Ch'eng-kuan Commune

Flour Mill: milling charge is based mainly on power consumption

Hsin-hsiang C. Ch'i-li-ying Commune agricultural machine station

Batch production of power tillers; engines purchased for 700 yuan from Hsin-hsiang ti-ch'ü #2 diesel engine pl.; engine is model 195 12 h.p. diesel, 150 kg., 2000 rpm.; same engine used in Lin C., slightly less expensive here

Ch'i-li-ying: processing fee at flour mill 0.01 yuan/kg.

Commune machine shop produces seeder, price fixed "by the brigade" at 35 yuan

Commune grain storehouse: price for grain sold to the state is 0.13 yuan (presumably per catty)

Briefing at production brigade: grain milling fee is .01 yuan per chin (contradicts above? different mill?); no fee for cotton ginning because all cotton is sold to the state

Selling price for grain: Q. Has it gone up since 1962? A. Basically no, but there have been readjustments

Wu-hsi County Iron-Steel Plant

1974 gross output value was "over 9 million yuan"; output consisted of 10,000 tons each of steel ingots and rolled steel (reinforcing bars and angle irons); value of both products was included in calculating overall gross output value; therefore average price of all products was approximately 9 million/20,000 = 450 yuan/ton

Therefore assuming that angle irons were produced in small quantity (we saw none being produced or on hand) and/or that their price is similar to that of reinforcing rods, the price of steel ingots may be calculated at 400 yuan/ton

Electric power—average cost .07 yuan/kwh

Conversations in Wu-hsi

Moped (motor bicycle) about 250 yuan

Power tiller about 2000 yuan

Wu-hsi Clay Figurine Plant: Gross value: 37 million yuan for 7 million figurines, so the average ex-factory price is about 0.43 yuan

Shanghai Shaped Steel Tube Plant

1974 gross output value 15 million yuan; processed 9000 tons of all metals, therefore the average price of their output is 1667 yuan/ton; output seems to consist mainly of steel tubes, but also includes aluminum, copper and brass

Shanghai Ma-lu Commune

Machine shop manufactures diesel engines for which the price is 550 yuan/set; this is model 1E65F air-cooled 1 cylinder diesel, 3.5 h.p., 2000 rpm., weighing 38 or 42 kg. depending on the materials used

Shanghai Chia-ting County Agricultural machine repair and manufacturing plant

Producing rice transplanters (1260 units "so far" this year); price (without engine) is 1000 yuan per set

Ma-lu Commune

Grain and cotton purchase prices have not risen in recent years

Visit to street committee

Price data obtained in family visits:
rice: 16.5 fen/catty (Grade 1); 14 fen (Grade 2)
pork: 0.9 yuan/catty

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Published by:
Intermediate Technology Publications, Ltd.
9 King Street
London WC2E 8HN
United Kingdom

Paper copies are 1.60 British pounds

Available from:
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SMALL SCALE CEMENT PLANTS

A STUDY IN ECONOMICS by JON SIGURDSON

Small scale cement plants have recently been attracting more and more attention from international agencies and industrial economists concerned with rural development. In China there are more than 2800 active small scale plants and more than 200 in Europe (Spain, Yugoslavia, France, Germany and Italy). This booklet examines the criteria which would justify the establishment of mini cement plants in developing countries and specifically compares the situation in India with that in China, where more than 57% of cement is produced by small plants.

The quality of the cement produced is also discussed and comparisons are drawn between cement from mini cement plants and that of portland cement. A short bibliography is provided as well as designs of vertical shaft kilns taken from a Chinese book on small scale cement plants.

Jon Sigurdson, the author, is presently Research Fellow, Engineering, at the Scandinavian Institute of Asian Studies in Copenhagen, Denmark. He is also the author of a monograph, *Rural Industrialisation in China*.

ISBN 0 903031 46 9

Intermediate Technology Publications Ltd

Small Scale Cement Plants

by Jon Sigurdson

Published 1977

9 King Street, London WC2E 8HN, U.K.
ISBN 0 903031 46 9
Exclusive Distributor:
ISBS, Inc.
P. O. Box 555
Forest Grove, OR 97116

Contents

List of Illustrations

ACKNOWLEDGEMENTS

The printing and publication of this booklet has been made possible by a generous donation from the Claremont Trust. The Intermediate Technology Development Group gratefully acknowledges their generosity.

The illustrations on pages 21-24 are based on diagrams from *Small Scale Cement Factories: Equipment and Construction* (Xiao xing shuinichang shebei anshuang), compiled by Ren Fuquan, published and printed by the Chinese Building Industry Press, Peking, China (first published 1959, second edition October 1973). Table 6 and Diagram B are taken from *Small (Scale) Cement Manufacture*, Hunan People's Publishing House, 1974.

The translation of the captions to this material was made by Alison Bailey. The illustrations were re-drawn by Peter Trounce.

Introduction

This is the first of a series of occasional papers which, it is hoped, may prove useful to planners and decision makers, to government ministries and businessmen who may be involved in rural and urban development.

While this particular paper deals with the economics, the policy and the infrastructure necessary for small scale cement plants to succeed, other papers will deal not only with economic analysis of appropriate technologies but will touch on wider issues of development in poor countries.

These are not technical papers: while they do include a general description of the technology, they concentrate on the social and economic aspects that are involved.

The publication of this paper is particularly timely because the Intermediate Technology Development Group is currently involved in a project to set up a commercial pilot plant in India to produce 25 tons of portland cement a day, in association with the Appropriate Technology Development Association of India.

Jon Sigurdson, the author, is presently Research Fellow, Engineering, at the Scandanavian Institute of Asian Studies in Copenhagen, Denmark. He is also the author of a monograph, *Rural Industrialisation in China.*

Mini Cement Plants

Mini cement plants have recently attracted attention from international agencies and from industrial economists concerned with development. The substantial research carried out by the Cement Research Institute of India and the more recent activities of UNIDO to provide standardized designs is an outcome of this interest.[1]

The global production of cement was 700 million tons in 1974 most of which was produced in rotary kilns. However, approximately 5 per cent came from vertical, usually relatively small kilns, most of which are located in China. The World Cement Directory gives 72 locations in 17 countries – China not included – which together have more than 200 kilns in operation. (See table 1). The majority of the vertical kilns outside China are found in France, Germany, Italy, Spain and Yugoslavia. In addition, more than 2800 small scale cement plants – usually one active kiln each – are today operating in China.

Table 1
Global Survey of Vertical Shaft Kilns

Country	*Number of locations*	*Number of active kilns*	*Capacity (tons 10^3)*	*Production (tons 10^3)*
Algeria	1	1	50	n.a.
Kenya	1	6	700	630
Morocco	1	1	140	116
Rhodesia	1	2	316	269
Zaire	1	4	280	286
Iran	1	2	n.a.	n.a.
Japan	1	10	n.a.	542
Australia	1	2	n.a.	n.a.
Belgium	1	3	n.a.	84
France	7	28	n.a.	n.a.
Germany, West	8	39	n.a.	n.a.
Hungary	1	5	300	n.a.
Italy	24	45	n.a.	n.a.
Poland	1	6	192	148
Spain	14	37	n.a.	n.a.
Switzerland	1	1	55	36
Yugoslavia	7	29	n.a.	n.a.
	72	221	Estimated capacity: 10,000	

Source: World Cement Directory, The European Cement Association, Cembureau, Paris 1972

1. The presentation here is an adaptation from an article *Small Scale Plants in Cement Industry – Use of Vertical Shaft Kiln Technology in China* published in the Economic and Political Weekly (Bombay), Vol.XI, Nos.5-7, Annual Number, February 1976. The study of mini cement plants is part of a larger study of local small scale industry in China which is being published by Harvard University Press – *Rural Industrialization in China*, Cambridge, Mass. USA, 1977. Additional research has been carried out during September and October 1976 at the Research Policy Program, University of Lund, Sweden.

