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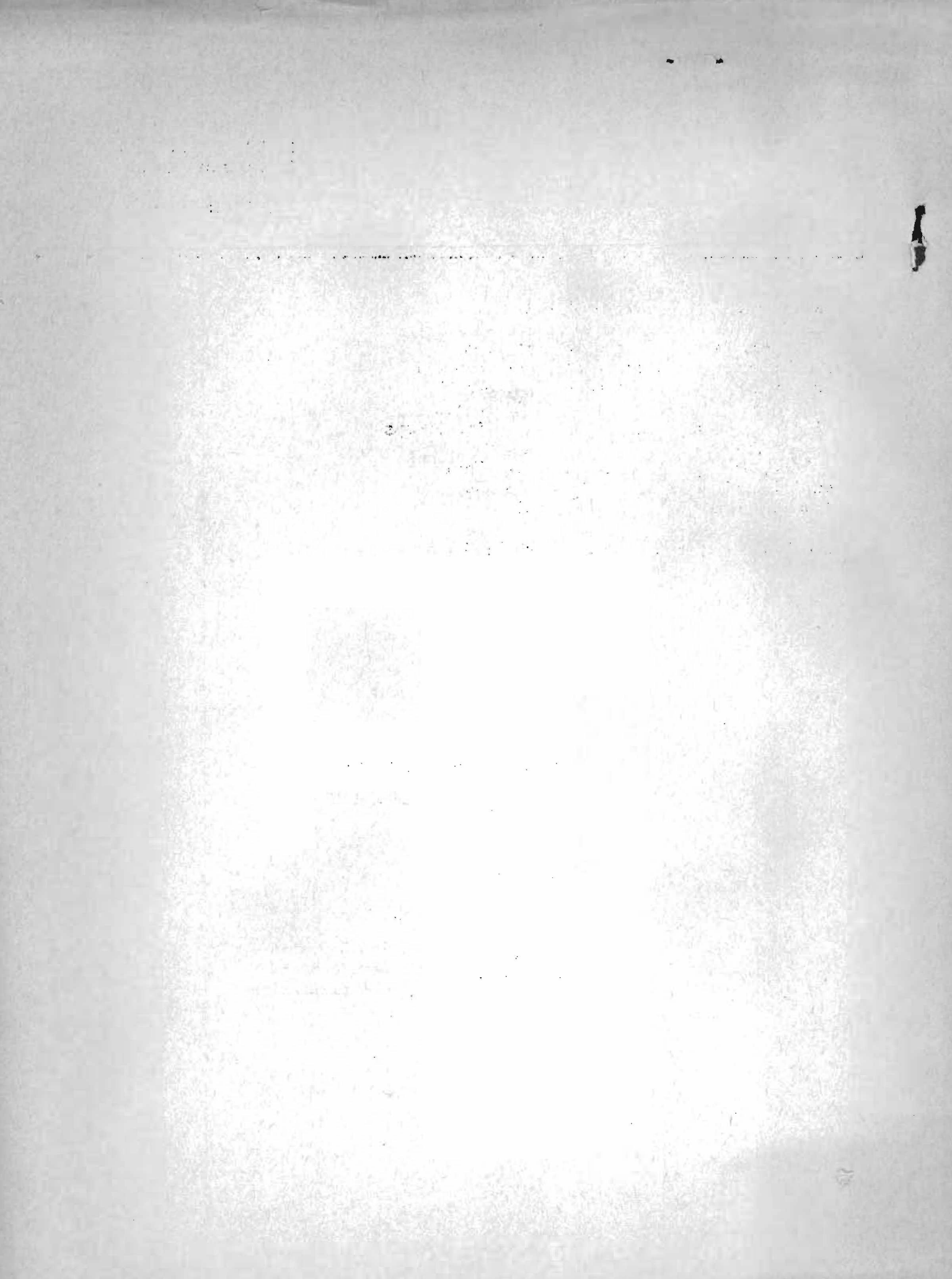
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PROGRAMMING DATA AND CRITERIA

FOR THE CEMENT INDUSTRY

Presented by

The Research and Evaluation Division  
Centre for Industrial Development  
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Prepared by

The Research and Evaluation Division

Centre for Industrial Development



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F O R E W O R D

The need for detailed data on inputs and investment costs for individual industries has been felt by many developing countries engaged in planning their industrial development in connexion with the programming of projects for specific industries. The elaboration of development plans is in general started with highly aggregated projections, but it cannot be confined to this macro-economic level; it is also necessary for operational purposes to link aggregative planning to that of individual industry sectors. Furthermore, availability of pre-investment data is essential in cases where it is necessary to make a preliminary evaluation of the feasibility of establishment of specific industries. In all cases, it is not enough to collect data based on the industrial practice in industrial countries; these have to be analyzed and adjusted to the economic and technological conditions of the under-developed countries.

The two studies presented here have been prepared by the Research and Evaluation Division of the Centre for Industrial Development, Department of Economic and Social Affairs, under the work programme formulated by the Committee for Industrial Development (E/3600), and endorsed by the Economic and Social Council in resolution 872 (XXXII); they form part of a series of studies designed to develop a body of data for a certain number of selected industries of interest to under-developed countries along the lines described above.

The first study, "Pre-Investment Data for the Cement Industry", contains investment and other input coefficients for the cement industry based on analysis of data originating in a certain number of countries, both in developed and under-developed areas. The second study relates to the industry of "Nitrogenous Fertilizers Based on Natural Gas"; in the latter study major emphasis is placed on the analysis of the differentials in fixed investment and other major input requirements in this industry between a developed country (in this case the United States of America), and a typical developing country.

Pre-Investment Data for the Cement Industry

Introduction

Two major considerations have led to the selection of the cement industry as a pilot study in the industrial development data project. Firstly, certain technical characteristics make this industry particularly suitable for international comparisons. Secondly, the establishment of cement plants in newly developing countries is of sufficient importance to merit direct attention.

The technology of the production of cement is a relatively simple one, there being basically few variants--wet and dry processes--whose requirements differ by an amount well within the order of magnitude of estimating errors.<sup>1/</sup> The dry process may be produced either in rotary kiln plants or in automatic shaft kiln plants. This study, however, is confined mainly to rotary kiln plants (wet and dry), but automatic shaft kiln plants are discussed briefly, because of limited data, in Appendix I. In general, the technological characteristics of local raw materials, particularly their water content, determine the choice between the wet and dry processes. Cement is moreover a relatively homogeneous product; standard portland cement accounts for over 90 per cent of total output of this item in the United States and Japan and practically all the output in most under-developed countries.

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<sup>1/</sup> Technological problems are discussed in Appendix I to this study. Cement is also produced, although on a limited scale, as a by-product of several industries, one of which is iron and steel, the raw materials being the blast furnace slag.

The procedure which has been followed in this study is based upon an examination of the principal components of cost of production and of investment, drawing upon experiences in both developed and under-developed countries. International comparisons are undertaken in order to discover the variations in these elements. An examination of the causes of these variations is then presented to assist those interested in programming the establishment of this industry in the less developed countries, with special attention given to factors which are particularly relevant in the latter countries. The data have been drawn from engineering sources; in some instances, however, particularly with respect to fuel and energy inputs, these have been derived from aggregate data for the entire industry. It should be kept in mind that engineering data often reflect conditions which relate to the particular projects from which the data are drawn and to that extent should be crosschecked with data derived from a more aggregated source material. A certain number of data used in this study have been reproduced in the Appendix I as an aid in programming the establishment of cement plants in developing countries.

