setting up of a cement producing plant, particularly after the freight pooling system came into existence in 1956, is to have its various components such as the limestone quarries, the clinker plant and the cement grinding and packing plant situated in the vicinity of each other. Sometimes, however, there is departure from this conventional set up and what is known as split location is resorted to. When this is done, the clinker capacity is established near the source of he raw material, namely, limestone quarries while the cement grinding and packing plants are established at a different site, usually near some centre where cement is consumed in sufficiently large quantities.

So long as limestone was being utilised as the principal raw material the idea of split location was confined within the above narrow scope. However, the situation has been changing over the years due to two factors. There has been substantial increase in the production of steel in the country and as a result, large quantities of blast furnace slag (BFS), which can be utilised as a supplementary component material for the production of cement, are becoming available. Secondly, a number of thermal plants have been and are being set up in the country and as a result, fly ash which can also be used as supplementary component material for the production of Portland Pozzolana Cement is becoming available in larger quantities.

As a result of the above developments, the idea of split location has to be examined from various angles, particularly from the point of view of the increased use of BFS and fly ash as supplementary component materials for the production of cement. The various factors which have to be examined are the economics of the proposition depending upon the locality, demand for cement, availability of clinker, BFS and pozzolanic materials like fly ash, facility for putting up a grinding unit, blending or inter-grinding of the various materials etc.

It could as well be a framework of policy that all new cement plants now in the planning and design stage should be examined for possibilities of split location system.

9.8 Policies Relating to Bulk Supply of Cement

Bulk supply of cement is becoming more and more popular. In some of the advanced countries over 70% of the total quantity of cement produced is supplied in bulk whilst in India there are only two bulk distribution centres - one in Delhi and the other in Bombay. In view of certain clear advantages and disadvantages in the bulk supply of cement in comparison with bagged supply, the question as to under what set of parameters bulk supply should replace the bagged supply requires a detailed consideration. Supply of cement in returnable drums/containers also merits serious consideration particularly in view of the circumstances obtaining in some of the developing countries.

9.9 Policies Relating to Packaging

As at present, packing cost is in-built in the total pricing structure of cement; it being a controlled commodity in India. Packing cost is reviewed and announced by the Cement Controller, Government of India quarterly depending upon the variation in price of jute which is the material of packaging cement for domestic market; packaging material for export is kraft paper (presently export of cement has been stopped with a view to meeting its shortage in domestic market). Price of jute is announced by the Jute Commissioner, Government of India. While announcing the cost of packing element, the Cement Controller also takes into account the use of old gunny bags. The ratio of old to new bags to be used for packing cement by the plants is controlled at about 40:60. The Cement Controller also allows adjustment in this ratio even up to the extent of 70:30 to ensure that the total price is not exceeded.

There is a tremendous need to conserve a scarce commodity like cement. The wastage of cement due to seepage and also deterioration due to ingress of moisture has been attributed to the permeable character of the packing in loose-textured jute bags. Improved methods of packing cement as developed by CRI and discussed earlier could be a solution on which policies have to be formulated.

9.10 **Policies Relating to Standardization of Plant and Machinery**

Varieties of designs and sizes because of different collaborations have effect on delivery period, replacements and costs. Unification of design through necessary dimensional standardization of plant and machinery for conventional plants and standardization of mini plants will go a long way in the faster and more orderly development of the industry. As a beginning a National Standard, i.e. Indian Standard Specification entitled "Dimensions and Materials of Cement Rotary Kilns, Components and Auxiliaries (Dry Process with suspension preheater)" IS: 8125 - 1976 has already been brought out and CRI has standardized design of mini cement plant. Government, as a policy, could cause implementation of these standards through mandatory directives. Some, however, hold the view that such mandatory directives will be a retrograde step in so far as advancement of technology is concerned.

9.11 **Policies Relating to Pricing of Cement**

The cement industry in India has been subject to price and distribution control except for a brief period during 1966-67 when it was subject to informal self-control by the industry itself under the overall guidance of the Government.

The Tariff Commission which enquired into the price structure of the cement industry in its report submitted to the Government of India in 1974, had suggested the concept of the standard cost for the industry as a whole based on a system of weighted averages - a weighted average price for the industry as a whole, special additional price for high cost units and a fund into which the difference between the weighted average retention price and the actual retention price would be paid for meeting the additional price given to high cost units. The scope of the fund was also enlarged to reimburse the difference in actual railway freight incurred and the provision in the F O R price. Thus while the weighted average retention price secured a reasonable price to the manufacturer, the F O R price secured cement to the consumer at a uniform reasonable price through the country.

Another reason generally advanced for the slow growth of the industry is the strict price control and the inadequate and meagre return provided which is insufficient to pay a reasonable dividend to the shareholders. This has been overcome with the recent decisions of the Government to give an additional price to high cost units set up in hilly and remote areas and fixing the price of new units/expansions on the basis of a net post tax return of 12% on the net worth limited to an amount of Rs 230/- out of a fixed investment of Rs 650/- per tonne. It will be noted that this decision does not cover the existing units and both the decisions are at present applicable only upto 31.3.1979 when the present price period expires.

A section of the industry has been of the view that the regional imbalance in the setting up of capacity is due to the operation of freight pool, that it is not in vogue anywhere else in the world and that but for it additional capacity could have come up in the traditionally deficit areas. In a vast country like India, cement has to move over long distances to the various consumption points and freight is an important aspect in the ultimate consumer price. Freight pooling system has assured the availability of cement in all parts of the country at the same price. The Tariff Commission examined this arrangement and came to the conclusion that in the interest of overall economy and of the consumer, the freight pooling system should be continued to ensure equal availability and inform price of cement all over the country.

A High Level Committee has now been appointed by the Government of India with a view to undertaking a comprehensive review of the Indian cement industry covering the production, distribution and pricing aspects and the Committee is presently pursuing this task.

9.12 Policies Relating to Appropriate Technology

Since in most cases the social costs and the social aspects of a technology are lost sight of in the midst of the normal practice of considering techno-economic viability of projects, Government would have to take special steps to bring home the advantages of appropriate technology. Whilst the technologists should as a general rule arrive at such solutions which are viable without incentives or concessions, until the various advantages of appropriate technology are realised and appreciated by the concerned population, Governments could provide incentives and concessions to make projects based on appropriate technology attractive. The loss of revenue to or the expenditure incurred by the Government in doing so could be compensated by spreading these on the entire industry; for example, if 25% of the total cement production in a country is the contribution from mini cement plants, the costs or expenditure on account of concessions and incentives to mini cement plants could be recovered by spreading them over the remaining 75% of the production by the industry. These could be reviewed from time to time as socio-economic developments take place and balanced.

10 CONCLUSION

From the foregoing, it is evident that no single technology can be stated as Appropriate Technology for all countries, under all circumstances and at all times. That technology which is "appropriate" in the given techno-socio-economic framework is the one that should be adopted. It is seen that even in the Indian scene quite clearly the technologies of large cement plants, the technologies of medium cement plants and the technologies of mini cement plants are all relevant and have all their own place and their own role to play. In spite of the diversities that we see in the Indian scene and in spite of the fact that there is place for a variety of technologies in the manufacture of cement, there can at the same time be seen a continuous thread of unity in this diversity. This in fact is likely to be the position with reference to the other developing countries wherein in spite of all the diversities amongst them there would be certain unifying factors which play an important role in the decision making relating to technologies for the development of the cement industry and in their ultimate role in industrialization and socio-economic development of these countries. A continuous and intensive cooperation amongst the developing countries on the basis of complementarity will be the most important base fabric on which development can be speeded up.