Analysis of Chinese Cement Industry

The US Bureau of Mines has in a recent study pointed out that the Chinese cement industry is becoming a world factor.[1] Current output of more than 40 million metric tons is catching up with the leading industrial countries and is continuing to rise. China manufactures ordinary portland cement as well as portland blast furnace slag cement and pozzolana cement.[2]

The most striking feature of the Chinese cement industry is the recent and rapid introduction of vertical shaft kiln technology which is used in most small scale cement plants. The number of small cement plants, almost all of them located in rural areas, has increased from about 200 in 1965 to more than 2,800 in 1975. Total production from small plants has during the same period increased from roughly 5 million tons to an estimated 25 million tons. So, the average size of such plants has decreased considerably – from about 25,500 tons per year in 1965 to 10,100 tons in 1975.

The annual production of cement has tripled in the period 1965-1975 and now stands at roughly 48 million tons. The share coming from small, rural plants has consequently increased from roughly 35% to 57%. Furthermore, most plants are very small. A number of relatively large small cement plants have also been built during the period. Some more information on this development is provided in table 2.

Table 2
Estimated Production in Small Cement Plants in China

Year	Small plants: *Total number*	Small plants: *Average size (tons)*	Big plant: *Production (million tons)*	Small plant Production (million tons): *Total*	Small plant Production (million tons): *% total production*	Total Production *(million tons)*
1949						0,7
. . .						
1957						6,9
. . .						
1965	200	25,500	9,9	5,1	34	15,0
. . .						
1969				7,9		
1970			15,5	10,4	40	25,9
1971	1,800	7,400	16,9	13,3	44	30,2
1972	2,400	7,400	19,2	17,7	48	36,9
1973	2,800	7,100	19,9	19,9	50	39,8
1974					>50	41,8
1975	>2,800	>10,100	21,6	28,3	57	49,6

1. Wang Kung-ping: *The People's Republic of China – a new industrial power with a strong mineral base.* Bureau of Mines, US Department of the Interior, Washington 1975.
2. *Cement Standards of the World. A Comparative Summary.* Fourth Edition. Cement Research Institute of India, New Delhi 1975.

The purpose of this paper is twofold. First, it describes in a very condensed form some of the reasons for developing mini cement plants in China. Second, an attempt will be made to show that the same technology may not be appropriate in India's economic development (or that of other developing countries) even if justifications for mini cement plants appear to be identical to those in China. That is unless government attitudes and a number of national policies are changed.

The kilns in China's modern small cement plants – usually operated by counties or prefectures – generally have the following features:

1. the feed is uniform nodules obtained from a simple disc nodulizer
2. the kiln is fed more or less continuously by a team of men working on the top of the kiln
3. clinker formation is confined to the upper portion of the kiln
4. draught is usually induced and heat exchange takes place in the lower portion of the kiln
5. clinker discharge is usually discontinuous
6. fuel economy is good because
   a. fuel is being interground into the nodules
   b. there is efficient heat exchange within the kiln
   c. and porous clinkers, which need less energy for grinding

An important consideration may be the fact that the initial smallness of a plant enables the capacity of the plant to grow with the local demand. This may make overall costs lower than if a large capacity plant had been set up from the very beginning.

The production costs in very small plants are initially fairly high, but usually considerably reduced when plant size is increased and the technique is fully mastered. A major reason for achieving comparatively low production costs may possibly be that plants have been constructed using large amounts of idle or scrap equipment. This has then been provided at opportunity costs which have been much lower than if new equipment had been available through central plan allocations.

An industrial handbook lists investment costs for cement plants of different sizes. The investment cost is reported to be 1.2 million yuan for a plant with designed annual production of 32,000 tons which is the standard design for the small cement plants. This gives an investment cost of 37.5 yuan per ton. Larger plants with rotating horizontal kilns give investment costs of 19.5 yuan and 17.6 yuan per ton for plants producing 492,000 and 709,000 tons per year respectively. (See table 3). It should also be noted that the large plants produce a cement of higher quality and that the product in the larger plants is likely to be of a more even quality.

Investment cost reported at my visits to small cement plants in 1971 and 1973 indicates that costs for the 32,000 tons per year plant may be slightly lower than the figures quoted. Coal consumption per ton of cement does not differ significantly for plants of different sizes.

What consequences do the different investment costs per ton cement have on the costs of the finished product? The pricing of cement is ambiguous and dependent

Table 3
Production of cement in plants of different sizes
¥1.00 = US $ 0.50

Annual production	No. & type of kilns	Cement quality	Coal consumption Total (tons)	Coal consumption per ton	Employment	Investment Total (million ¥)	Investment per ton	Investment per worker	Production per worker (tons)
32,000	2 vertical	400	7.6	238 kg	358	¥1.2	37.5	3,350	89
492,000	2 rotary	500	126	256 kg	810	¥9.6	19.5	11,850	607
709,000	3 rotary	500	168	237 kg	972	¥12.5	17.6	12,860	729

Source:
Site and Transport Planning for Industrial Enterprises. China's Industrial Publishing House (Compiled by Peking Industrial Construction Planning Bureau, Ministry of Construction and Engineering), Peking. January 1963 (first edition)

Table 4
Comparison of investment costs in indigenous small-scale and larger-scale with imported large-scale cement plants

Origin	Plant size (million tons)	Cement quality	Investment	Total (million)	Investment per ton	
Foreign	1.0	>500	≈US $35.0 million	¥ 70.0	¥70.0	(incl site consturction)
Chinese	0.032	400		¥ 1.2	¥37.5	(incl site construction)
Chinese	0.79	500		¥ 12.5	¥17.6	(incl site construction)
Chinese	0.492	500		¥ 9.6	¥19.5	(incl site construction)

on the purpose it is used for. The ex-factory price is around 70 yuan per ton when taxes and planned profits are included. If depreciation, maintenance charges and possible capital charges are calculated to 25% of the investment costs this would then amount to 9.4 yuan per produced ton in the 32,000 ton plant and 4.4 yuan for the largest of the two mentioned plants using rotary kilns. There are, of course, other economies of scale. The wage costs become relatively less important with increasing plant size. Coal consumption per ton cement does not differ significantly for plants of different sizes and there is no reason to believe that electricity consumption would be significantly higher per ton cement in a small plant compared with a big one.

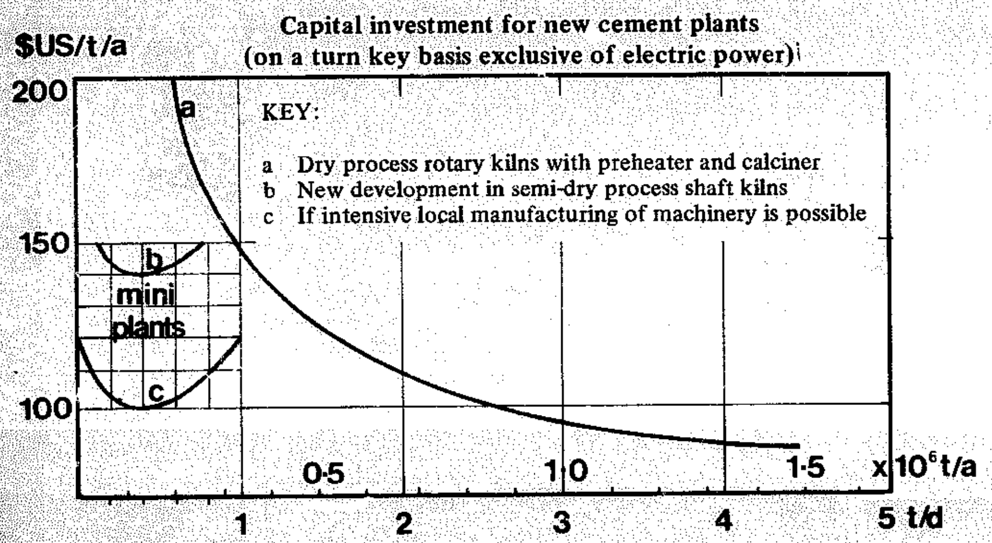
In the field of cement manufacture China is also using foreign technology to its advantage but not complete plants. According to a business report, the Machinery Export-Import Corporation has been discussing the importation of certain critical equipment for a cement plant with a production capacity in the range of 1.0-2.0 million tons per year. The total investment costs for a plant with an annual capacity of 1.0 million tons per year would be US$35.0 million (1975). If this amount is converted into yuan at the official exchange rate and is calculated as costs per ton cement it would amount to 70.00 yuan per ton which would include costs of site construction and all peripherals. This is considerably higher than the domestic alternatives as presented in table 4.