Cement is essentially a resource-tied commodity. Barring exceptional circumstances, cement plants are located close to the quarries of the two basic raw materials, clay or shale and limestone.<sup>2/</sup> For this and other reasons, which are noted below, the analysis will not distinguish between quarrying and manufacturing, but will treat the production as an integrated

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<sup>2/</sup> Location problems are also discussed below.

process. It may happen that limestone, which is also an important raw material for other industries, would be purchased from local mining concerns. Appendix I contains some data on inputs for quarrying which permits the identification of the input coefficients concerned.

The composition of unit cost for producing cement is indicated in Table 1; the figures are in the nature of orders of magnitude. In the course of this study the major components of cost will be analyzed individually.

## Section 1

### Analysis of Investment Requirements

Fixed investment includes equipment for the cement plant and quarrying installations, cost of erection, cost of buildings and storage facilities, land clearing and improvements (drains, sewers, necessary roads, etc.) and miscellaneous administrative and engineering expenses. Because of location problems and the large amounts of power used in production, electric power generating equipment is also sometimes being installed on the plant site. Investment requirements for each of these items and their individual components depend in the first place on technical requirements and in the second place on the requirements of the local situation. For more detailed data involved in feasibility analyses, each of these items will have to be examined individually; for the present purpose, which is to provide an indication of the order of magnitude of the investment requirements, these items are aggregated into broad categories

on the assumption that such aggregates are less likely to be affected by the individual circumstances. In the analysis which follows attention will be given to the main variations which are indicative of the problems of quantification involved in programming industry in the newly developing countries.

On the technical level, the prime determinants of plant capacity are the size and number of kilns. The capacities of the other equipment, including equipment in the quarry, crushers and mills, are chosen in conformity with these key items. There appears to be considerable standardization of sizes for those items which bulk large in investment costs; this is due apparently to the efforts of the manufacturers specializing in this type of equipment to reduce their own production costs. As far as the under-developed countries importing this equipment are concerned, the selection of a desired size capacity within the medium range of operation generally selected by these countries should not raise serious problems, in view of the fact that a practically continuous range of capacity in the medium range is available on the international market.

As indicated below, considerable flexibility exists with regard to material handling equipment at the plant and for the quarry. There is also a large degree of latitude with respect to automated quality control devices. Finally, equipment for dust collection varies widely in efficiency and investment costs, the newest and most efficient facilities accounting in some instances for an important portion of total investment.<sup>3/</sup>

Requirements for building and storage facilities are also related to size of operations but local conditions play a very important role in

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<sup>3/</sup> In several newly constructed plants in the United States, cost of dust collecting equipment comprised about 5 to 8 per cent of total fixed investment.

determining costs for these items; climate and local standards of accommodation are among such factors. Similarly, land clearing and improvement are affected by location and general regional development. For example, remote sites would require roads and construction of railway sidings for transport.

The influence of scale of operations on total investment costs may be observed on the basis of data available for a number of countries, shown in Chart 1. Data for the United States relate to wet-process plants built in recent years; the data for the Federal Republic of Germany are based upon estimates for dry-process plants derived from a German engineering handbook for this industry, while the Soviet data relate to typical plant designs of recent years. The three sets of data indicate the existence of a constant elasticity between size and total investment costs; that is, a constant ratio between the percentage increase in size and the percentage increase in total investment costs. The elasticity varies from 0.64 in the German data, 0.66 in the U.S.S.R. data to 0.77 in the United States data.<sup>4/</sup>

Direct comparisons of the absolute levels of these costs (see Table 2) are extremely difficult for several reasons. The difficulties which beset international comparisons of data expressed in domestic currencies are well known.<sup>5/</sup> The data from the U.S.S.R. for the value of equipment have been

<sup>4/</sup> The relatively high value for the United States may be partly due to the fact that they are derived from (reported) investments in actual plants, whose design often involves provision for expansion in the near future. This is particularly true of the smaller plants, thus tending to bias the scale factor upward. The data for the other countries presumably applies to plants with balanced capacities at each level.

<sup>5/</sup> See article on "Capital Intensity and Costs in Earthmoving Operations" in United Nations Bulletin on Industrialization and Productivity, No. 3 (Sales No.: 60 II.B.1).

converted from rubles into dollars, using a ruble/dollar ratio of 8 to 1; this ratio is based on the ruble price of one rotary kiln and the dollar price for a kiln with comparable specifications. The current official rate, which is equivalent to about a 10 to 1 ratio for Soviet prices prior to the 1961 revaluation of ruble denominations and prices, appears to be too high for many Soviet capital goods. In an earlier study undertaken by the United Nations Secretariat on construction equipment, it was found that a rate of 4 to 1 appeared to be appropriate for these types of goods.<sup>6/</sup> Since the cement equipment industry is among the less advanced sectors, it is felt that the exchange rate for cement investment goods should be higher than that used previously in these studies; as will be seen below the rate which has been chosen nevertheless involves a number of difficulties.

Similar difficulties affect to some extent the comparison of the data for the Federal Republic of Germany with those for the United States. There is some evidence that in terms of purchasing power equivalent for industrial equipment the German mark rate vis-à-vis the United States dollar<sup>7/</sup> was substantially higher than the former official rate.

The lower costs for German equipment as compared to the United States, result in part from the exclusion in the German data of costs of land, land clearing and other development costs involved in opening up the quarry; in

<sup>6/</sup> In this study, a "real" parity exchange rate was estimated. It was derived by comparing the prices of capital goods in the Soviet Union with similar capital goods on the international market. In the Soviet Union, price differential policies tend to favour capital goods in the producer goods sector as compared to those in the consumer goods sector. For more detailed discussion on the subject see Ibid. p.21.

<sup>7/</sup> See the studies prepared by the Organization for European Economic Co-operation: An International Comparison of National Products and the Purchasing Power of Currencies, (Paris, 1959), and Comparative National Products and Price Levels (Paris, 1958).

addition, the United States data include power generating equipment while the German data do not. The data for the United States plants apparently also include additional equipment for dust collection; highly automatized systems for measuring raw material inputs; more elaborate conveying equipment, and more elaborate building and storage facilities.

Investment data for plants in developing countries are now brought in for purposes of comparison. In Table 3 are presented data on the investment costs for plants which result either from estimates or from actual construction records in these countries. Data for a hypothetical German plant described below are presented in the same table as Plant A. Other observations designated B to H in this study are based on unpublished data made available to the United Nations.

An attempt was made to make the data comparable as far as possible. The cost of power plants, when included in the estimates, was excluded. Additional costs necessitated by the particular characteristics of the project such as remoteness of the site, which necessitated the provision of housing facilities for plant personnel, access roads, railroad extensions, etc., were also excluded. The costs of ocean freight, insurance, and local transportation of equipment were retained in the comparison. The estimates in these proposals are based mainly on European equipment prices, adjusted to prices of 1960 in order to take account of the difference in the dates to which the estimates relate.

In addition, a large international firm with experience in the cement industry has provided estimates of a range of unit fixed investment costs

corresponding to selected scales of operations for plants which are generally suited to the conditions of the under-developed countries (see Table 4). It is stated that such plants, including quarries, cover basic minimum equipment requirements and building storage facilities; transport costs for imported equipment, installation of the equipment and land preparation have been taken into account.

Both sets of data show variation in unit costs with scale similar to that in the developed countries. The general level of costs for the seven proposed or actual plants is higher than that presented for the Federal Republic of Germany and somewhat higher than the minimum levels suggested by cement industry experts. In part, the differences between the data taken from the developing countries and those for the German plants reflect the additional costs of ocean freight, import profits, internal transportation and handling of the equipment. As to the cost of construction, while this tends to be lower in developing countries due to lower labour costs, the high costs of imported materials which are used in these installations tend to offset the former.

On the other hand, the figures in both sets are considerably lower than those corresponding to the United States practice. With respect to this difference, it has been pointed out earlier that the United States cost data cover the cost of a large number of quality control equipment which is not generally found in the under-developed countries and the use of elaborate dust collecting equipment.