ACKNOWLEDGEMENT

The following documents have been freely consulted; facts, figures and data have been profusely drawn therefrom:

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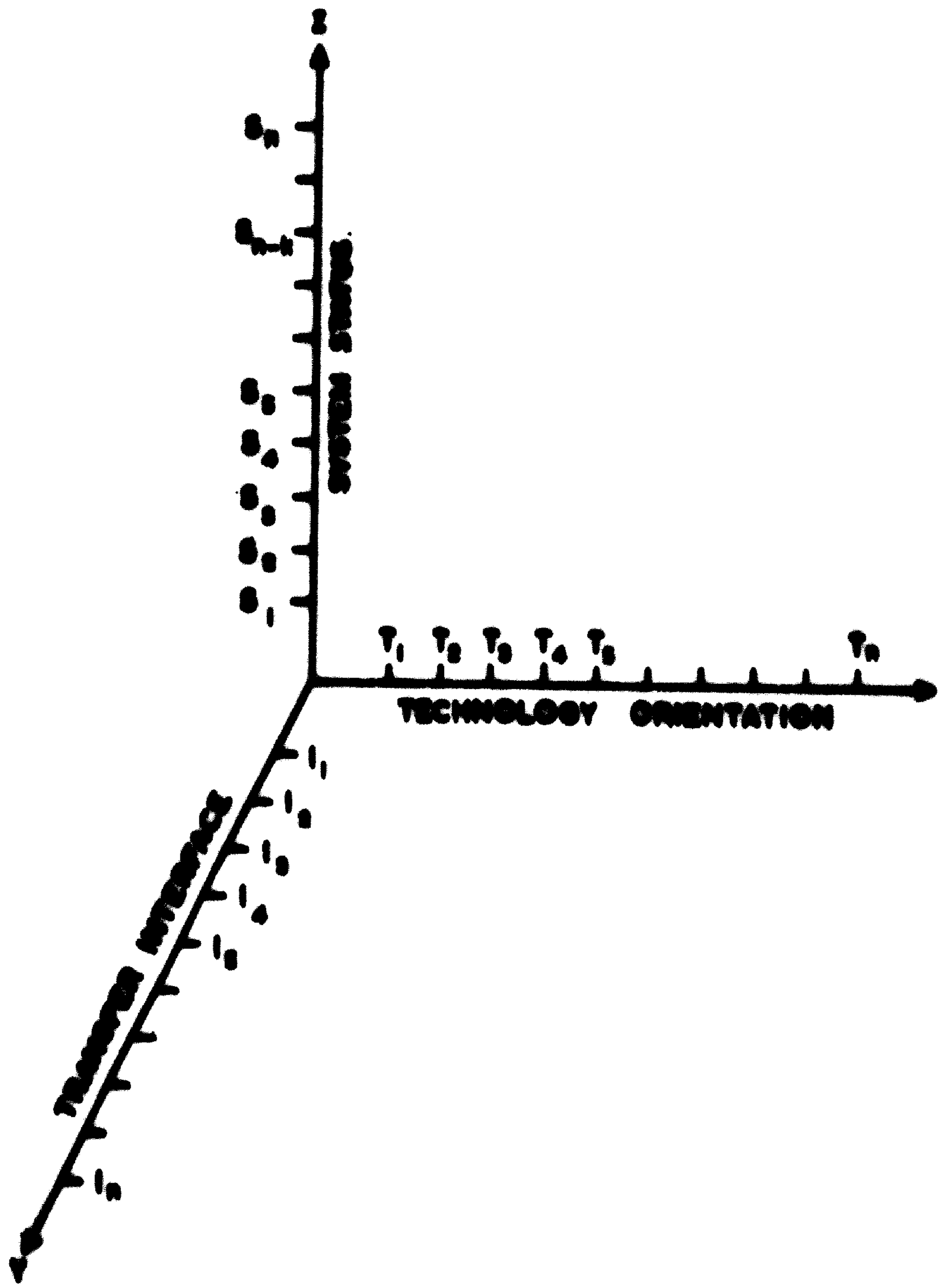