In a report commissioned by UNIDO in 1973 it is claimed "Today it is possible to build a vertical kiln cement plant at a fraction of the cost of conventional plants, which permits the economical establishment of a cement industry on a small scale". The author, Steven Gottlieb, points out that "during the late fifties studies were conducted and published about a new modernized vertical kiln which led to a better understanding of the processes involved in it. Based on this work, substantial improvements were made – vertical kiln plants were built which proved that they can produce uniform and excellent quality cement, in smooth, troublefree operation. Vertical kiln cement proved to be competitive in every respect, performing well in the most involved concrete structures, such as concrete platforms for oil drilling in the sea bed off shore in Australia . . . "[1]

In a more recent UNIDO report[2] it is argued that " . . . a plant producing 100,000-120,000 t/a would be the most economic size. However, this may not be the case as a high degree of standardization and on-site manufacturing could bring down costs considerably. For instance, according to investigations made by the Cement Research Institute of India (CRII), New Delhi, the most economic shaft kiln would have a production of 25,000-33,000 t/a.

The CRII has also carried out extensive investigations regarding shaft kiln operations. Indian experts have designed, fabricated and successfully operated, for more

1. *Development note for the calcining and sintering of cement clinker and other materials in a new shaft kiln*, prepared for UNIDO by Steven Gottlieb, UNIDO/ITD, 223, 13 November 1973.
2. *Development of Appropriate Technology for Small-Scale Production of Portland Cement in Least Developed Countries and Regions* RP/INT/76/021 (16 September 1976). The report is based on the work of Harald C. Boeck, who on a UNIDO mission visited four shaft kilns and one cement plant with a test kiln for an oil-fired shaft kiln.



than two months, a 2 t/d shaft kiln producing quality clinker. It is interesting to note that solar energy is used for drying nodules".

When deciding location, size and technology for the cement plants it appears that in China transportation costs are much more important than investment costs per ton of finished product. That is to say that economies of scale due to reduced investment costs per ton of cement for large centrally located plants rarely compensate for the increased transportation costs compared with widely distributed smaller plants. Now production costs depend on the efficiency of the plants and many of the small plants are of course initially much less efficient than the larger plants. However, because of the lumpy character of some production factors of the large plants, the demand may not immediately match the production capacity. A lowered utilization of capacity would then immediately lead to higher production costs.

Local manufacture of cement can, according to available reports, be achieved in a small plant of standard design with a capacity of 32,000 tons per year at approximately 40 yuan per ton. A substantial number of China's more than 2,000 counties have all the necessary raw materials for producing cement. And press reports from China now mention that small cement plants have been set up in 80% of all counties. There can be no doubt that the high costs of transport – in the absence of railways or waterways – have been a significant factor in the Chinese emphasis on local manufacture in relatively small plants were the plant capacity has been chosen to match the market requirements of a county or part of a county.

Transportation Costs

To understand this fully, it is necessary to look more deeply into the question of transport costs. The transportation system is, compared with industrialized countries, underdeveloped in many parts of China. Railway or cheap water transport is not generally available. A majority of the more than 2,000 counties have to rely on small lorries, horse-carts or still more primitive means of transport. The relative

Table 5
Transportation Costs in Hopei Province

Railway	¥ 0.010/ton km	(100 km coal)
	¥ 0.015/ton km	(100 km pig iron)
	¥ 0.017/ton km	(100 km cement)
	¥ 0.018/ton km	(100 km steel)
	¥ 0.027/ton km	(100 km steel products)
	¥ 0.045/ton km	(100 km fertilizer)
Lorry	¥ 0.24 /ton km	(flat rate)
Horsecart	¥ 0.21 /ton km	(11-15 km)

transportation costs in the early '60s in Hopei province (where Peking is located) are given in table 5. The apparently high costs for transporting by lorry may reflect the use of small capacity vehicles, poor roads and also a conscious shadow-pricing of this means of transportation.

The influence of transport costs can more easily be understood by looking at two different alternative ways of meeting an assumed annual demand of 32,000 tons in each of nine counties. It must be assumed that an average region with nine counties would cover approximately 22,500 km^2. The general policy today is that each county – where raw materials are available – should have its own cement plant. The centralized alternative is to build a rotary-kiln plant producing 9 x 32,000 tons annually. To minimize transport costs this would then be located in the centre of the region. See figure on page 13.

The average increased distance (alternative 1) for sending cement to the county centers – before redistribution – would be: $\frac{4 \times 50 + 4 \times 70}{9} = 53\text{km}$

In the absence of cheap railway or waterway transport the cement produced centrally would then have to be manufactured at a cost which is at least:
53 x ¥0.24 = ¥12.70 lower than cement produced in the county centers if transported by lorries. If transported by horse and cart the costs of the central plant must be at least 53 x ¥0.41 = ¥21.70 lower in order to complete with cement produced locally in the counties.

It therefore seems likely that the cost difference between big rotary kilns and small vertical kilns is not sufficient for centrally located plants to be built to meet the counties' need for cement, particularly so when other factors – favourable to the smaller local plants – are taken into consideration.

It should be noted that in certain counties some regions are covered by railways or waterways, which provide cheap transport. On the other hand, there are many regions -- in urgent need of cement – where transportation costs are much more in favour of local cement plants than in the example discussed above.

However, it should also be noted that cement produced in small local plants must be consumed locally if the reasoning above is to be correct. It also assumes that the costs of transporting the raw materials should be equal.

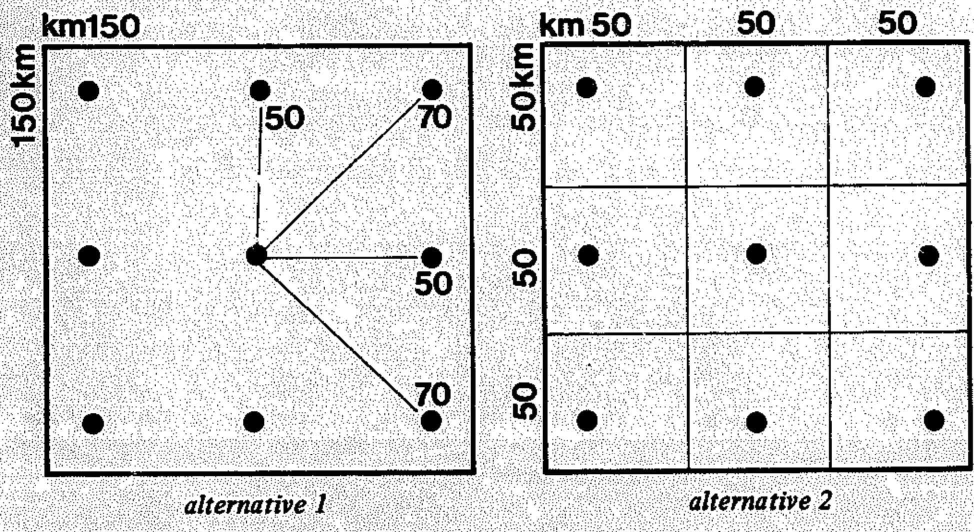
The widespread diffusion of mini cement plants has had a considerable effect on employment. A small plant producing 20,000 tons per year employs around 200 persons. The total increase in industrial employment in small scale cement plants would then correspondingly be at least 140,000 persons. A substantial number of rural plants are smaller and more labour-intensive than the example cited here.

Thus it can be safely assumed that the total direct employment effect from rural cement plants (manufacturing only) would amount to at least 250,000. This number is at least 10 times higher than employment would be in a small number of modern large scale cement plants producing the same quantity of cement and using a rotating kiln with an annual capacity of roughly 500,000 tons.