Further discussion of the possibilities of reducing investment costs through substitution of labour for capital is dealt with below, in connexion with the discussion of the data on labour inputs.

As a guide to the composition of fixed investment expenditure, the following ranges of costs, as suggested by cement experts, are given. Quarry and plant equipment account for 50 to 60 per cent of the fixed investment for plants without power generating equipment, quarrying equipment being some 5 to 10 per cent of total. Building and construction costs generally account for 30 to 35 per cent and miscellaneous administrative and engineering expenses account for the remainder. An additional 10 per cent (i.e., 20 per cent of equipment cost) may be added for expenses of transport in the case of imported equipment while the installation of power plants may add 10 to 15 per cent to the fixed investment costs. These data are of orders of magnitude similar to those suggested by the data for individual plants which are shown in Appendix I to this study.

## Section 2

### Analysis of Labour Requirements

There are two principal problems relating to labour requirements which are explored in this section. The first relates to the influence of scale of operations on labour inputs; the second is concerned with labour capital substitution and will be examined in the light of the discussion above on capital requirements.

Data on labour requirements for cement production for different scales of operation of plant indicate the total requirements increase very slightly

with increases in size of plant; consequently, labour inputs per unit of output fall sharply as scale increases. Data which are available for a wide range of size of plant in Japan, the U.S.S.R. and the United States are shown in Chart 2 and Table 5. These figures refer to production workers only; allowances must be made for supervisory and administrative personnel.

Estimates for selected countries of labour inputs, expressed in terms of man-hours per ton of cement, are contained in Table 6. These have been estimated on the basis of aggregate industry-wide statistics. It is interesting to observe that there are generally minor differences in the average level of labour inputs among the western European countries and the United States, while the difference between India and the other countries is significant; the latter point shall be discussed below.

As indicated in the discussion of investment requirements, the capital input data for the Federal Republic of Germany and the United States lead to the expectation that labour inputs in the Federal Republic of Germany would be higher than in the United States. Comparable investment data are not available for other European countries to permit an evaluation of the variations in these instances.<sup>8/</sup>

On the basis of detailed statistics available for the cement industry in Japan, the U.S.S.R. and the United States, an attempt has been made to analyze inputs of the various components of the labour element; these data appear in Table 7. This comparison is, of course, subject to many errors including the possibility of differences in definition and scope of the various categories of labour. Judging by the description found in the

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<sup>8/</sup> A study of the cement industry in the United Kingdom which appeared in The Structure of British Industry, edited by Duncan Burns (Cambridge 1958) indicates that the equipment in this industry is relatively old.

sources, the content of the category "production and related workers" in Japan and the United States would seem to be conceptually close to "workers" in the U.S.S.R. The Japanese data exclude quarry labour, although it is possible that this item is included in the estimate of non-production employees. It is, nevertheless, felt that for the purpose of the rough comparison which is being undertaken at this point these data are sufficiently similar in definition.

It can be seen that the divergencies in labour inputs are not uniform for all groupings. This is more readily obvious if the data are rearranged in the form of relatives with figures for the United States assumed equal to 100. The relative man-hours per ton in the major categories are as follows:

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Item	U.S.A.	Japan	U.S.S.R.
Quarrying	100	--	150
Plant Operation			
Direct	100	100	250
Indirect	100	200	400
Administration	100	275	275
	<hr/>	<hr/>	<hr/>
Total labour	100	150	300

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The previous discussion of capital inputs indicated that for the U.S.S.R. these inputs were high but noted the difficulties involved in the conversion problem. The data on labour inputs suggest that in fact there is considerably

less investment requirement per unit of output in the U.S.S.R. Moreover, as will be seen below, power input per unit of output which is a crude indicator of mechanization is also lower in the U.S.S.R., than in the United States. This may be due to the relatively low level of mechanization of material handling, in-plant transportation and various other auxiliary operations in the U.S.S.R. cement industry; there are indications to that effect in the literature<sup>9/</sup> and the data of Table 7 appears to corroborate this situation.

In the case of Japan, the lack of data on capital requirements prevents further evaluation. It has been observed that also in Japanese industry material handling and other operations are carried out with a relatively low level of mechanization.

The data in Table 7 support this observation. On the other hand, as regards direct labour inputs, the Japanese condition seems to correspond closely to that of the United States.

Table 8 indicates that labour input per ton of cement in several of the above-mentioned plants relating to developing countries also shows, as might be expected, a declining trend with increasing size. This table indicates further the use of a large labour force for quarry operations in plants B and C. The substantially higher labour requirements in the latter operations would seem to reflect the substitution of labour for capital, as appears from the following estimates of investment in quarry as percentages of total equipment costs in five of these plants.

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<sup>9/</sup> See, for example, Loginov, op.cit., p.117; M.F.Iurov, "Nekotorye voprosy komplekanoi mekhanizatsii i avtomatizatsii" (Some problems of comprehensive mechanization and automation), Tsement, No. 6, 1960.

<u>Plants</u>	<u>Percentage of Total</u>
B	5.9
C	5.1
F	9.6
G	8.1
H	7.9

Moreover, from the description of the equipment used in plants F, G, and H, there appears to be a considerable amount of transport machinery not related to the quarrying operations as such but which is used to convey the crushed stone from the quarry or primary crusher. The substitution of labour for capital thus seems to be even greater than indicated by the above data. Nevertheless, it should be kept in mind that there are limitations to the extent to which quarry equipment can be replaced.<sup>10/</sup>

It was pointed out in the discussion of investment requirements that, while it was possible to vary capital inputs in quarrying operations, the order of magnitude of savings through substitution of labour was small relative to total investment. Labour input data, on the other hand, indicate

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<sup>10/</sup> Many of these factors have been explored in a study on "Earth-Moving Operations", published by the United Nations in Bulletin for Industrialization and Productivity, No. 1, op. cit. Among these factors may be cited the smallness of the site which limits the amount of labour that can be used, and the capacity of the cement plant itself, as well as the physical limitations inherent in manual handling of heavy rock.

that, in spite of the small magnitude of capital saving, the increase in labour inputs in quarrying operations can be very large.<sup>11/</sup> As can be seen from the data in Table 8, labour inputs in quarrying operations can increase by as much as ten times, increasing the total labour inputs by as much as fifty per cent. This of course reflects in part the decrease in labour coefficient associated with scale; nevertheless it serves to illustrate the order of magnitude of possible capital labour substitution.

With respect to the administrative and technical personnel required both in developed and developing countries, it should be pointed out that many of the differences among countries reflect organizational and institutional arrangements characteristics of the countries concerned.

Attention was drawn at the beginning of this section to an estimate of labour inputs in India which are far in excess of that estimated for the more advanced countries. The source from which this estimate has been taken indicates that the data exclude quarrying operations, but gives no further indication of the factors leading to this situation. Recent studies of the cement industry in India indicate that a very large proportion of the plant in operation is extremely old and requires considerable labour inputs to maintain production. In these circumstances there is a tendency to fabricate spare parts on the site, an operation which is highly labour-intensive. This consideration would not apply in estimating labour requirements for a newly established industry.

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<sup>11/</sup> This statistical peculiarity has already been noted in the study by the United Nations Secretariat of earth-moving operations. It was found in one case that the capital stock per unit of excavation required by a mechanized technique was about twice that required by a labour-intensive one; at the same time the latter required an input of labour per unit of excavation 15 times higher than the former. See "Capital Intensity and Costs in Earth Moving Operations", Bulletin on Industrialization and Productivity, No. 3, op. cit.