FIGURE I TRUE DIMENSIONS OF APPROPRIATE TECHNOLOGY

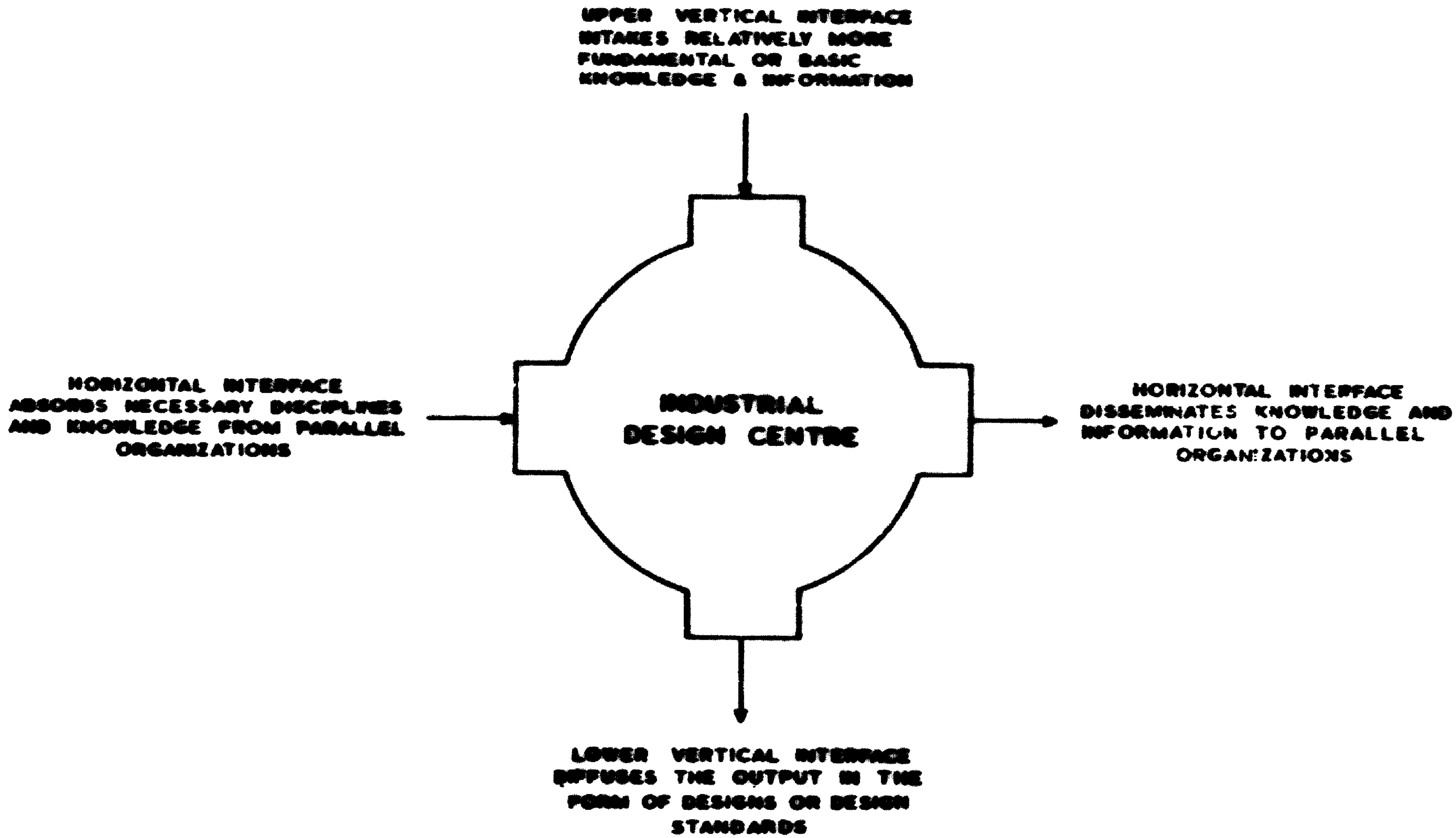


FIGURE 2 THE TECHNOLOGY TRANSFER INTERFACE SYSTEM

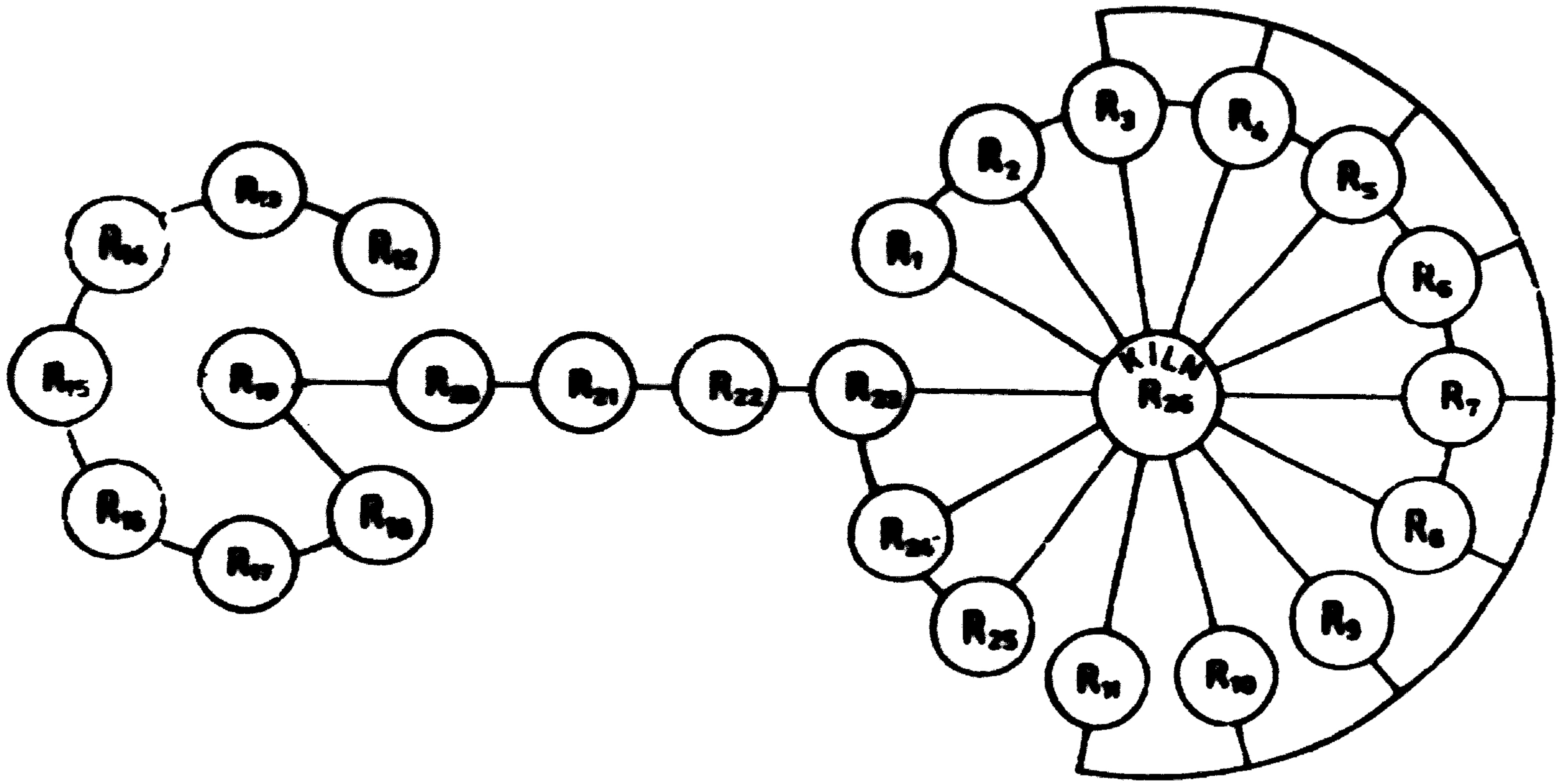
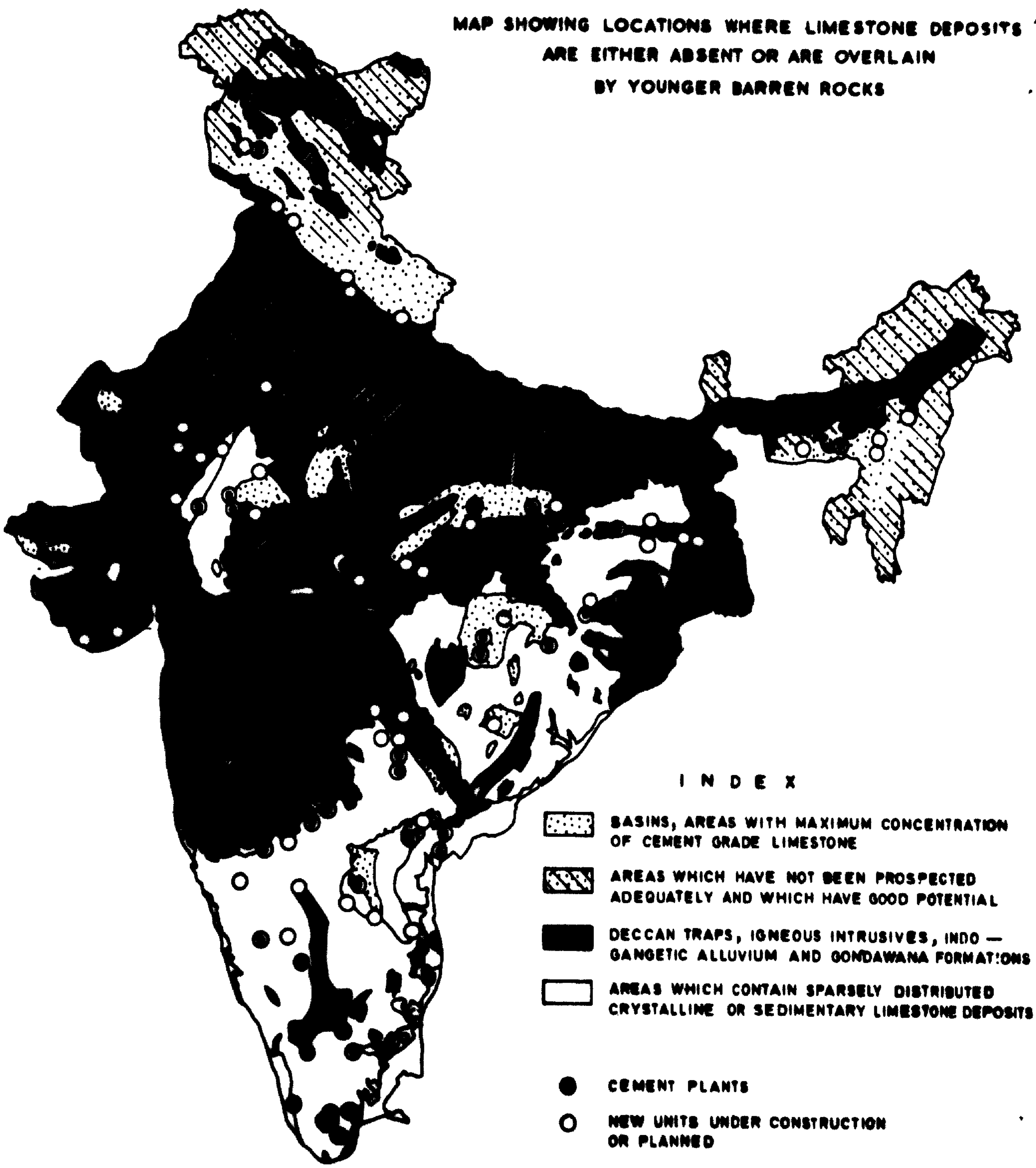