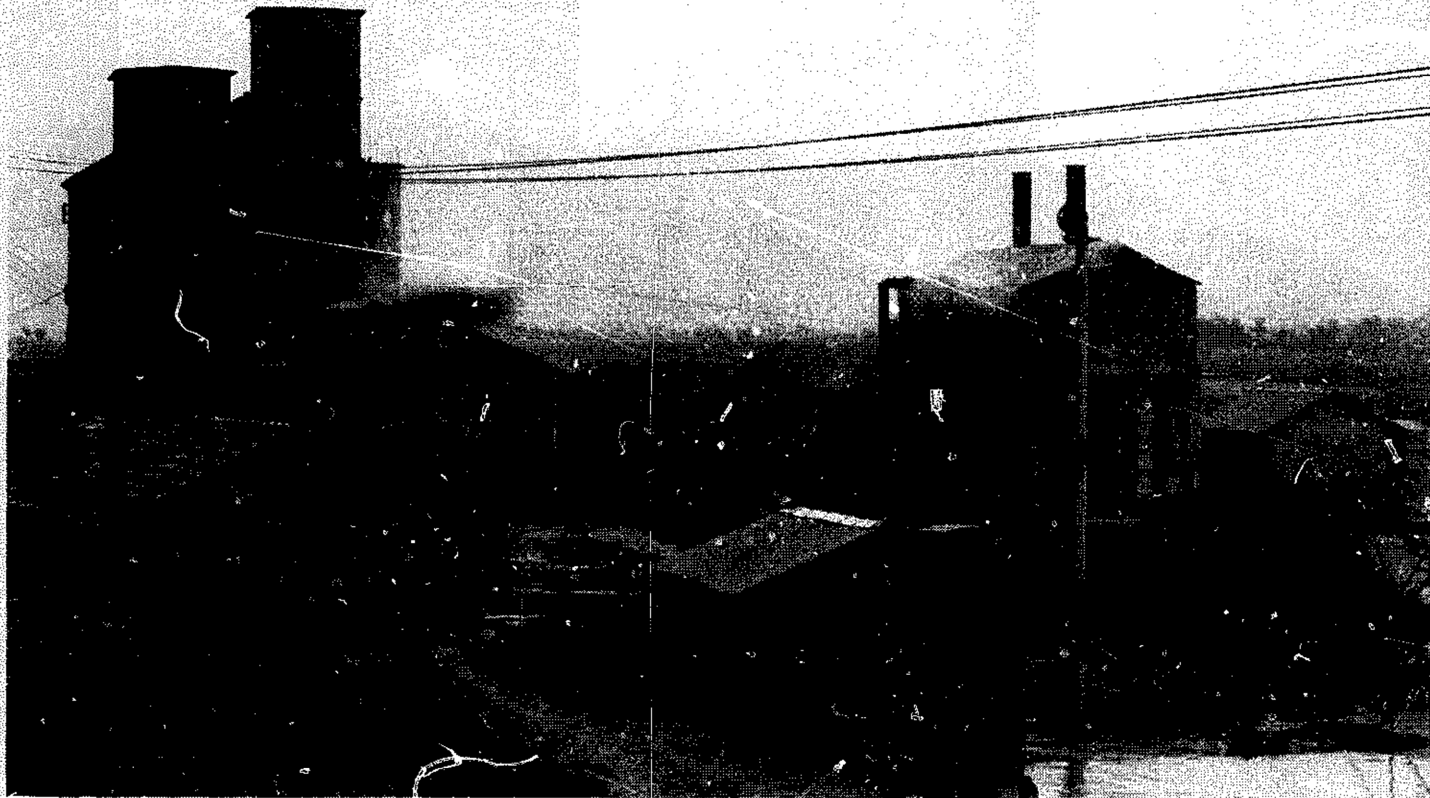
There are other important labour force considerations aside from the direct employment effect. Firstly a large number of people are being trained in the process of industrial technology. Secondly, a sizable number of people inside production units have received training in organizational skills. A smaller but still sizable number have been trained in administrative skills relating to the procurement of machinery and raw materials, distribution of products and coordination with other industrial units.

To understand the development of mini cement plants in China it is necessary to see a particular plant and the industrial sector as elements in a complex system. This industrial system must be analyzed at the regional, sectorial and national level. The system must provide consistency if a certain manufacturing technology is going to be introduced into it.

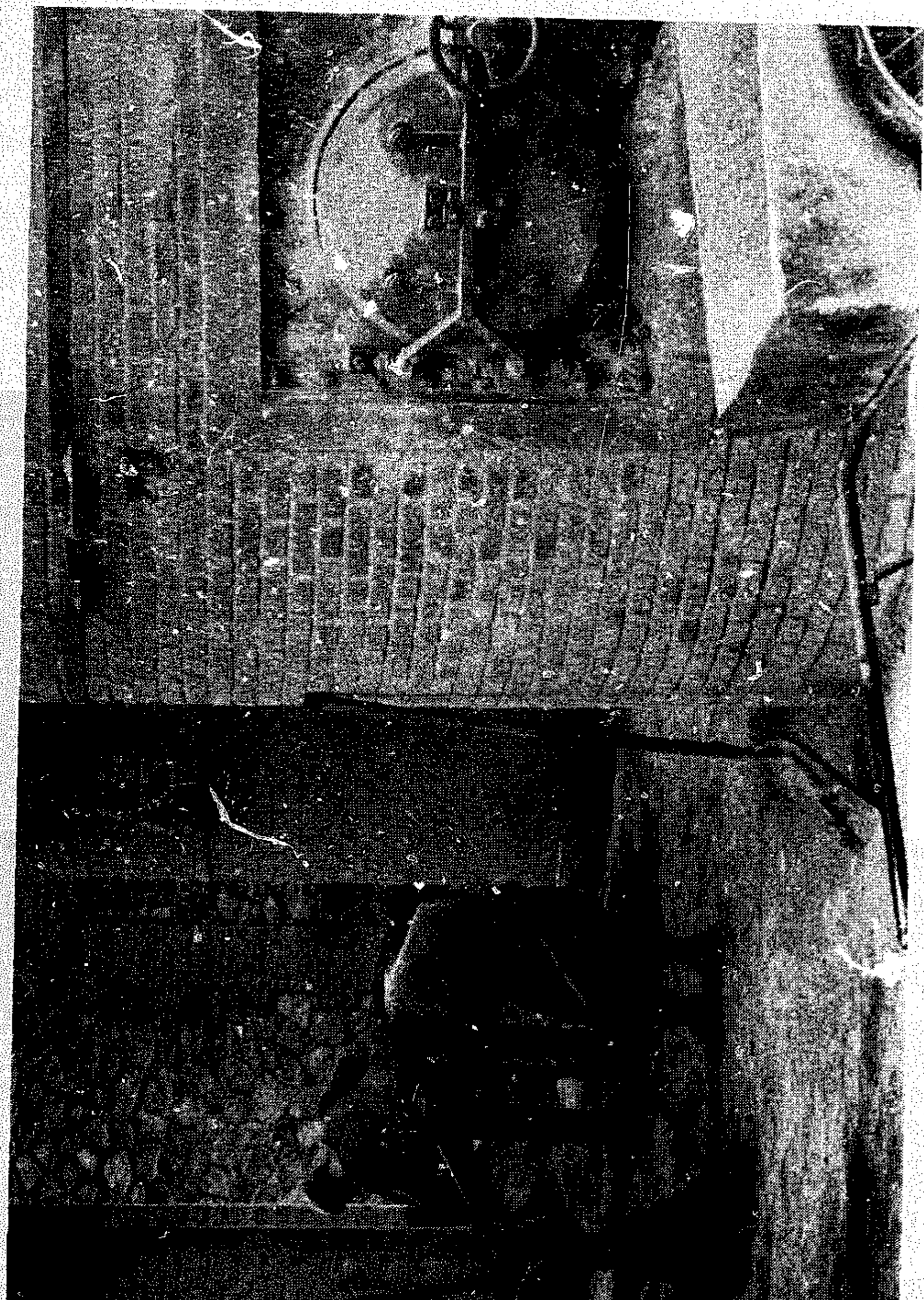
Consequently, when formulating plans for the role of rural technologies and small scale industries these must not be seen as an end in themselves. Usually, each segment of small scale industry in most developing countries has tended to be considered in isolation. Questions of scale and technology have usually been dealt with, constrained by the existing system, within a narrow framework of policy and short time horizons.