On the basis of the discussion above, particularly with regard to the information available for new plants in under-developed countries, a rough indication of production labour requirements in these countries can be given by the following figures providing the range of magnitudes (assuming 2,400 hours per man-year):

<u>Annual Capacity of Plant</u> <u>(In thousand tons)</u>	<u>Number of workers required</u> <u>(per thousand tons)</u>
50	1.4 - 1.7
100	1.1 - 1.4
200	0.9 - 1.2
300	0.8 - 1.0
400	0.7 - 0.9

To summarize, labour inputs per unit of output vary significantly with size of operation. Moreover, there are variations corresponding to alternative methods of materials handling in the plant proper while a considerable latitude exists with respect to quarrying operations.

Section 3

Other Inputs

A. Fuel

Fuel inputs represent a substantial share of total operating costs in the manufacture of cement. The choice between the energy sources is dependent upon local conditions, the relative prices of coal, gas and fuel oil and the capital costs associated with the use of each source. The technical factors bearing upon this choice are beyond the scope of the present study.

In the view of a number of experts in this field, there appears to be no significant variation in unit fuel requirements with changes in scale of operations. There is some evidence of slight fuel savings in the larger kilns but these are not significant. The principal factor affecting fuel needs is the choice between use of either of the two basic processes since the wet process requires somewhat more fuel than the dry process. In Table 9, data on average fuel inputs (expressed in terms of million kilo-calories per ton of cement), are given for a number of countries.

The differences among countries can be seen to be relatively minor. The estimate given as a production norm for the U.S.S.R. reflects the estimated consumption for newer plants with recent technical innovations to save fuel. It is reported that the Japanese industry is currently making considerable efforts to reduce fuel requirements through the improvement of kiln design and the use of heat reclaiming devices. With respect to the data for the U.S.S.R., it has been reported that the desire of the

government to mechanize output from the existing plants in the particular year for which the data had been collected has led to a utilization of kilns over their rate of capacity with consequent higher fuel expenditure.<sup>12/</sup> Data for recently built plants in the United States indicate that such plants require fuel inputs of the same order of magnitude as the norms indicated for the U.S.S.R.

Low fuel inputs have been projected for the new plants in the developing countries for which data are analyzed in this study. The dry process plants (Plants B and C in the earlier tables) which employ gas as fuel are estimated to require 1.2 million kilo—calories per ton of cement. The wet process plants (Plants F and G, using gas and furnace oil respectively) are estimated to require 1.39 million kilo—calories. It can be seen that the fuel requirements of these new plants using new equipment are comparable to those of new plants in developed countries, as mentioned in the previous paragraph.

The possibilities for reducing fuel input by redesigning basic equipment now in use have received some attention by technologists. It appears that the amount of fuel that can be saved through redesign or modification of machinery is of the order of 15 per cent; the possible net saving should of course take into account the cost of the equipment changes and the fact that these modifications would require some additional maintenance.

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<sup>12/</sup> See Loginov, op. cit., page 126.

B. Electric power

There appears to be little change in electric power consumption with changes in the scale of operations. The power inputs are largely related to the nature of the raw material inputs and also to the quality of the final product.<sup>13/</sup>

On the basis of aggregate data average consumption of power in the United States in 1959 was 129 kilowatt hours per ton, while in Japan in 1957 the comparable figure was 138 kilowatt hours per ton.

In the U.S.S.R., consumption is estimated at 100 kilowatt hours per ton. The considerably lower figure for power consumption in the U.S.S.R. reflects a number of the above factors. First, there appears to be some evidence that, on the average, softer raw materials are used; second, the quality of the cement is on the average different from that used in other areas. Finally, the lower level of mechanization in the ancillary processes, such as materials handling, which was noted above in the discussion of capital requirements, reduces power input. It would appear in this connexion that Japanese power consumption should also be lower than in the United States in view of the similar situation with regard to materials handling, so that the higher input of energy in Japan should reflect primarily the nature of the raw materials used in cement manufacture.

In developing countries, power consumption for the above-mentioned Plant F, which intends to use soft limestone, was assumed at 110 kilowatt hours per ton, a figure close to the U.S.S.R. average. On the other hand,

<sup>13/</sup> Particularly soft raw materials, such as marl and chalk, require less grinding. In the U.S.S.R., consumption per ton of cement varies from 35 to 40 kilowatt hours per ton for chalk to 120 kilowatt hours per ton for hard limestone.

Plant F where harder raw materials will be used, power consumption was assumed at a somewhat higher level, 120 kilowatt hours per ton. The proposed power consumption figures for both plants are based on actual performance in the country of two plants, one using hard and the other soft limestone as raw materials.

C. Other material inputs

Under the assumption made earlier that quarrying is part of the cement production process, the only raw material input which is necessary for production is gypsum. Estimates of these inputs per 1,000 tons of ordinary Portland cement range from 30 to 50 tons, i.e. between 3 and 5 per cent by weight of final product. Variations are apparently due to the quality of the raw material and that of finished product. Standards for the proportion of additives vary considerably from country to country, as do quality specifications for final product. For example, the gypsum content of ordinary Portland cement in the United States is about 2.3 per cent; in Japan, 4 per cent; in the U.S.S.R., 9 per cent. Varieties of Portland cement can contain large proportions of additives; for example, slag-Portland cement in the U.S.S.R. contains over 50 per cent of additives, and Pozzolan-Portland, about 30 per cent.

D. Transport and shipping costs

In view of the relatively low price per unit of output, transport and shipping costs play an important role in determining the feasibility of any cement plant, and in particular, its location and size. In order to

illustrate this point the following data have been taken from a feasibility study relating to the establishment of a cement plant in a southeast Asian country. It was estimated that the cost of production in a proposed 300 thousand ton plant at a specified location would be the equivalent of \$13 per ton. Railway freight charges to two major markets located some 100 miles and 600 miles from the plant were estimated to be the equivalent of \$2.60 per ton and \$10 per ton, respectively, or some 10 to 70 per cent of production cost; this should be compared to the range of variation of about 100 per cent in the cost of production as a function of size for capacities ranging between 100 thousand to one million tons. Thus it is obvious that the size of the market and the resulting transport factor may be of a magnitude comparable to the size factor and should be carefully considered before reaching any conclusions on the establishment of individual plants. An example of the variations in unit costs of production of cement as a function of size are shown in Table 10; the data on unit costs are given only to illustrate this point and may not reflect the actual supply conditions in the individual countries.

In this connexion, mention may be made of the bulk shipping techniques developed in industrial countries in order to reduce transport and bagging costs,<sup>14/</sup> particularly where markets can be reached by water routes. This type of transport is extremely cheap for plants with very large capacities but involves some additional investment in equipment that include shipping

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<sup>14/</sup> Since local materials may be used for bagging, no estimate is provided at this time of the costs involved in this operation. See the data in Appendix I.

loading and unloading facilities which for most under-developed countries require additional foreign exchange outlay. These shipping techniques involve substantial economies of scale and they are economical if there is relatively high concentration of demand in consuming centres.

It may also be noted that for countries with limited markets and poor supplies of raw material, there are certain advantages in the establishment of facilities for storing and bagging cement imported by the above bulk shipping techniques. The establishment of such facilities would provide some employment opportunities and would also permit the marketing of cement at favourable prices, based on the low cost bulk cement from large scale producers.

A novel system of distribution which has particular interest for developing countries involves the construction of grinding mills in large cement consumption centres located at large distances from cement plants. These mills would be supplied with clinker from large scale economic plants, and grind it with locally obtained additives. Since clinker is easier to handle and is relatively impervious to spoilage and spillage losses, additional savings would ensue in packing, materials handling, storage and freight. It would also permit greater concentration of clinker production with resulting gains from economies of scale. In the U.S.S.R. which has had some experience in this field, it is felt that the system is appropriate when consumption levels at the local points are of the order of magnitude of between 40 and 50 thousand tons per year, at distances of at least between 300 and 500 kilowatts from the clinker plants.<sup>15/</sup>

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<sup>15/</sup> Loginov, op. cit., pp. 167-172.