FIGURE 3 INTER-RELATIONSHIPS IN VERTICAL SHAFT CEMENT KILN

FIG. 4

MAP SHOWING LOCATIONS WHERE LIMESTONE DEPOSITS ARE EITHER ABSENT OR ARE OVERLAIN BY YOUNGER BARREN ROCKS



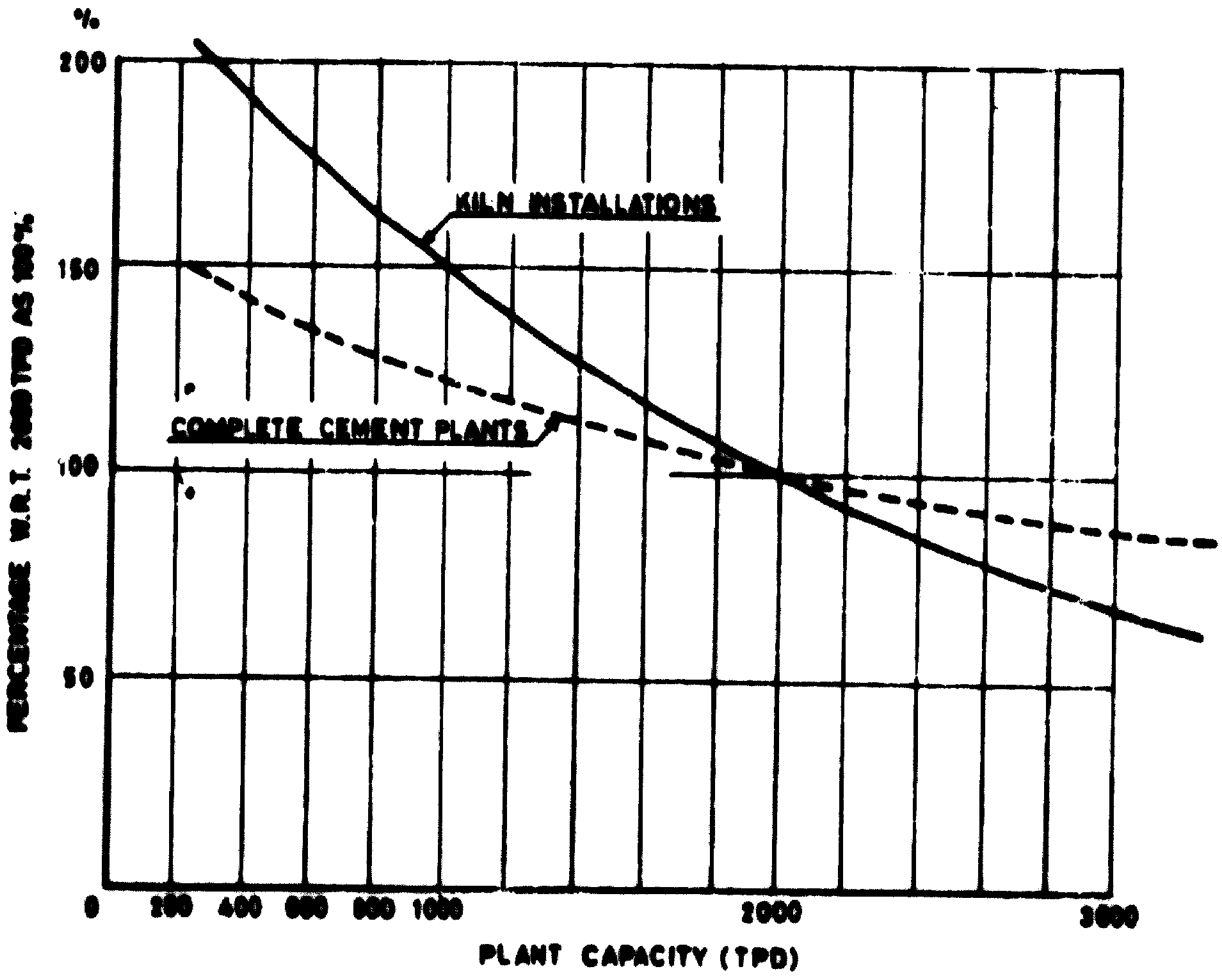


FIGURE 5 CAPITAL INVESTMENT COSTS

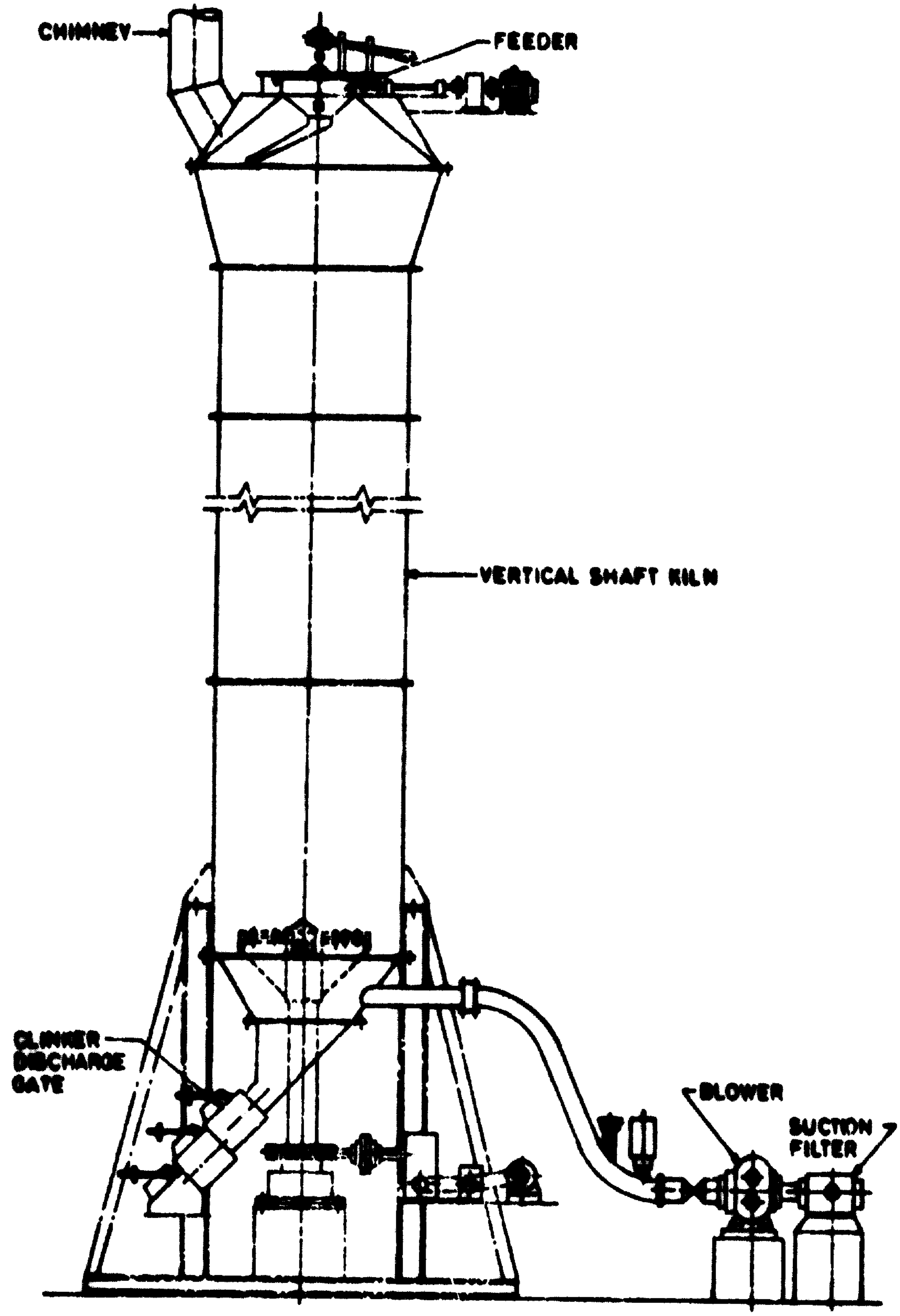


FIG. 6 GENERAL ARRANGEMENT OF CRI TYPE VERTICAL SHAFT KILN FOR VISVAKARMA MINI CEMENT PLANTS

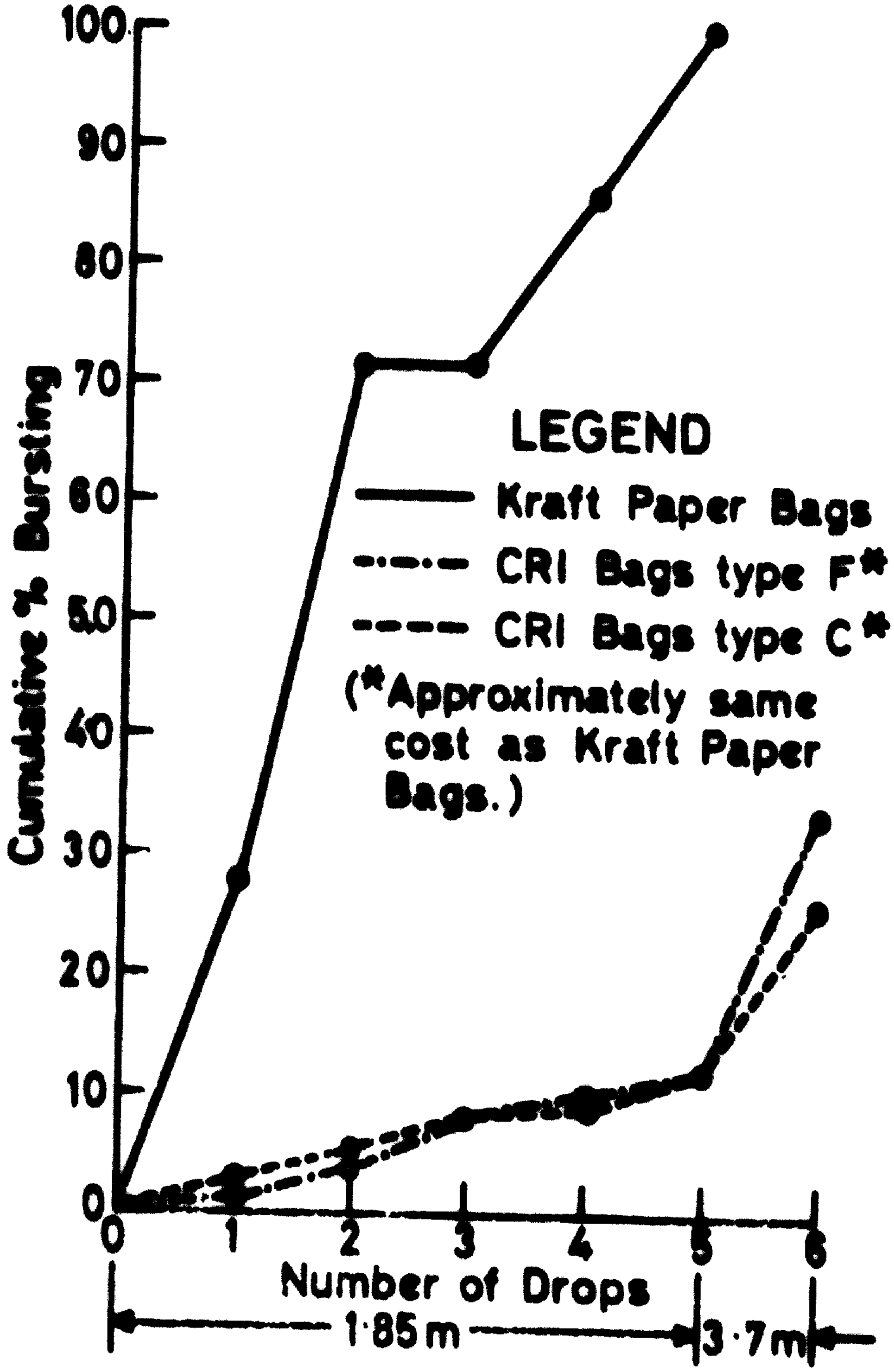


FIGURE 7 COMPARATIVE PERFORMANCE OF CRI BAGS VIS-A-VIS KRAFT PAPER BAGS USED IN ADVANCED COUNTRIES

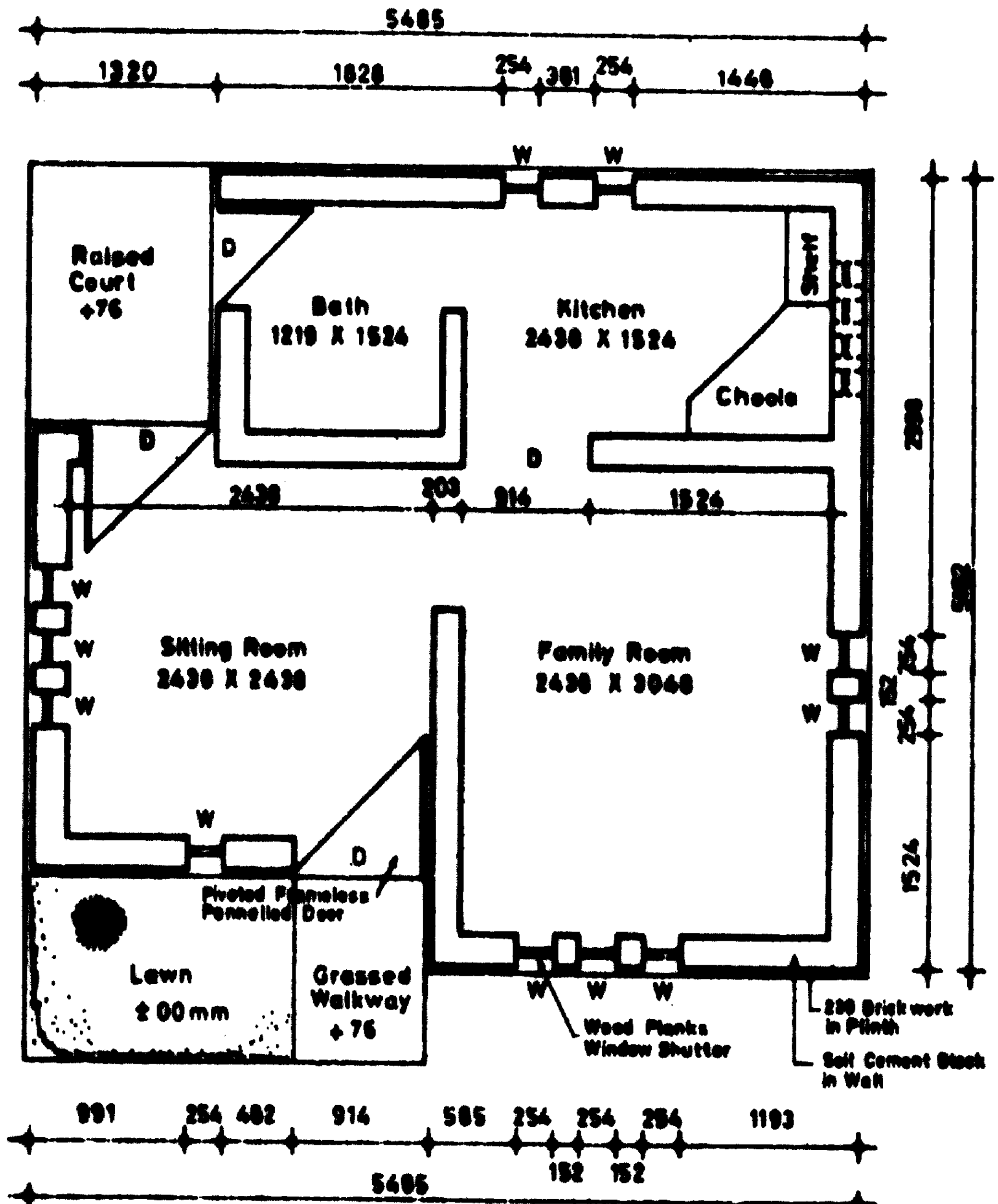
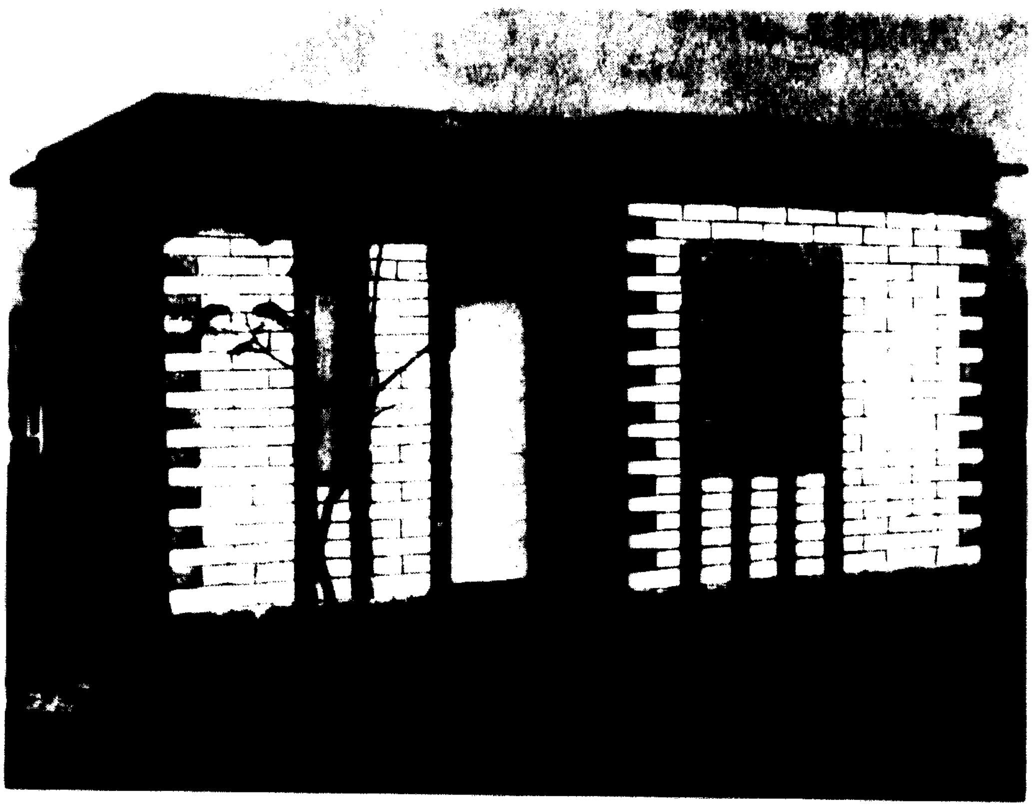


Fig. 8. CRI RURAL HOUSE



PERSPECTIVE VIEW OF CRI LOW COST HOUSE

Annexure I

ESTIMATES OF CAPITAL COSTS

of a 50 tpd Mini Cement Plant (CRI-Type) - Situation B

Sl No	Item	Cost (Rs/Lakhs)
A	Land	0.90
B	Civil Works	
B.1	Civil Engineering Infrastructure	0.97
B.2	Buildings and structures	16.61
B.3	Contingencies	0.88
	SUB TOTAL (B)	18.46
C	Machinery & Equipment	
C.1	Cost of Equipment as erected	55.74
C.2	Contingencies	1.67
	SUB TOTAL (C)	57.41
D	Projecting Costs	
D.1	Preliminary expenses	1.50
D.2	Engineering of Project	
	i/ Detailed project report	0.75
	ii/ Detailed engineering	5.00
	iii/ Supervision during construction, erection, start-up and commissioning	1.50
D.3	Training expenses	0.25
D.4	Start-up expenses	1.00
D.5	General construction charges	2.25
D.6	Interest on capital held up during construction period	3.66
	SUB TOTAL (D)	15.91
E	Fixed capital cost ('A' to 'D')	92.68
F	Initial spares	2.22
G	Capital cost ('E' + 'F')	94.90