Alternative plant locations

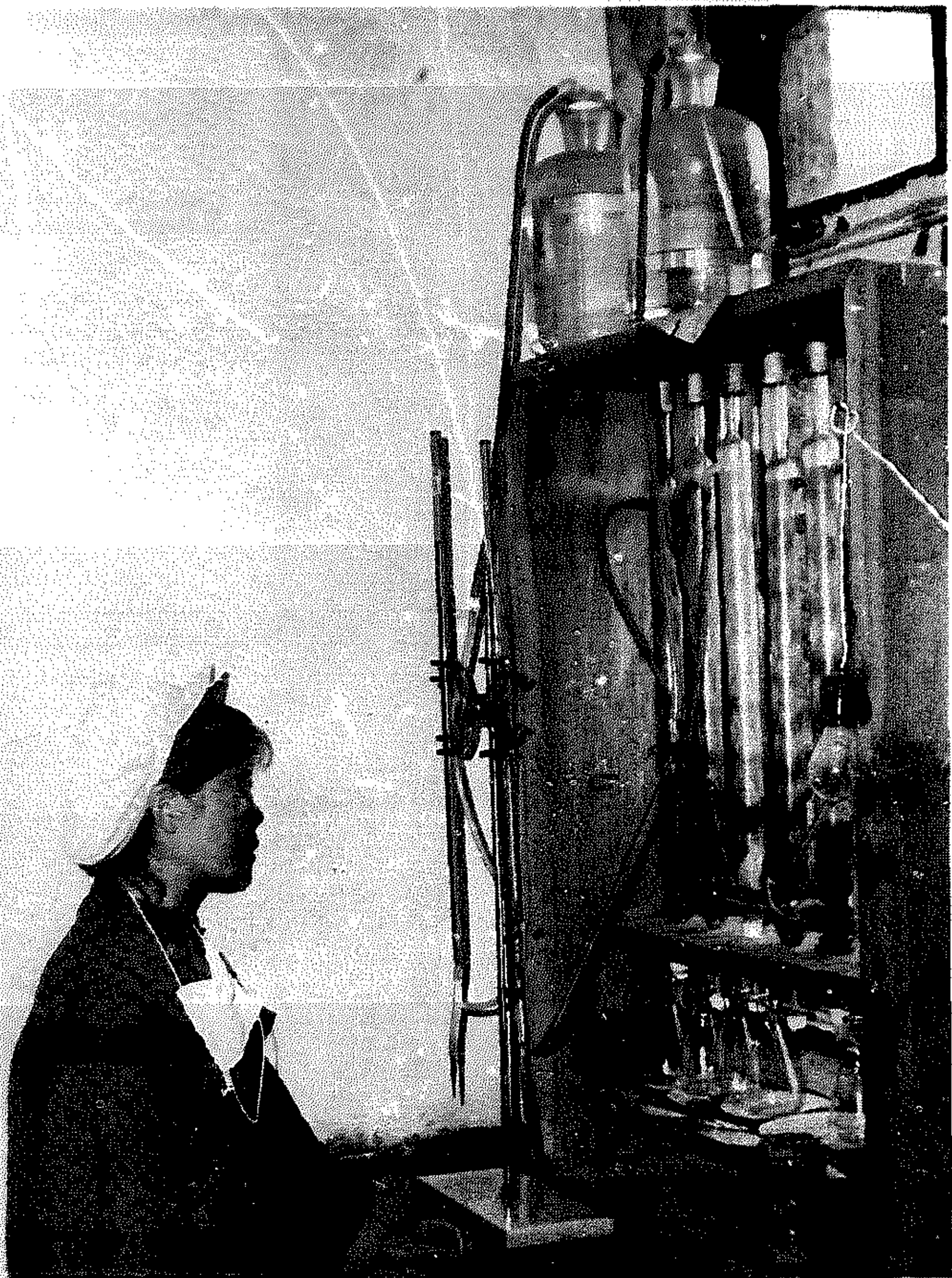


A general view of the plant. The kilns are on the right and the silos are on the left.



A view of the furnace. Clinker discharge is on the right.

Weighing materials in the laboratory.



Laboratory testing materials at the plant.

Comparison with India

The local small cement plants – aside from farm machinery and local engineering – provide one of the most successful examples in China of using alternative technologies for rural industrial development. The question immediately arises why this approach has not been duplicated in other developing countries. However, the feasibility of small cement plants has been studied and I will use such information to bring out certain similarities and differences.

I have chosen a comparison with India for several reasons. First, the level of economic development is similar to that of China. Second, the justifications and constraints generally apply to India as well. Third, the order of magnitude of cement production in the two countries is the same. However, China today manufactures 57% of her cement in small plants while all the production in India comes from conventional large plants.

Recently, the development of mini cement plants in India has been promoted by the Ministry of Industrial Development through the Appropriate Technology Cell. The Cement Research Institute of India has been commissioned to carry out a number of studies. According to these, mini cement plants are justified in a large number of locations and production costs are claimed to be close to those in big plants – at least under laboratory conditions – according to the Institute.

Experimentation in small scale cement plants in India can be traced back to the Indo-Chinese War in 1962 when people within the Indian Defence establishment took a number of initiatives designed to provide localities in outlying areas with cement plants. A pilot plant at Jorhat in Assam is obviously such an example. However, *Science Today* (Bombay) reports in a special section on cement in the January issue 1975 that "the shaft kiln technology has not become popular in the country. The first shaft kiln was put up rather hurriedly by the defence scientists in a Border area in 1963 with imperfect know-how and transferred to the Tamil Nadu Industrial Development Corporation the same year. The plant failed".

In the early '70s the chairman of a working group on small sized plants requested a group of three persons to:

1. Assess the comparative costs of setting up different sizes of cement plants along with the costs of raw materials and other inputs required
2. To make suggestions regarding location of small size plants
3. To find out the possibility of supplying a package plant including nodulizer, shaft kiln and other components.
4. To prepare a cement map of India giving details regarding size and location of existing cement plants.

A number of small plants have been set up, on an experimental basis, all of which were evaluated by the group. A detailed examination of the existing four experimental plants revealed that economic viability could not be ascertained for two of them. Certain doubts were also expressed about the quality of cement. Available technical and economic data from the remaining two plants enabled the working group to conclude that "depending upon the availablity of mineral deposits, installation of . . . cement plants of 30-tonne and 100-tonne per day capacity can be deemed appropriate". This size range would most likely include the major part of the cement produced in small plants in China – if not the total number of existing small plants.

Designs of mechanical supports for the various operations such as conveyor systems, silos, nodulizers and kilns depend on the types of raw materials used and the scales on which the operations are carried out. Technologically there is no special factor restricting the scaling down of the process. However, the process must be economically viable – at least when all external factors are taken into consideration.

The group further argued that the location of small scale cement plants in different regions of the country depends on the availability of basic raw materials and that transport costs need not be a constraint if the cement is produced where the market is. Furthermore, as vertical shaft kilns are utilized for producing limited quantities of cement, the marketing would not be a main constraint. Consequently small scale vertical shaft kiln cement plants can be located in areas where communication and transport facilities are not well developed but where limestone and coal are available in limited quantities sufficient to sustain the plant for about 20-25 years.

On the basis of these criteria the group prepared a list of approximately 35 locations suggesting that either plants of 30 tonne per day or 100 tonne per day should be set up in these places. It was further suggested that a phased programme should be initiated and that seven primary locations should be chosen so that their experience could be used in the remaining plants to be set up later on. However, no such programme has been initiated and there are a number of contributing factors which have hindered duplication of the Chinese approach in India. Primarily, the plant designs and technical process may not have been fully developed. Consequently, economic and technical data were not sufficient to convince either central planners or local entrepreneurs.

A number of technical details are of critical importance. Among these are quality of fuel, the temperature at which ash forms, the preparation of the size of nodules, patterns of feeding, and draught control. The cone angle must differ for various materials.

The Cement Research Institute of India (CRII) today claims to have solved all the technical problems and to have achieved a breakthrough in the design of the rotary grate and the transmission for its drive. CRII has studied the interaction of cone angles and various materials in order to get high quality clinker. CRII also claims to have developed an excellent design for a rotary nodule feeder operating at the kiln top.

All this indicates that India has achieved a technical competence in the design of mini cement plants that matches or surpasses China – at least under laboratory conditions.

Constraints on Mini Cement Plants

"Feasibility" of mini cement plants is influenced by the demand situation. The projection for cement demand in India is now being lowered with consequences for the mini cement plants – as the demand can now more easily be met within the existing industrial structure. However, we can assume that there is a demand for the small plants. But it should be realized that the viability of small cement plants is at least partly a reflection of demand created through substantial public works programmes and other construction activities in rural areas. More such activities may be implemented in China than in India.