Table 1. Composition of Unit Cost for Cement Production  
in Selected Countries  
(Percentage of total)

Item	Germany (Fed. Rep.)	U.S.S.R.	U.S.A.
Depreciation	21.6	9.6	22.5
Wages	8.2	22.3	13.9
Fuel	21.0 )	37.1	14.3
Power	12.5 )		12.6
Others	36.7 <sup>b/</sup>	31.0 <sup>c/</sup>	36.7 <sup>b/</sup>
Total	100.0	100.0	100.0

Sources: Germany (Fed. Rep.) Otto Labahn, Cement Engineers' Handbook,  
(Berlin, 1960);  
U.S.S.R. Loginov, Cement Industry, Prospects and Development,  
(Moscow, 1960);  
United States: See Appendix I to this study.

a/ Dry process plant with 100,000 ton per year capacity; item "Others" includes cost of raw materials, packing, maintenance, overhead, taxes interest on fixed capital, social security contributions and miscellaneous.

b/ Includes direct material, maintenance, overhead, interest on fixed capital, and miscellaneous.

c/ Includes value of raw and purchased materials (24.6 per cent) and miscellaneous items (6.4 per cent).

Table 2. Fixed Investment Related to Scale of Plant in Selected Countries

(In dollars per ton of capacity)

Capacity in tons per year	Germany (Fed.Rep.) <sup>a/</sup>		U.S.S.R. <sup>b/</sup>		U.S.A. <sup>b/</sup>	
	in dollars	As Percentage of cost for 200,000 ton plant	in U.S. dollars	As Percentage of cost for 200,000 ton plant	in dollars	As Percentage of cost for 200,000 ton plant
33,000	48	200	...	...	...	...
66,000	35	146	...	...	...	...
100,000	29	121	...	...	65	120
200,000	24	100	63	100	54	100
400,000	19	79	40	64	45	83
500,000	...	...	36	58	43	80
1,000,000	...	...	29	46	30	56

Sources: Same as Table 1.

<sup>a/</sup> Dry process plant.

<sup>b/</sup> Wet process plant, including power generating equipment. A ruble/dollar ratio of 8 to 1 used for conversion.

Table 3. Fixed Investment in Cement Plants Proposed for Developing Countries

(In thousand dollars )

	Plant A <sup>a/</sup> (1960)	Plant B (1959)	Plant C (1959)	Plant D (1955)	Plant E (1955)	Plant F (1960)	Plant G (1960)	Plant H (1960)
Capacity (tons per year)	100,000	66,000	100,000	100,000	200,000	335,000	400,000	400,000
Process	Dry	Dry	Wet	Wet	Wet	Wet	Wet	Dry
Machinery and Equipment Erected <sup>b/</sup>	(1,381)	(2,205)	(2,805)	(1,700)	(3,070)	(5,050)	(6,023)	(6,140)
Quarry Equipment	119	130	144	140	280	485	485	485
Cement Making								
Machinery	1,262	2,075	2,661	1,560	(2,790)	(4,565)	(5,538)	(5,650)
Burning and Cooling	...	...	...	...	1,150	2,388	2,464	2,280
Milling Facilities	...	...	...	...	490	1,307	1,416	1,580
Others	...	...	...	...	1,150	870	1,658	1,780
Building, Foundation, Silos	881	698	928	784	1,900	2,955	3,929	3,920
Utilities, Contingencies and Others <sup>c/</sup>	476	633	796	893	1,940	3,196	3,987	3,950
Total Fixed Investment	2,738	3,536	4,529	3,377	6,910	11,201	13,939	14,020
Fixed Investment Per Ton Adjusted to 1960 Prices	\$ 27.4	\$ 55.7	\$ 47.1	\$ 40.5	\$ 41.5	\$ 33.4	\$ 34.8	\$ 35.0

<sup>a/</sup> Plant A is a hypothetical German plant introduced for comparison purposes.

<sup>b/</sup> Except for plant "A", ocean freight and insurance charges are included.

<sup>c/</sup> "Utilities" include water supply and drainage facilities, vehicle pool as well as internal roads. It includes also electrical equipment such as starters, transformers, cables, high and low voltage installations, distribution boxes. "Others" include repair shop, spare parts, laboratory equipment, site development and engineering fees.

Source: Appendix I.

Table 4. Estimated Minimal Fixed Investment Costs  
per Ton of Capacity Appropriate to  
Developing Countries

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Plant Capacity Tons per year	Fixed Investment Dollars per ton
50,000	45-50
100,000	35-40
200,000	30-35
400,000	25-30

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Source: See text p. 7.

Table 5. Production Workers Related to Plant Capacities in Certain Countries  
(Production Workers per 1,000 tons annual capacity)

Plant Capacity Thousand tons per year	Japan <sup>a/</sup>	U.S.S.R. <sup>b/</sup>	U.S.A.
100	1.24	...	0.75
200	0.82	1.55	0.48
400	0.62	0.93	0.32
500	0.58	0.78	0.30
1,000	...	0.54	0.15

Sources: Japan Ministry of Labour, Yearbook of Labour Statistics, 1960, (Tokyo, 1960); U.S.S.R.: Loginov, op cit. p.191; U.S.A.: Estimates based on experts' opinions and data from a case history study of 18 new plants, published in Rock Products, (May 1958 and May 1959).

a/ Excluding quarry labour. The Japanese data were derived from statistical averages relating average man-hour per ton to several actual output scales. (See Appendix I) Because capacity utilization in the industry as a whole was 74 per cent in 1959 and an increase in production does not require a proportionate increase in the labour force. Labour force requirement when related to capacity will probably be lower than those given here.

b/ Based on data for typical plant designs in the U.S.S.R., 1958.

Table 6. Average labour productivity in major cement producing countries  
(Man-hours per ton of cement unless otherwise specified)

Country	Year	Production and related workers	Administrative and clerical staff	Total	Share of production and related workers as percentage of total
France.....	1960	1.83	0.50	2.33	77
Germany (Federal Republic).....	1958	2.25	0.23	2.48	91
	1959 <sub>a</sub> /	1.84	0.34	2.18	84
	1960 <sub>a</sub> /	1.76	0.34	2.10	84
India <u>b</u> /.....	1956	11.00	1.9	12.90	85
Italy.....	1960	2.02	0.36	2.38	85
Japan <u>c</u> /.....	1958	1.79	0.74	2.53	71
	1959	1.54	0.72	2.26	68
Netherlands.....	1960	1.19	0.25	1.44	83
Switzerland.....	1960	1.34	0.25	1.59	84
USSR.....	1958	3.51	0.62	4.13	85
	1959	3.13	0.55	3.68	85
	1960	2.86	0.50	3.36	85
United Kingdom..	1960	2.54	0.63	3.17	80
United States...	1958	1.33	0.28	1.61	83
	1959	1.22	0.26	1.48	82
	1960	1.25	0.28	1.53	82

Source:

India: Financial Trends and Productivity in the Cement Industry, Association of Indian Trade and Industry (Bombay, 1959), p.78. Estimated on the assumption of 2,400 hours per year.

Japan: Some data on the Cement Industry (Onoda Cement Company) No. 12, 1961 (mimeographed), pp. 45 to 46 (graph).

Table 6. (continued)

- United States: Output: United States Bureau of Mines, Minerals Yearbook, 1960, p.30. Employment and weekly hours paid: Bureau of Labour Statistics, Employment and Earning Statistics for the United States, 1909-1960 (Bulletin 1312), p.80. Ratio of hours paid to hours actually worked: Bureau of Labour Statistics, Monthly Labour Review, January 1962, p.36.
- USSR: Annual Output per worker: Loginov, op. cit. p.111; Tsement, No. 5, 1961, p.6. Annual hours worked: Krasnov, I.D. Ekonomika stroitel'noi industrii USSR (The Economics of the Construction Industry of the USSR), Moscow: 1960, p.263. Allowance was made for progress towards a seven-hour day in 1959-60 (from 2,280 to 2,200 hours per year). Production workers assumed to be 85 per cent of total personnel) (see Appendix I).
- Others: Output and employment: OEEC, The Cement Industry in Europe, July 1961. Hours per year adapted from ILO, Yearbook of Labour Statistics, 1961.