EQUITY CAPITAL	35%	= 33.22 Lakhs
LONG TERM LOAN (Carrying interest at 9.5% per annum)	65%	= 61.68 Lakhs

Annexure II

WORKING CAPITAL REQUIREMENT

for a 50 tpd Mini Cement Plant (CRI-Type) - Situation B

Sl No	Item	Inventory period	Quantity	Unit Rate	Amount (Rs/Lakhs)
1	Raw Materials				
	1.1 Limestone	3-months	4692 (t)	20.45	0.96
	1.2 Clay	1.5-months	497 (t)	6.25	0.03
	1.3 Coke breeze	4-months	984 (t)	203.79	2.01
	1.4 Gypsum	2-months	125 (t)	109.18	0.14
2	Utilities				
	2.1 Power	1-month	159333 (KWH)	0.24	0.38
	2.2 Water	-	-		-
3	Stores & Consumables	1-month			0.10
4	Salaries & Wages	1-month			0.71
5	Repairs & Maintenance	2-months			0.24
6	Overheads	1-month			0.10
7	Insurance Charges	3-months			0.10
8	Stock of Inventory				
	8.1 Goods in process upto clinker	15-days	675 (t)	125.04	0.84
	8.2 Finished goods upto naked cement	7-days	324 (t)	182.11	0.59
9	Packing Material	1-month	25500 (Bags)	1.59	0.41
					6.61

MARGIN MONEY (EQUITY)	40%	- Rs 2.64 Lakhs
SHORT-TERM LOAN	60%	- Rs 3.97 Lakhs

RATE OF INTEREST 15%

Annexure III

ANNUAL COST OF PRODUCTION OF CEMENT

in a 50 tpd Mini Cement Plant (CRI-Type) - Situation B

4TH YEAR OF OPERATION (90% - 15296 TONNES OF CEMENT) (330 WORKING DAYS/YEAR)

Sl No	Item	Unit	Consumption factor per tonne of cement	Annual requirement	Rate/Unit (Rs)	Total Amount (Rs/Lakh)	Amount per tonne of cement (Rs)
1	Raw Materials :						
1.1	Limestone	tonne	1.227	18768	20.45	3.84	25.09
1.2	Clay	tonne	0.260	3997	6.25	0.25	1.62
1.3	Coke Breeze	tonne	0.193	2952	203.79	6.02	39.33
1.4	Gypsum	tonne	0.049	750	109.18	0.82	5.35
2	Power	KWH		1912000	0.24	4.59	30.00
3	Stores & Consumables					1.22	8.00
4	Salaries & Wages					8.46	55.31
5	Repairs & Maintenance					1.44	9.41
6	Overhead Expenses						
6.1	Manufacturing					0.61	4.00
6.2	Administrative					0.61	4.00
7	Depreciation of fixed assets					5.22	34.13
8	Amortization of projecting cost					1.37	8.96

Sl No	Item	Unit	Consumption factor per tonne of cement	Annual requirement	Rate/Unit (Rs)	Total Amount (Rs/Lakh)	Amount per tonne of cement (Rs)
9	Insurance charges					0.39	2.55
10	<u>Financial Expenses</u>						
10.1	Interest on long term loan @ 9.5% p a					2.93	19.16
10.2	Interest on short term loan @ 15% p a					0.60	3.92
11	Cost of production of naked cement					38.37	250.83
	Add payment to Research Account					0.08	0.50
						38.45	251.33
12	Selling overhead expenses					0.46	3.00
13	Total cost of sales					38.91	254.33

Annexure IV

BREAK-EVEN ANALYSIS

for a 50 tpd Mini Cement Plant (CRI-Type) Situation B

Sl No	Item	Amount
1	Sales quantity (tonne/year)	15296.00
2	Net sales realisation per tonne of cement	314.75
3	Annual Cost of Production :	
A	Fixed elements : (Rs/lakhs)	
	i/ Power	4.59
	ii/ Salaries & Wages	8.46
	iii/ Stores & Consumables (25%)	0.30
	iv/ Repairs & Maintenance (75%)	1.08
	v/ Overhead Expenses	1.22
	vi/ Depreciation	5.22
	vii/ Insurance	0.39
	viii/ Amortization of Projecting Costs	1.37
	ix/ Financial Expenses	
	a/ Interest on long-term loan	2.93
	b/ Interest on short-term loan	0.60
	TOTAL	26.16
B	Variable Elements : (Rs/lakhs)	
	i/ Raw Materials	10.93
	ii/ Stores & Consumables (75%)	0.92
	iii/ Repairs & Maintenance(25%)	0.36
	iv/ Selling Expenses	0.46
	TOTAL	12.67

Total of variable components of production cost/tonne = 82.83

$$\text{Break-even point} = \frac{\text{Total of fixed components of production cost}}{\text{(Net sales realisation/tonne - total variable cost/tonne)}} \times \frac{100}{\text{Normal capacity}}$$

$$= \frac{26,16,000}{314.75-82.83} \times \frac{100}{15,296}$$

$$= 73.7\%$$

ESTIMATES OF COST OF PRODU[illegible]

FOR A 50 TPD MINI CEMENT P[illegible]

SNo	YEARS OF OPERATION	I	II	III	IV
	PRODUCTION (QUANTITY IN TONNES)	111[illegible]	13483	15182	[illegible]
	ITEMS	Rs/LAKHS	Rs/LAKHS	Rs/LAKHS	Rs/LAKH[illegible]
1	RAW MATERIALS:-				
	a DOMESTIC	3·56	4·32	4·86	4·[illegible]
	b IMPORTED	—	—	—	—
2	FUEL AND POWER	8 18	9 85	10·57	10·6[illegible]
3	STORES AND CONSUMABLES	1 14	1·22	1·22	1·2[illegible]
4	WAGES AND SALARIES	7·90	8·46	8·46	8·4[illegible]
5	REPAIRS AND MAINTENANCE	1·34	1·44	1 44	1 44
6	OTHER INPUTS (IF ANY) (a) PACKING CHARGES	—	—	—	—
	(b) OTHER WORKS EXPENSES	0·57	0·61	0·61	0·61
7	RENT TAXES AND INSURANCE ETC.	0·36	0·39	0·39	[illegible]·39
8	INTEREST ON (a) WORKING CAPITAL	0·60	0 60	0·60	—
	(b) LONG TERM LOAN	5·86	5·51	4·73	4 10
9	DEPRECIATION	12·40	10·15	8 34	6 [illegible]
10	AMORTIZATION OF PROJECTING COST	1·37	1·37	1·37	1·3[illegible]
11	OTHER ADMINISTRATIVE EXPENSES	0·57	0·61	0·61	0·61
12	SELLING EXPENSES	0·43	0·46	0·46	0·4[illegible]
	A TOTAL MANUFACTURING EXPENSES	44·28	44 99	43 66	41·0[illegible]
	SALES (QUANTITY AND VALUE)	(1103 t) 34·95	(13483 t) 42·44	(15182 t) 47·79	(1529[illegible] 48·1[illegible]
	OTHER INCOME	—	—	—	0 [illegible]
	B TOTAL INCOME	34·95	42·44	47·79	48 [illegible]
	OPERATING PROFIT (B-A)	- 9·33	-2·55	4·13	7 1[illegible]
	LESS TAXATION	—	—	—	—
	" INVESTMENT ALLOWANCE RESERVE	—	—	—	2·9[illegible]
	NET PROFIT	- 9·33	-2·55	4·13	4·2[illegible]