It is of interest here to consider that the rural demand for cement in China in the period before 1965 was partly met by deliveries from urban-based cement plants. As a consequence of increased self-sufficiency in rural areas, that production in urban areas which was previously allocated for rural consumption has now been reallocated to a considerable degree for urban projects. As a result, the expansion of rural cement plants has had the effect of making more cement available for urban projects without corresponding investment in the urban-based sector of the cement industry. Most of the small cement plants have been built by counties or people's communes which have raised funds, procured local equipment and trained technical personnel locally

Further, it appears that the existence of a relatively under-developed transport system in China has favoured the proliferation of mini cement plants. This may indicate a smaller role for such plants in India than in China. This becomes more obvious when the length of the railway network is compared – it is 95,000 kilometres in India compared with 48,000 kilometres in China serving a larger area.

There are a number of further constraints:

1. The development of design has now been completed and it may be fully tested. But considerable development costs have still to be covered to carry out local adaptation to sort out teething problems and train local technicians. A local entrepreneur may have certain apprehensions with regard to these problems and the costs they are likely to incur. The risks involved may produce a bias in favour of technology in well established large plants.
2. Still more constraints are likely to be found at national level, namely the problem of national transport policy; and the influence of the Association of Cement Manufacturers. The mini cement plants are no doubt seen as a potential threat to access to raw materials, as well as a threat of a reduced or at least a more slowly growing market. The Association is therefore likely to influence industrial licensing policy in favour of the big plants.

Now, it is important to analyze the wider ramifications as to where the particular kind of intermediate technology used in mini cement plants should be placed. It appears that national policies have completely eroded one of the more important base elements for mini cement plants – that of providing for captive local markets. In a report from the Tariff Commission[1] published in 1974 it is pointed out that

1. *Report on The Comprehensive Review of the Cement Industry and Revision of Fair Ex-Works Prices Payable to the Producers.* Government of India, Tariff Commission, Bombay 1974.

regional balance in the cement industry has at least partly been influenced by the present system of freight pooling and fixing of selling price on f.o.r. (free on rail) destination basis. The basic principle underlying the concept of freight pooling is that cement should be made available in different parts of the country more evenly and more or less at a uniform price. Until 1974 the freight, was equalized only up to the nearest railhead.

However, the special circumstances and the justification for mini cement plants is no doubt realized, as indicated in the following extract from the Tariff Commission's report:

> "Even though the normal trend should be to have plants of bigger and bigger size, it does not obviate the necessity of having to put up some small plants in special circumstances, geographical or otherwise where plants of bigger size may not be appropriate. For instance, in hilly regions or areas which are difficult of access there may not be adequate transport facilities for transporting large size kilns. Moreover, in such places, demand may be relatively small but transport of cement from elsewhere quite expensive on account of the freight and other transport difficulties involved. It will be in the overall national interest to locate smaller plants at such places provided adequate limestone deposits are within easy reach. This approach will not only correct regional imbalances but will also cut down necessary long rail haulage and heavy transport costs".

But, the report also includes the following comment from the Ministry of Industrial Development:

> "Government agree with the Tariff Commission that in the interests of overall economy of the country and that of the consumer, the freight pooling system should be continued to ensure the equal availablity and uniform price of cement all over the country. The position may be reviewed towards the close of the Fifth Plan period to see if any modifications are called for in the system".

It was then decided to accept " . . . the suggestion of the Commission that the freight pooling should operate at least up to all the district headquarters in areas which are not served adequately by the railways. The cost of transport from the rail head to the district headquarters by road would be covered by a freight pool in accordance with the formula for road transport of cement as may be applicable from time to time".

Having attempted to analyze the role of mini cement plants in China I would argue that the freight pooling system in India has eroded an important element – the economic base that would justify mini cement plants, i.e. captive markets for local demand.

This is also surprising in the light of the arguments put forward by the Railway Board:

> "The Railway Board has stated (1973) that the regional imbalance in the production of cement without any relationship to demand is encouraged to a great extent by the existence of a uniform f.o.r. (free on rail) through the scheme of equalization of freight. As a result rail transportation charges need not be taken into account by the producers when locating their plants".

The Railway Board calculated that with proper distribution of cement factories in different parts of the country in accordance with the demand, the railways could have moved over 18 million tons of cement in 1970-71, instead of the 11 million tons actually transported, deploying the same quantum of resources.

This is one example indicating some of the elements which require to be brought in line if appropriate technologies are going to be used.

Comparison of Quality

The quality of the cement is another dimension where India and China have opted for very different approaches. Robin Spence who has made a study of alternative cements in India points out "All the Indian pilot plants have been concerned with the production of Portland Cement to meet in full the requirements of the Indian standards. Otherwise, it is argued, no market for the cement will be found. This implies a level of technology, as well as management, supervising skill and quality control, which it would be difficult to provide in each of a large number of small plants".[1]

The Chinese planners have accepted a quality differential even if they have attempted to produce a high quality cement which can be used for most purposes. The managers of small scale plants in China claim that the quality number of their cement usually exceeds 400. This means 400 kp per cm^2 and is the test value when measuring compressive strength after 28 days. This corresponds to 39.5 MN/m^2. Altogether there are, in accordance with state regulations, six classes of cement – in terms of compressive strength These are 200, 250, 300, 400, 500 and 600 kp/cm^2. Assuming that testing methods are comparable with those specified by British Standards Institution, the cement produced in small scale plants compares favourably with portland cement from large scale plants. However, recent visitors to small scale cement plants in China have questioned the quality statements and claim that the locally produced cement would fall in the range of 250-325 if tested according to British (BSI) standards. In spite of this controversy, the Chinese use of locally produced cement for most construction purposes in rural areas has not been questioned on quality grounds. The quality, in terms of strength, of locally produced cement is lower than cement produced in large rotary kilns, and the quality is on the whole likely to be uneven. This leads to the conclusion that these localities will have to "import" cement of higher qualities for certain projects where a higher quality is required.

The quality of cement used for various purposes in rural areas is spelled out in a recently published book.[2] The products covered include irrigation works, building blocks, bridges, ferrocement boats, pipes, cement rollers and a number of other products. According to this information, based on the experience of specific production units located all over the country, almost all products can be manufactured using No. 400 cement. However, the ferrocement boats require No. 500 cement. The same requirement applies to structural elements when building houses.

Even if it has not been proved without doubt that small scale cement plants are feasible in India it appears that the country could provide conditions for setting up

1. *Alternative Cements in India*, by Robin Spence (Intermediate Technology Development Group), London 1976 (unpublished).
2. *Cement Products For Rural Uses*. China's Construction Industry Publishing House, Peking, September 1974 (First printing).

a relatively large number of small vertical shaft kilns in a number of locations. However, a number of constraints – some of which have been mentioned – continue to hinder this development.

Basic differences between India & China

The basic difference between India and China in promoting mini cement plants appears to be as follows: in India the promoters have only treated the "hard" technology of cement manufacture. They have almost overlooked the small businessman's problems and not considered the need for comprehensive system approach. Organization-building, overall economics, cultural considerations and community development have been separated from the "hard" technology of machines and equipment and have been only marginally dealt with. In China, on the other hand, it is the softer technologies that have received the major emphasis in the design of projects and the implementation of programmes. However, the Chinese softer technologies are only vaguely known and require to be better monitored, assessed, documented and disseminated outside China.

Bibliography

PRC – People's Republic of China

There are three major categories of Chinese-language technical literature known to the author:

1. General handbooks
2. One series of technical reprints, first published in 1973
3. One series of technical (specialized) material, first published in 1972 (generally published in 10,000-20,000 copies).

Selected items from the three categories are listed below.

Small (Scale) Cement Manufacture. Hunan People's Publishing House, November 1974.

Installing Small Scale Cement Factory Equipment (Enlarged edition). Compiled by Ren Fu-quan. China's Building Industry Publishing House. First edition October 1959. Second edition October 1973.

Collection of Experience in Technical Innovations in Cement Industry., Vol.1. China's Building Industry Publishing House. First edition July 1974.