- a/ Based on December employment.
- b/ Excludes quarrying and includes contracted labour. The source calls the data "not comparable with other countries".
- c/ Quarry labour is excluded from published "Production workers" data, but may be included in the "Total" and (residually estimated) "Administrative".

Table 7. Average labour requirements by type, selected countries  
(Man-hours per ton of cement)

Type of labour and function	Japan (1959)		USSR (1957)		United States (1959)	
	Man-hours	Per Cent	Man-hours	Per Cent	Man-hours	Per Cent
<u>Production and related workers</u>						
Quarry.....	...	...	0.27	6.1	0.17	11.5
<u>Cement plant proper</u>						
Direct:						
Raw material preparation..	0.24	)			0.20	
Fuel preparation.....	0.06	)	0.98		0.05	
Clinker grinding.....	0.11	)			0.12	
Burning (kiln).....	0.20		0.52		0.20	
Sub-total	0.61	27.0	1.50	33.9	0.57	38.5
Indirect:						
Power plant and electrical equipment.....	0.27		-		0.06	
Equipment maintenance and repair.....	0.39		0.49		0.27	
Material handling, storage and transport.....	0.12	)	1.02		-	
Packing and shipping.....	0.15	)			0.15	
Other.....	-		0.44		-	
Sub-total	0.93	41.1	1.95	44.1	0.48	32.4
Total production and related workers.....	1.54	68.1	3.72	84.2	1.22	82.4
<u>Non-production employees</u>						
Engineering and technical.	...		0.38		...	
Clerical and office.....	...		0.16		...	
Guards, janitorial and others.....	...		0.16		...	
Sub-total	0.72	31.9	0.70	15.8	0.26	17.6
	2.26	100.0	4.42	100.0	1.48	100.0

Table 7 (continued)

Sources:

Japan: Production and related worker man-hours from Onoda Cement Company, Some Data on the Cement Industry, No. 12, 1961, p.45 (mimeographed, Japanese). Total estimated from graph, ibid., p.45. The residual, ascribed here to non-production employees, may include quarry workers.

USSR: See Appendix I for production and related workers. Other personnel estimated from percentage of total labour force in 1957 (Loginov, on.cit., p.118)

United States: Total and major breakdown from Appendix I. The breakdown of production workers is estimated from data in Tsement (Moscow), No. 2, 1961, p.30. The latter source reports an average total for the United States industry in 1959 of 1.29 man-hours, ranging from 0.475 to 2.30.

The comparability of some sub-categories between countries is not reliable. Materials handling personnel in the United States is apparently included in "Direct". In Japan, quarry labour is excluded from published production worker statistics; materials handling in the USSR includes transport of quarry materials to the plant. The major categories, however, appear to be roughly comparable.

Table 8. Estimated labour productivity in projected plants<sup>a/</sup>  
(Man-hours per ton of cement and percentage of total)

Type of labour	Plant A (100,000 tons capacity)		Plant B (66,000 tons capacity)		Plant C (100,000 tons capacity)		Plant F (335,000 tons capacity)		Plants G & H (400,000 tons capacity)	
	Per- centage	man- hours	Per- centage	man- hours	Per- centage	man- hours	Per- centage	man- hours	Per- centage	man- hours
<u>Production and related workers</u>										
Quarrying.....	24.2	0.50 <sup>b/</sup>	35.3	1.35	36.5	1.18	5.3	0.15	5.5	0.13
Plant Operation.....	58.9	1.22	49.5	1.89	49.9	1.61	70.8	2.01	68.9	1.64
Of which:										
maintenance and repair.....	...	... <sup>b/</sup>	9.4	0.36	11.1	.36	3.22	0.66	23.9	0.57
Sub-total	83.1	1.72	84.8	3.24	86.4	2.79	76.1	2.16	74.4	1.77
<u>Administrative and technical staff</u>										
Laboratory.....	4.8	0.10	2.9	0.11	3.1	0.10	0.3	0.18	6.3	0.15
Technical supervision.....	4.8	0.10	5.8	0.22	4.6	0.15	3.9	0.11	3.4	0.08
Administration.....	3.4	0.07	6.5	0.25	5.9	0.19	7.4	0.21	7.5	0.18
Security.....	3.9	0.08	—	—	—	—	6.3	0.18	8.4	0.20
Sub-total	16.9	0.35	15.2	0.58	13.6	.44	23.9	0.68	25.6	0.61
Total	100.0	2.07 <sup>b/</sup>	100	3.82	100	3.23	100	2.84	100	2.38 <sup>c/</sup>

Source: Estimated from data on labour force for each plant shown in Appendix I. Staff requirements for plant A are on a daily basis, i.e., no provision has been made for reserve labour to cover vacation and sick leave or absenteeism. Continual presence in each position was therefore, assumed, depending on the number of work days per week in which each operation is conducted (see Labahn, op.cit., p.75). For the remaining plants, it is assumed that the labour force incorporates reserve requirements, and an average actual work time of 2,400 man-hours per man-year was adopted.

a/ Plant symbols coincide with those in table 4.

b/ Excluding (contracted) quarry labour for removal of overburden and repair shop labour.

c/ Data apply to plant G. Plant H has identical requirements except for an additional .05 man-hours needed in the raw grinding department.

Table 9. Fuel inputs for cement production in selected countries  
(In million kilo-calories per ton)

Country	Yearly average	Wet process	Dry process
Japan.....	1957	1.9	1.6
U.S.S.R. <sup>a/</sup> .....	1958	2.04	1.62
United States.....	1959	2.1	1.9

Sources: Japan: Japan Productivity Center, International Cooperation Administration, The Cement Industry in Japan (Tokyo, 1958);

U.S.S.R.: Loginov, op.cit.;

United States: United States Bureau of Mines, Minerals Yearbook (Washington, 1960).

a/ Target norms for 1958 were 1.46 and 1.13-1.25 million kilo-calories per ton for wet and dry processes, respectively.

Table 10. Illustrative unit costs for selected scales of operation in certain countries

Capacity in tons per year	Germany (Federal Republic of)		U.S.S.R.		United States	
	In dollars	As percentage of cost for 200,000 ton plant	In dollars	As percentage of cost for 200,000 ton plant	In dollars	As percentage of cost for 200,000 ton plant
33,000.....	21	150	...	...	...	...
66,000.....	17	121	...	...	...	...
100,000.....	16	107	...	...	22	116
200,000.....	14	100	14	100	19	100
400,000.....	12	86	11	79	17	89
500,000.....	...	...	10	71	16	84
1,000,000.....	...	...	8	57	12	63

Sources: Same as for table 1.