ANNEXURE V

S OF COST OF PRODUCTION AND FROFITABILITY

FOR A 50 TPD MINI CEMENT PLANT (CRI-TYPE) SITUATION B

II	III	IV	V	VI	VII	VIII	IX	X
483	15182	15296	15296	15296	15296	15296	15296	15296
/Lakhs	Rs/Lakhs	Rs/Lakhs	Rs/Lakhs	Rs/Lakhs	Rs/Lakhs	Rs/Lakhs	Rs/Lakhs	Rs/Lakhs
·32	4·86	4·91	4·91	4·91	4·91	4·91	4·91	4·91
—	—	—	—	—	—	—	—	—
65	10·57	10·61	10·61	10·61	10·61	10·61	10·61	10·61
22	1·22	1·22	1·22	1·22	1·22	1·22	1·22	1·22
46	8·46	8·46	8·46	8·46	8·46	8·46	8·46	8·46
44	1·44	1·44	1·44	1·44	1·44	1·44	1·44	1·44
—	—	—	—	—	—	—	—	
·61	0·61	0·61	0·61	0·61	0·61	0·61	0·61	0·61
39	0·39	0·39	0·39	0·39	0·39	0·39	0·39	0·39
60	0·60	—	—	—	—	—	—	—
51	4·73	4·10	3·52	2·93	2·34	1·76	1·17	0·58
·15	8·34	6·84	5·68	5·03	4·19	3·48	3·39	2·90
37	1·37	1·37	1·37	1·37	1·37	1·37	1·37	1·37
61	0·61	0·61	0·61	0·61	0·61	0·61	0·61	0·61
46	0·46	0·46	0·46	0·46	0·46	0·46	0·46	0·46
4·99	43·66	41·02	39·28	38·04	36·61	35·33	34·64	33·57
483 t) 2·44	(15182 t) 47·79	(15296 t) 48·14	(15296 t) 48·14	(15296 t) 48·14	(15296 t) 48·14	(15296 t) 48·14	(15296 t) 48·14	(15296 t) 48·14
-	-	0·03	0·23	0·17	0·20	0·61	1·04	1·06
2·44	47·79	48·17	48·37	48·31	48·34	48·75	49·18	49·20
2·55	4·13	7·15	9·09	10·27	11·73	13·43	14·54	15·68
—	—	—	—	—	—	—	6·54	7·75
—	—	2·94	8·09	3·72	—	—	1·14	—
2·55	4·13	4·21	1·00	6·55	11·73	13·43	6·86	7·93

CASH FLOW STATEMEN

FOR A 50 TPD MINI CEMENTPLANT (CRI-TYPE: SITU

S.No	ITEM	CONSTRUCTION PERIOD	YEAR I	YEAR II	YEA III
(A)	**SOURCES OF FUNDS**				
1	Net Profit before taxes with interest added after depreciation and investment allowance.	–	-2.87	3.56	9.4
2	Increase in Share Capital (i) Equity (ii) Preference	35.86	– –	 –	
3	Depreciation	–	12.40	10.15	8 3
4	Investment allowance	–	–	–	–
5	Increase in long term loan/ debentures	61.68	–	–	
6	Increase in deferred payment facilities	–	–	–	–
7	Increase in unsecured loans and deposits	–	–	–	–
8	Increase in bank borrowings for working Capital	3.97	–	–	–
9	Sales of fixed assets/ investments	–	–	–	–
10	other item – Amortisation of projecting Cost.	–	1.37	1.37	1.3
	TOTAL 'A'	101.51	10.90	15.08	19.1
(B)	**DISPOSITION OF FUNDS**				
1	Projecting Cost	13.66	–	–	–
2	Increase in Capital expenditure	81.24	–	–	–
3	increase in current assets/ inventories/ others	5.14	0.74	0.13	–
4	Decrease in long term loan / Debentures	–	3.70	8.24	6.5
5	Decrease in Unsecured loan/ Deposits	–	–	–	–
6	Decrease in deferred payment facilities	–	–	–	–
7	Decrease in bank borrowing for Working Capital	–	–	–	[illegible]
8	Increase in investments	–	–	–	–
9	interest	–	6.46	6.11	5.3
10	Taxation	–	–	–	
11	Dividend on Equity (amount and rate)	–	–	–	2.8 (8%
12	Other Expenses				
	TOTAL 'B'	100.04	10.90	15.08	18.
(C)	OPENING BALANCE	–	1.47	1.47	1.4
(D)	NET SURPLUS (A – B)	1.47	–	–	0.4
(E)	CLOSING BALANCE.	1.47	1.47	1.47	1.9

ANNEXURE VI

CASH FLOW STATEMENT

FOR A 50 TPD MINI CEMENTPLANT (CRI-TYPE) SITUATION B

	CONSTRU-CTION PERIOD	YEAR I	YEAR II	YEAR III	YEAR IV	YEAR V	YEAR VI	YEAR VII	YEAR VIII	YEAR IX	YEAR X
... added after depreciation and investment	—	-2.87	3.56	9.46	7.33	2.39	9.24	14.07	15.19	14.19	16.26
Equity / Preference	35.86	—	—	—	—	—	—	—	—	—	—
	—	12.40	10.15	8.34	6.84	6.68	5.03	4.19	3.48	3.39	2.90
	—	—	—	—	3.92	10.22	4.96	—	—	1.52	—
...ntures	61.68	—	—	—	—	—	—	—	—	—	—
...acilities	—	—	—	—	—	—	—	—	—	—	—
...nd deposits	—	—	—	—	—	—	—	—	—	—	—
...or Working Capital	3.97	—	—	—	—	—	—	—	—	—	—
...ents	—	—	—	—	—	—	0.94	—	—	0.99	—
... projecting Cost.	—	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.33
TOTAL 'A'	101.51	10.90	15.08	19.17	19.46	19.66	20.54	19.63	20.04	21.06	20.49
	13.66	—	—	—	—	—	—	—	—	—	—
	81.24	—	—	—	—	—	3.72	—	—	4.35	—
...ventories/ others	5.14	0.74	0.73	—	—	—	—	—	—	—	—
...ebentures	—	3.70	8.24	6.57	6.17	6.17	6.17	6.17	6.17	6.17	[illegible]
...Deposits	—	—	—	—	—	—	—	—	—	—	—
... facilities	—	—	—	—	—	—	—	—	—	—	—
...for Working Capital	—	—	—	3.97	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—
	—	6.46	6.11	5.33	4.10	3.32	2.98	2.34	1.73	1.17	[illegible]
	—	—	—	—	—	—	—	—	—	6.54	[illegible]
...and rate)	—	—	—	2.87 (8%)	2.87 (8%)	2.87 (8%)	3.59 (10%)	4.30 (12%)	[illegible]	[illegible]	[illegible]
TOTAL 'B'	100.04	10.90	15.08	18.74	13.14	12.56	16.41	12.81	12.95	[illegible]	[illegible]
	—	1.47	1.47	1.47	1.90	8.22	15.32	19.45	26.27	33.36	30.45
	1.47	—	—	0.43	6.32	7.10	4.13	6.82	7.09	-2.91	-0.44
	1.47	1.47	1.47	1.90	8.22	15.32	19.45	26.27	33.36	30.45	30.01

ANNEXURE VII

EXPECTED BENEFITS/ COSTS OF THE PROJECT
(Based on the 4th Year of operation)
For 50 TPD MINI CEMENT PLANT (CRI-TYPE) - SITUATION B

(A)	**OUT PUT AND PROFITS (Rs/lakhs)**		
1	CAPACITY OUT PUT (2 SHIFTS)		53.49
2(a)	VALUE OF OUT PUT (NET OF EXCISE DUTY)		48.14
(b)	OTHER INCOME		—
3	VALUE OF OUT PUT AS PERCENTAGE OF 1		90%
4	CHANGE IN THE STOCK OF GOODS		—
5	SALES (AT FACTORY PRICE), (2a-4)		48.14
6	RAW MATERIALS :-		
	(a) DOMESTIC		4.91
	(b) IMPORTED		—
7	FUEL AND POWER		13.61
8	**OTHER INPUTS (specify)**		
	(a) STORES AND CONSUMABLES	1.22	
	(b) RENT, TAXES AND INSURANCE	[illegible]	
	(c) OTHER WORKS EXPENSES	0.81	3.66
	(d) PACKING CHARGES	—	
	(e) REPAIRS AND MAINTENANCE	1.44	
9	GROSS VALUE ADDED (5-(6+7+8))		28.96
10(a)	DEPRECIATION	5.22	
(b)	AMORTIZATION OF PROJECTING COST	1.37	6.59
11	NET VALUE ADDED (9-10)		22.37
12	a) WAGES AND SALARIES		8.46
	b) ADMINISTRATIVE EXPENSES		0.61
	c) SALES EXPENSES		0.46
13	INTEREST		2.53
14	ROYALTY		—
15	GROSS PROFIT AND INTEREST (9-12)		19.43
16	OPERATING PROFIT [15-(10+13+14)]		9.31
17	TAX		5.38
18	NET PROFIT (16-17)		3.93
(B)	**PRODUCTIVE CAPITAL (Rs/Lakhs)**		
1	GROSS FIXED ASSETS		94.10
2	INVENTORIES		6.61
3	CAPITAL EMPLOYED (1+2)		101.51
4	NUMBER OF WORKERS		77
(C)	**CAPITAL OUT PUT RATIO**		
1	CAPITAL/VALUE OF OUT PUT (B3/A2)		2.11 : 1
2	CAPITAL/GROSS VALUE ADDED (B3/A9)		3.51 : 1
3	CAPITAL/NET VALUE ADDED (B3/A11)		4.54 : 1
4	CAPITAL PER WORKER (B3/B4) (Rs/LAKHS)		1.32
5	CAPITAL/WAGES AND SALARIES (B3/A12 a)		12.00 : 1
(D)	**PRODUCTIVITY INDICATORS (Ratio)**		