"Small Cement" Technical Reprints. Published by China's Building Industry Publishing House.

a) *Cement Manufacturing Knowledge*
b) *Raw Materials*
c) *Pulverization*
d) *Burning*
e) *Production Equipment*
f) *Chemical Analysis and Production Control*
g) *Simple Physical Testing*
h) *Cement without Fuel*

Collected Standards For Cement. Vol.1. (Shuini biaozhun huibian). Technical Standards Publishing House. Peking. 1970. 2nd printing 1973.

Selected Indian Publications on Mini Cement Plants

* 1. *Techno-Economic Feasibility Report for Setting Up Mini Cement Plants in North-Eastern Region of India.* May 1975 Cement Research Institute of India (CRII). (Sponsored by Ministry of Industry and Civil Supplies). Mimeographed. 158pp.

* 2. *Feasibility and Engineering of Mini Cement Plants in India.* March 1976. CRII. (prepared for National Committee on Science and Technology).

* 3. *Improvements in Nodulisation for Vertical Shaft Kiln.* CRII. January 1975.

* 4. *Design of Refractory Cone for Vertical Shaft Kiln.* CRII. February 1975.

* 5. *Design of Grate Drive System for Vertical Shaft Kiln.* CRII. April 1975.

* 6. *Trial Runs on the Mini Cement Plant at CRI Muduvathar.* CRII. April 1975.

* 7. *Modifications of Mini Cement Plants at Muduvathar before Second Trial Runs.* CRII, August 1975.

* 8. *Vertical Shaft Kiln Precalcinator* CRII. October 1975.

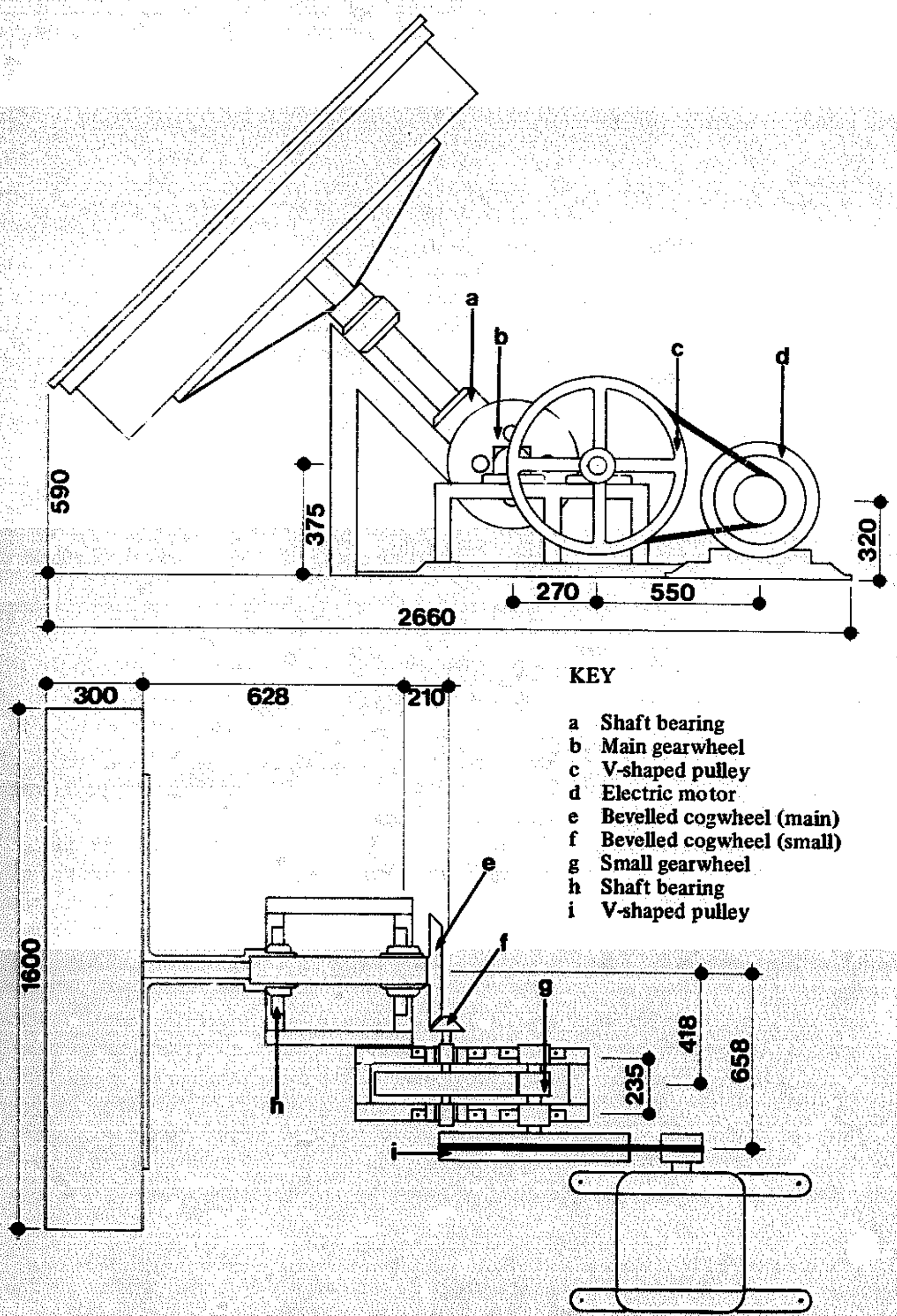
9. *Vertical Shaft Kiln for Cement Production: Feasibility Report.* Regional Research Laboratory, Jorhat 1971.

10. *Report of the Sub-group on Scaling Down Cement Plants* published in Group Reports, Second National Seminar on Appropriate Technology, Appropriate Technology Cell, Ministry of Industrial Development and Science and Technology, New Delhi. (1973).

* Source: Dr. J.C. Misra, Cement Research Institute of India, M-10 NDSE 11, New Delhi 110049.

Appendix: Some examples of Chinese small vertical kiln designs

The illustrations and text have been extracted from ***Small Scale Cement Factories: Equipment and Construction*** (Xiao xing shuinichang shebei anshuang), compiled by Ren Fuquan, published and printed by the Chinese Building Industry Press, Peking, China (first published 1959, second edition October 1973). Table 6 and Diagram B are taken from ***Small (Scale) Cement Manufacture,*** Hunan People's Publishing House, 1974.



Machinery for preparing hodules of limestone and coaldust

Table 6
Table of dimensions for kiln structures
(In millimeter units)

Kiln Number		I*	II*	III	IV	V	VI	VII
A		2500	2000	1500	1200	1000	800	600
B		2700	2200	1600	1300	1100	900	700
C		3000	2700	1900	1600	1300	1000	800
D		1100 x 2	900 x 2	1000	800	600	400	300
E		4000	3200	2800	2400	2000	1600	1200
F		6000	4800	4200	3600	3000	2400	1800
G		2700	2200	1100	1000	800	600	400
H		10000	8000	7000	6000	5000	4000	3000
I		15000	12000	10000	9000	7500	6000	4500
J		2400	2000	1600	1500	1400	1300	1200
K		1500	1400	1200	1000	800	600	400
Kiln	L	1100	1400	900	700	700	600	500
gate	Width	1100	1000	800	600	600	500	400
	No.	4	2.3	2	2	1	1	1

*(This kiln should be flexible enough to be changed to a mechanized vertical kiln.)

[1] E.g. in col II of the dimension table set out above, the inner diameter of the upper section of the kiln is 2.7m (C), the diameter of the middle section is 2.0m (A), and the diameter of the lower section is 2.2m (B). The kiln is 8.0m high – the best height:width ratio for the whole kiln is 1:4 or 1:4.2. The preheated area of the kiln's upper section is enlarged and so is bell-shaped.

When the raw material has been heated, it solidifies, reducing in volume at the same time. This means that it sinks into the section with the smaller diameter and fills the space. When the current of hot air rises the speed of the current decreases at the mouth of the bell-shaped section and so combustion below the material stays comparatively uniform. This prevents the raw material falling down the sides and causing the fire to blaze up.

Another advantage of this kiln is that cooling in the inner diameter area is diminished. This causes the air current to increase in speed which raises the cooling rate of the heated material. The cooling area of the inner diameter is a practical feature.