## Appendix I

### Data and Sources

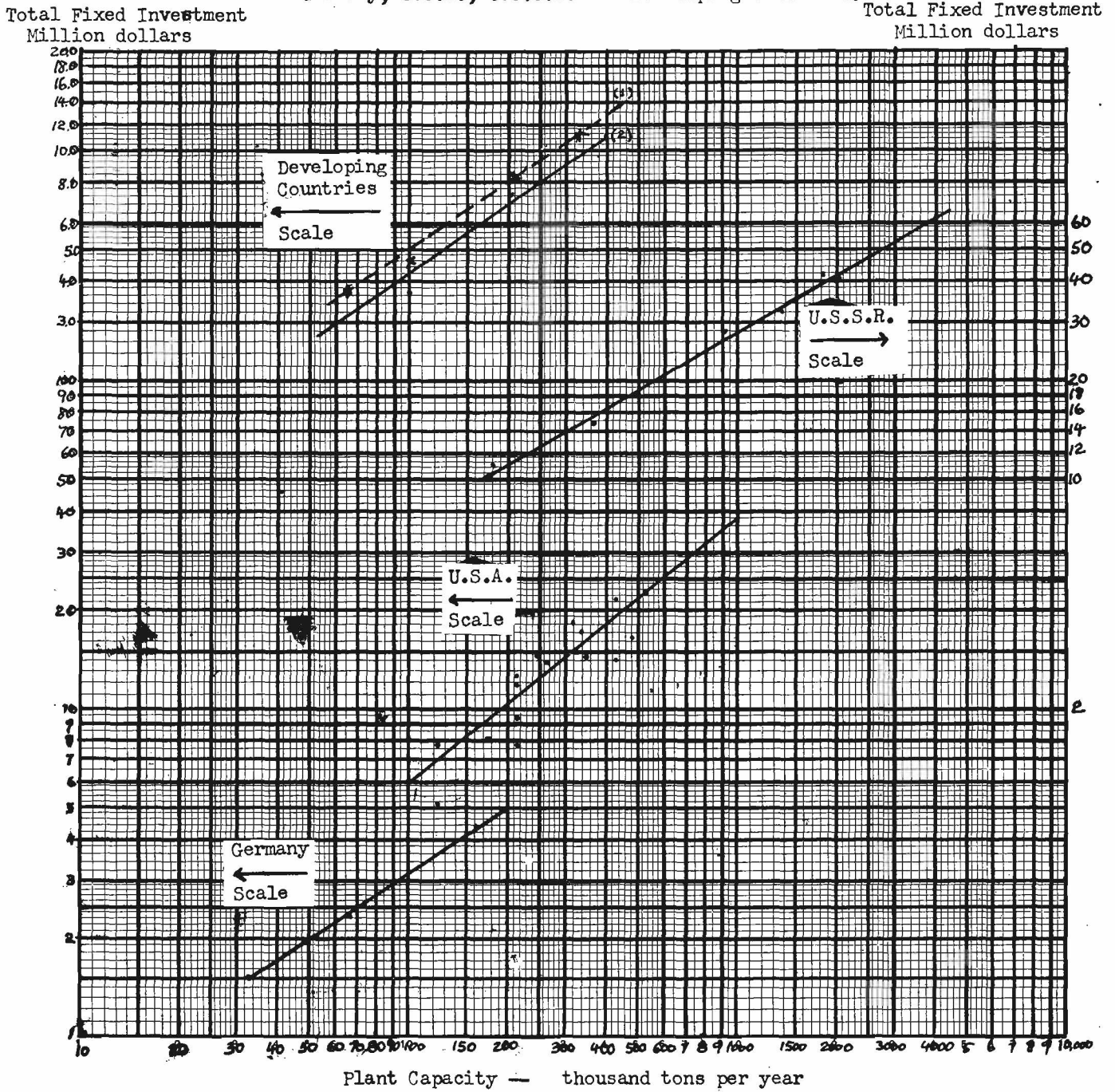
#### Introduction

The data used draw heavily on current literature in technical magazines, interviews with cement consultant firms, as well as feasibility reports for plants to be established in several developing countries. Data relating to the experience of the U.S.S.R. were derived mainly from: Loginov, Cement Industry, Prospects and Development (Moscow, 1960 (in Russian)); they relate to both industry averages, as well as model plants. Data for the Federal Republic of Germany are derived primarily from: Otto Labahn, Cement Engineers' Handbook. Data for Japan are taken mainly from: Onoda Cement Company, Some Data on the Cement Industry, October 1961, (in Japanese); Yasuhiko Ekeuchi and Masao Sato, "A Test Survey for the Analysis of Supply Conditions; a tentative estimation of production functions and capital coefficients for the cement industry", Keizai-Bunseki, Japanese Planning Agency, 1960 (in Japanese).

#### A. Raw material

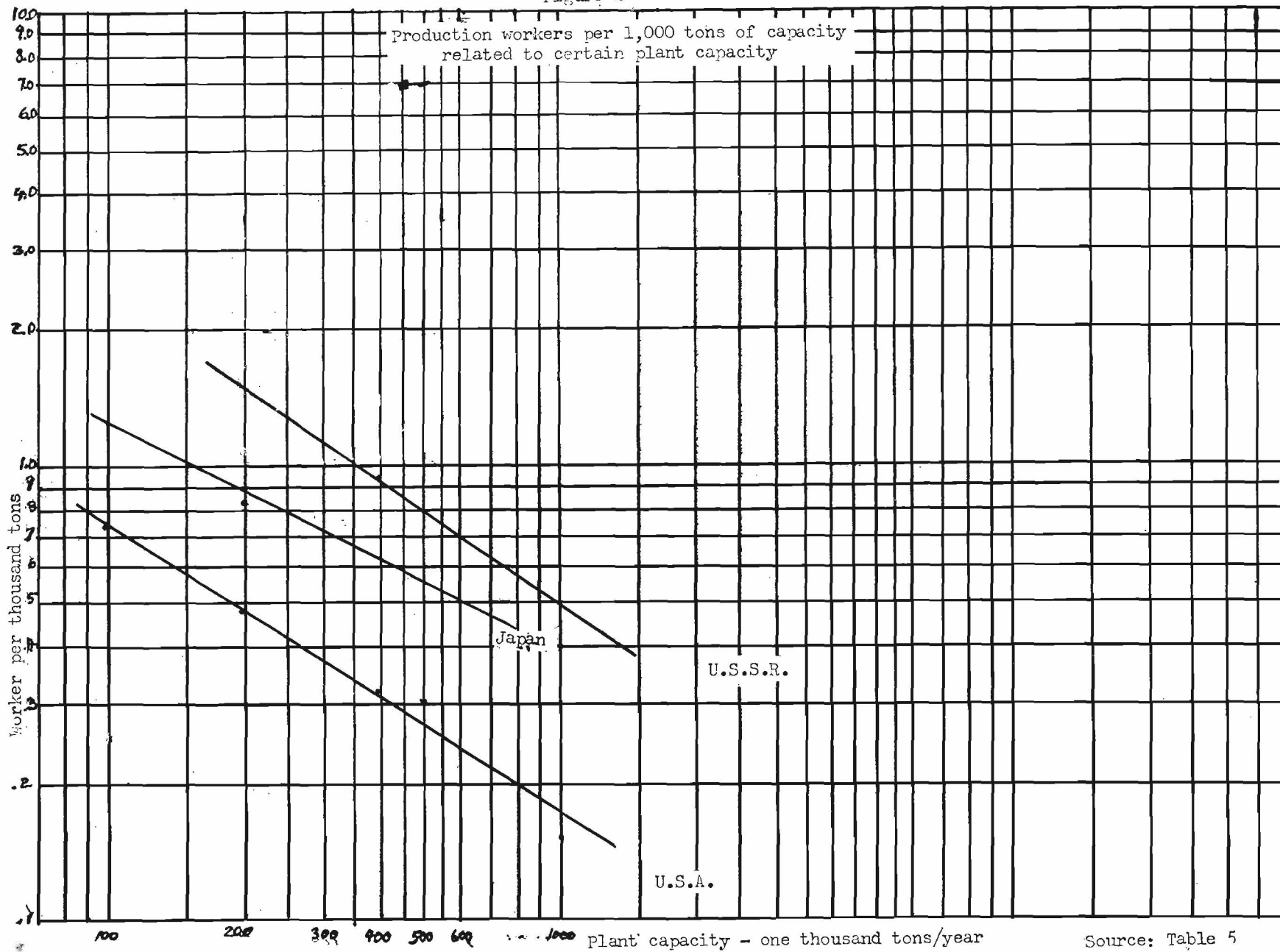
There are four basic chemical elements contained in cement: calcium, silicon, aluminum and iron. Raw material is available over most parts of the world. Following are the raw materials and their principal constituent chemical elements used in the production of cement: limestone (Ca); cement

Figure 1. Fixed Investment Related to Capacity in Germany, U.S.A., U.S.S.R. and Developing countries.