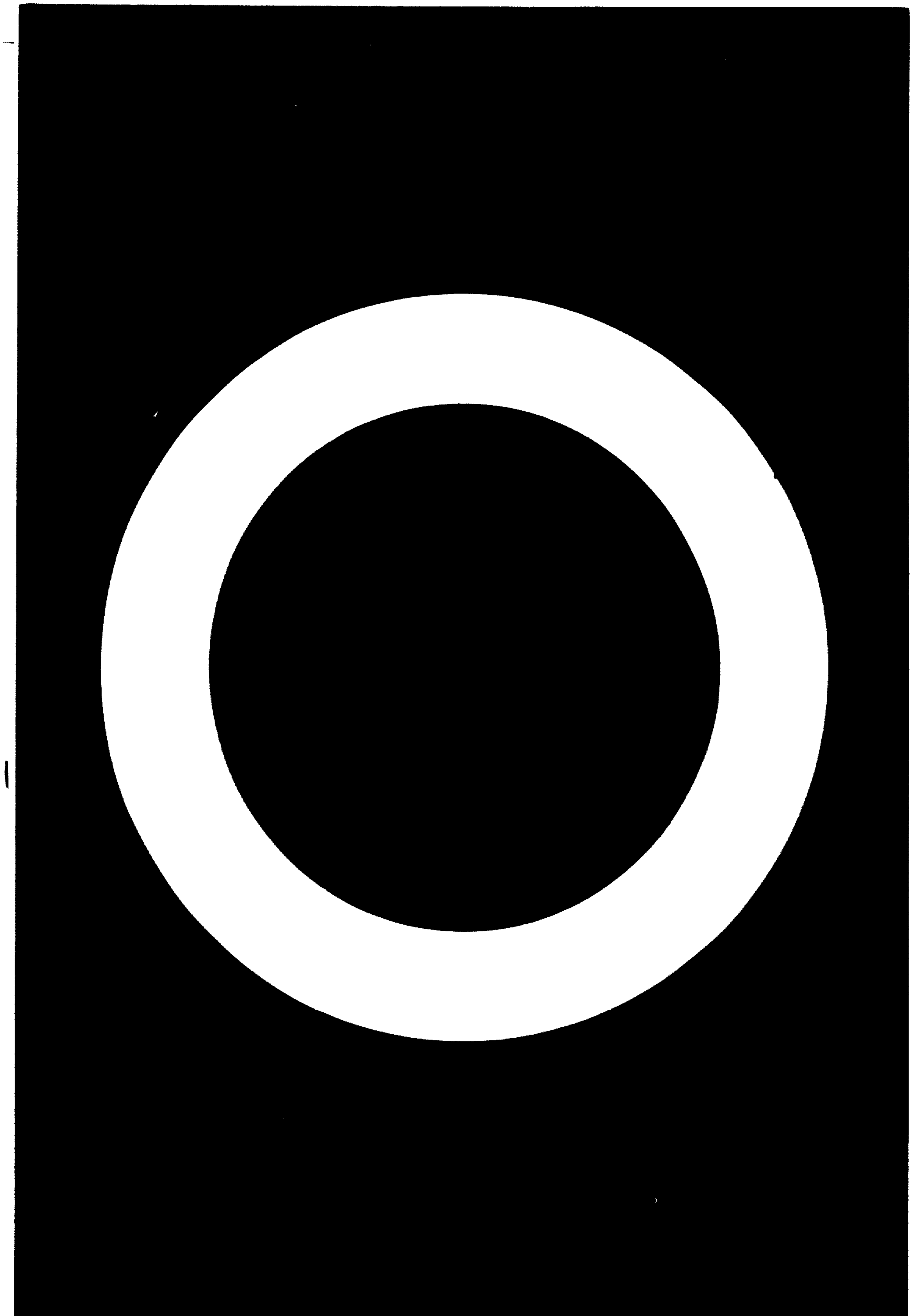
	[illegible]	[illegible]
13	INTEREST	2 [illegible]3
14	ROYALTY	—
15	GROSS PROFIT AND INTEREST (9-12)	19·43
16	OPERATING PROFIT [15-(10+13+14)]	9·31
17	TAX	5·38
18	NET PROFIT (16-17)	3 93
(B)	PRODUCTIVE CAPITAL (Rs/Lakhs)	
1	GROSS FIXED ASSETS	94 10
2	INVENTORIES	6 61
3	CAPITAL EMPLOYED (1+2)	101 51
4	NUMBER OF WORKERS	77
(C)	CAPITAL OUT PUT RATIO	
1	CAPITAL/VALUE OF OUT PUT (B3/A2)	2·11 : 1
2	CAPITAL/GROSS VALUE ADDED (B3/A9)	3·51 : 1
3	CAPITAL/NET VALUE ADDED (B3/A11)	4·54 : 1
4	CAPITAL PER WORKER (B3/B4) (Rs./LAKHS)	1 32
5	CAPITAL/WAGES AND SALARIES (B3/A12 a)	12·00 : 1
(D)	PRODUCTIVITY INDICATORS (Ratio)	
1	PRODUCTIVITY PER UNIT OF CAPITAL (A2/B3)	0·47 : 1
2	PRODUCTIVITY PER UNIT OF LABOUR (A2/B4)	0·63 : 1
3	PRODUCTIVITY PER UNIT OF WAGES & SALARIES (A2/A12 a)	5·69 : 1
(E)	INPUT STRUCTURES (Proportion percent)	
1	RAW MATERIALS/VALUE OF OUT PUT (A6/A2)	10·2 %
2	FUEL AND POWER/VALVE OF OUT PUT (A7/A2)	22·0 %
3	OTHER INPUTS/VALUE OF OUT PUT (A8/A2)	7·6 %
4	WAGES AND SALARIES/VALUE OF OUT PUT (A12 a/A2)	17·6 %
5	DEPRECIATION/VALUE OF OUT PUT (A10/A2)	13·7 %
6	INTEREST/VALUE OF OUT PUT (A13/A2)	7·3 %
7	ADMINISTRATIVE EXPENSES/VALUE OF OUT PUT (A12b/A2)	1 3 %
8	SALES EXPENSES/VALUE OF OUT PUT (A12c/A2)	1 0 %
9	OPERATING PROFIT/VALUE OF OUT PUT (A16/A2)	19·2 %
(F)	PROFITABILITY RATIO (Proportion Percent)	
1	GROSS PROFIT + INTEREST/CAPITAL EMPLOYED (A15/B3)	19 1 %
2	OPERATING PROFIT + INTEREST/CAPITAL EMPLOYED (A16+A13/B3)	12 6 %
3	OPERATING PROFIT/SALES (A16/A5)	19·2 %
4	NET PROFIT/EQUITY CAPITAL (A18/35 [illegible])	11·0 %
5	RATE OF DIVIDEND ON EQUITY SHARES — YEAR / %	1: -% ; 2: -% ; 3: 8% ; 4: 8% ; 5: 8% ; 6: 10% ; 7: 12% ; 8: 14% ; 9: 16% ; 10: 18%
(G)	REPAYMENT CAPACITY	
1	GROSS PROFIT LESS ROYALTY [A15-(A13+A14)] (RS Lakhs)	15·90
2	TAX PROVISION A 17	5·38
3	REPAYING CAPACITY (G1-G2)	10·52
*	NET SALES REALISATION PER TONNE HAS BEEN TAKEN AS Rs 314·75 WHICH	
	IS ARRIVED AT AS UNDER :- Rs TONNE	
	REVISED RETENTION PRICE 296·00	
	LESS REST [illegible] 0·5[illegible]	

295 [illegible]

Add 25[illegible] [illegible] 16 25

3 [illegible]

[illegible]



ANNEXURE VIII

THIS DOCUMENT HAS BEEN PREPARED BY THE STAFF OF CEMENT RESEARCH INSTITUTE OF INDIA UNDER THE GUIDANCE OF ITS DIRECTOR GENERAL AND VETTED BY AN EXPERT WORKING GROUP COMPRISING :

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Sh L SWAROOP Vice President (Operations) Dalmia Cement (Bharat) Ltd.	Member
Sh K P BANERJEE Dy General Manager (R & D) Larsen & Toubro Ltd.	Member
Dr S G BHATTACHARYA Industrial Advisor Bureau of Industrial Costs & Prices	Member
Sh K V A THAMPURAN Chief Engineer (Designs) The K C P Ltd.	Member
Sh J N RATHI General Manager Century Cement	Member
Sh B S RANGNEKAR Controller (R & D) Associated Cement Companies Ltd.	Member
Dr G M PANDYA Secretary Cement Manufacturers Association	Member

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