The reason for choosing this type of kiln is that the manufactured product is high in both quality and output, while the coal consumption remains comparatively low. (Refer to the table above and the illustration opposite for details of the kiln design).

1. This is an edited version of a translation from Chinese. Material has been faithfully copied from the original. However, there appears to be a proportional discrepancy between the figure given for G in Table 6 and the drawing, Diagarm B. We can only assume that this is the result of an error in the original publication.

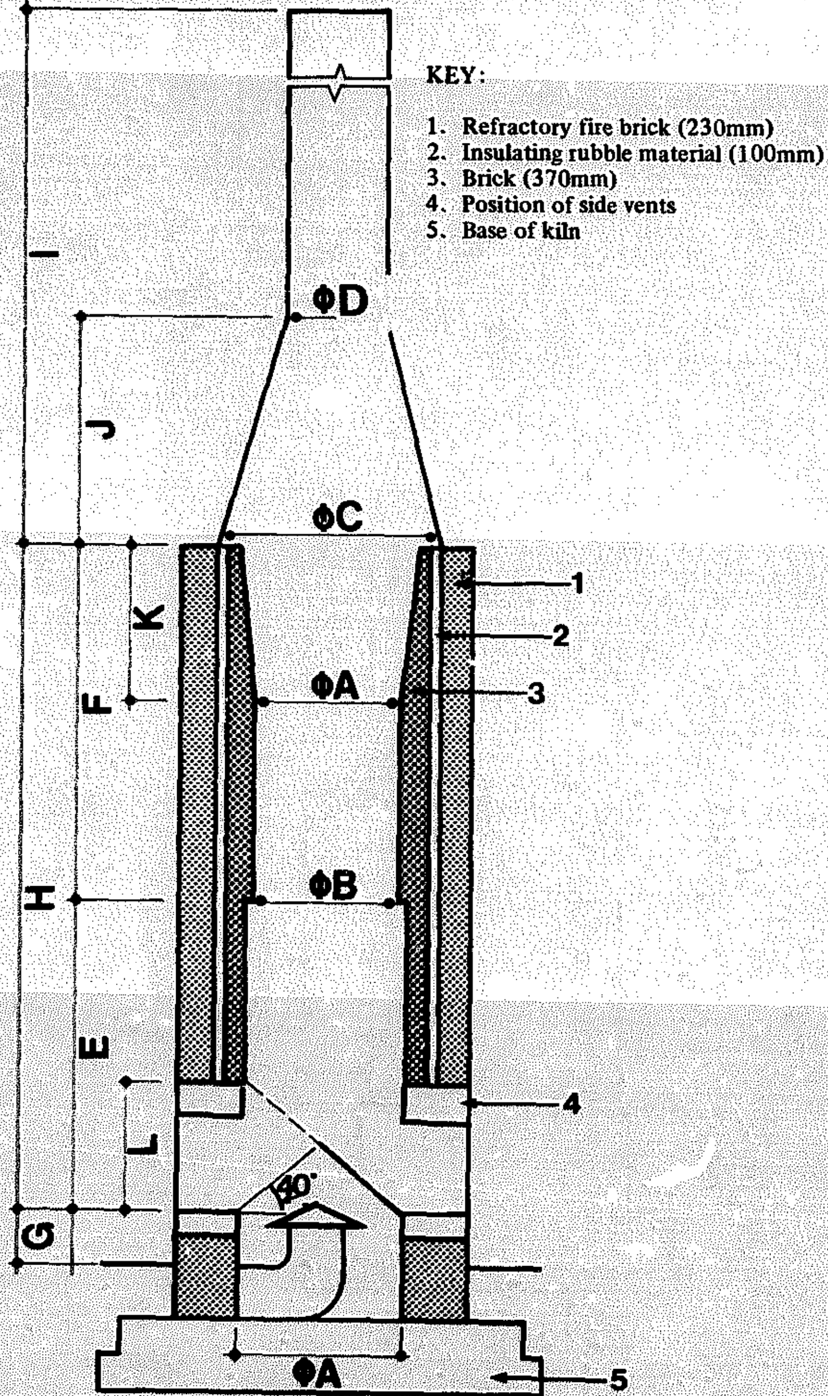


Diagram B Diagram of a vertical kiln
(Note: See table 6 for dimensions)

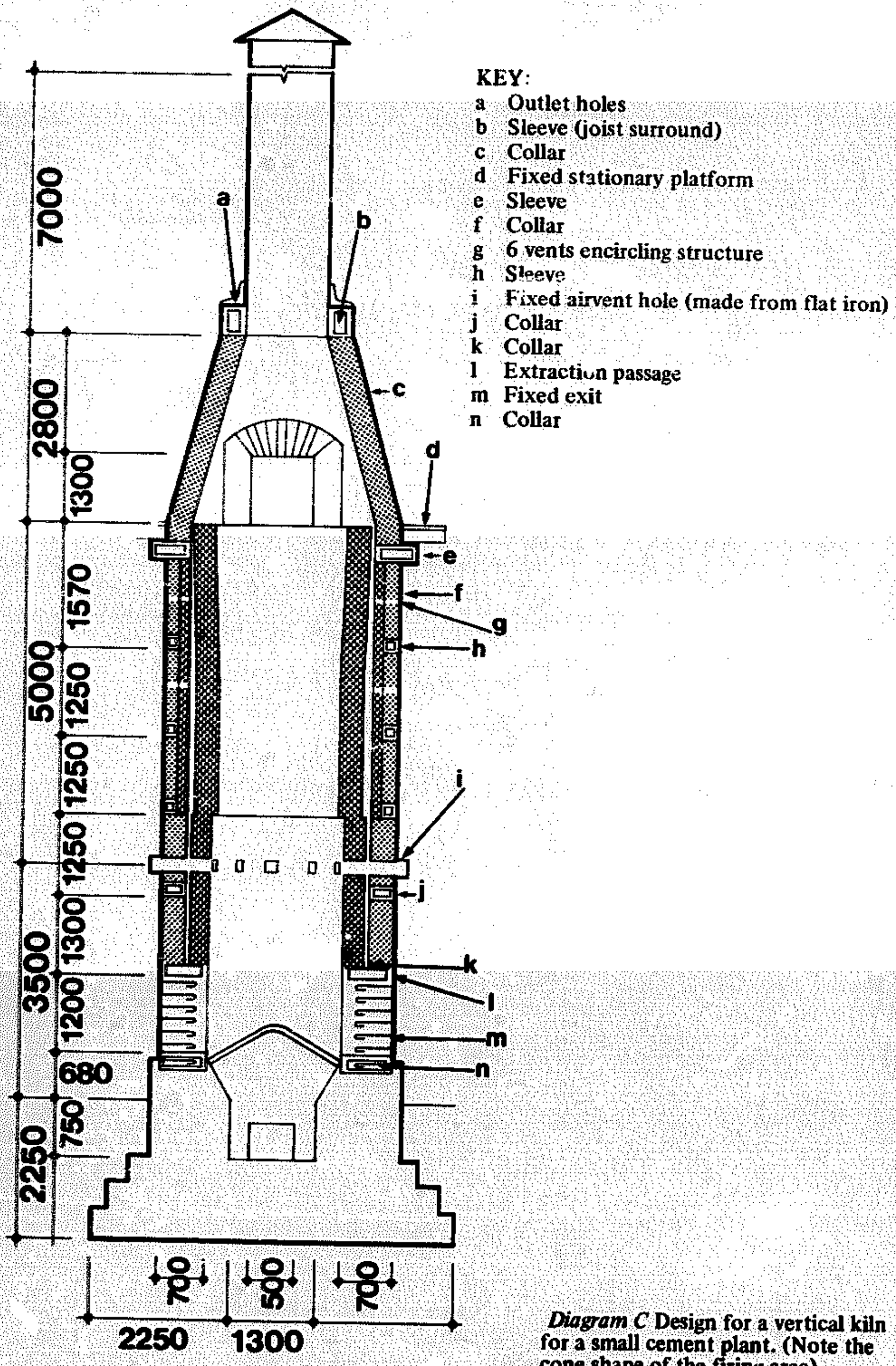


Diagram C Design for a vertical kiln for a small cement plant. (Note the cone shape of the firing area)