Source: Germany, U.S.A and U.S.S.R.: Same as table 1.  
 Developing countries: Tables 3 and 4.  
 Investment figures for curve (2) of developing countries adjusted to 1960 prices.

Figure 2



Source: Table 5

rock (Ca, Si, Al, Fe); marl (Ca); oyster shell (Ca); clay (Si, Al, Fe); shale (Si, Al, Fe); slag (by-product of pig iron smelting) (Si, Al, Fe); sand (Si); calcium carbonate-by-product-(Ca); sandstone (Si); bauxite (Al); diaspore (Al).

The use of the above-mentioned raw materials in cement production may be considerably limited when they contain a high percentage of an undesirable constituent, such as magnesium carbonate in limestone and other calcareous deposits, or excessive sulphur content in gypsum or pyrites.

B. Choice of processes

i. Dry vs. wet processes: The most important factor determining the choice is the water content of the primary raw material. If the water content is high, the wet process will be chosen. This is the case with marl, granulated blast furnace slag, and some clays. If water content is very low, the dry process is preferred. Between these two cases, there is no rule-of-thumb to decide between one process or the other. The following major points enter in the final decision:<sup>16/</sup> (1) wet process consumes 20 to 25 per cent more fuel per ton than dry process--very cheap fuel may favor the adoption of wet process; (2) consumption of power is less in the wet process, 4 to 8 per cent; (3) initial fixed investment costs about 10 per cent more in the dry process than in the wet process; (4) dust; less dust is generally released in the wet process than in the dry process.<sup>17/</sup> In the wet process, water is added to the raw materials to produce the slurry which usually contains 35-40 per cent water by weight.

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<sup>16/</sup> In the past, the wet process was preferred because it produced more uniform cement than dry process. This is no longer the case. Dry process equipment can be designed to produce cement which is homogenous enough for commercial purposes.

<sup>17/</sup> J. C. Witt, Portland Cement Technology (New York, Chemical Publishing Co., Inc., 1947).

ii. Other processes: The present study relates to standard portland cement.

Cement production from gypsum has been tried on a limited scale in some industrial countries. Cement is also obtained as a by-product of the sulphuric acid manufacturing process that utilizes gypsum as raw material. This process is rather highly capital intensive and in the opinion of an authority would not stand competition under normal market conditions for sulphur. This process should not however be dismissed altogether as unfeasible. It is conceivable that a country dependent on gypsum for the production of sulphur may have sufficient demand for both sulphuric acid and cement.

Other processes may be mentioned briefly: (1) Processes utilizing blast furnace slags and industrial waste, such as calcium carbonate (a by-product in manufacturing caustic soda); (2) Higher quality cements that require precision in proportioning raw mix, and in some cases, special processes and equipment, as well as additional storage facilities; they are: (a) high early strength cement; (b) low-heat hardening, including "hydraulic" cement used mainly in mass and underwater concrete construction, particularly large dams; (c) sulphate resisting cement.

C. Capacity and kiln technology:

Until quite recently, relatively small plants were considered most economical. The major economies of scale, it was felt in the United States, were obtained at the level of about 250 thousand tons per year.<sup>18/</sup>

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<sup>18/</sup> See S. M. Loescher, Imperfect Collusion in the Cement Industry, (Cambridge Harvard University Press, 1959), p.40.

Table I-1. Trends in Average Number of Kilns and Capacity per Plant in Selected Countries, End of Year

Country	and	Year	Total			Average per plant	
			Number of Plants	Number of Kilns	Capacity (in thousand tons)	Number of Kilns	Capacity (in thousand tons)
<u>Japan:</u>							
		1950	33	80	7,031	2.4	213
		Oct. 1961	49	173	31,175	3.5	636
<u>U.S.S.R.</u>							
		1950	62	192	12,472	3.1	200
		1958	83	286	37,350	3.4	450
		1965(Planned)	102	384	75,000	3.8	735
<u>United States:</u>							
		1950	152	...	45,855	...	300
		1960	176	...	73,850	...	420

Sources: Japan

-- Some Data on the Cement Industry: op.cit. p.91; Yasuhiko Ekeuchi and Masao Sato, "A Test Survey for the Analysis of Supply Conditions; a tentative estimation of production functions and capital coefficients for the cement industry," Keizai-Bunseki, Japanese Planning Agency, 1960, p.53.

U.S.S.R.

-- Loginov, op.cit., pp. 61,77, and 195; I.I.Kholin, "O tipe i moshchnosti namechaemykh k stroitel'stvu tsementnykh zavodav (On the type and capacity of cement plants slated for construction)", Tsement No. 2, 1958, p.12.

United States

-- United States Bureau of Mines, Minerals Yearbook for appropriate year.

The following table shows standard kilns and corresponding capacities for recently built plants in the United States and norms for model plants in the U.S.S.R.

Table I-2. Standard Kilns and Plant Capacities, Canada, United States and U.S.S.R.

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<u>Capacity tons per year</u>	<u>Number of Kilns and Dimension (diameter X length in meters)</u>
<u>I. Canada and U.S.A.</u>	
120,000	1 kiln - 3.05 x 122
210,000	" " - 3.50 x 130
260,000	" " - 3.66 x 137 or 3.73 x 130
340,000	2 kilns - 3.44 x 122
430,000	" " - 3.66 x 137
510,000	" " - 3.50 x 122 <sup>a/</sup>
1,000,000	2 kilns - 5.03 x 4.57 x 4.88 x 140.21 <sup>a/</sup>
<u>II. U.S.S.R.</u>	
230,000	2 kilns - 3.0 x 2.7 x 3.0 x 127 <sup>a/</sup>
450,000	" " - 3.6 x 3.3 x 3.6 x 150 <sup>a/</sup>
675,000	3 kilns - 3.6 x 3.3 x 3.6 x 150 <sup>a/</sup>
900,000	2 kilns - 4.5 x 170

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<sup>a/</sup> Dumbbell type kilns. Instead of one uniform diameter, they have two or more diameters extending over certain lengths of the kiln.

Sources: Canada and United States: "Case History Study of Ten New Cement Plants" and "Case History Studies of Eight Cement Plants Installed in 1958", Rock Products, (May 1958 and May 1959).

U.S.S.R.: Loginov, op.cit.

Table I-2 indicates that capacities of up to 260,000 tons per year may be built with one technological line. In the United States practice, starting with 340,000 tons, two or more technological lines prevail. In the U.S.S.R. experience, two technological lines start at 230,000 tons capacity. Returns to scale and the advisability of continuous cement production while overhauling equipment suggest the feasibility of planning at least two technological lines. Four technological lines are the maximum under U.S.S.R. planning norms.

From the point of view of developing countries, the lower limit to the range of scales may be of particular interest. Rotary kiln plants with capacities ranging between 35,000 and 50,000 tons per year have been built. Recent improvements in the automatic shaft kiln plants (discussed below), that are particularly adapted to low capacities, make them worthy of close consideration in this regard.

D. Initial fixed investment

1. Federal Republic of Germany. Total initial fixed investment for a rotary dry process plant with a capacity of 300 tons per day is estimated at 12 millions DM. The cost distribution is indicated in the following table.

Table I-3. Fixed Investment, Germany (Fed.Reo.), Plant A

Item	(in thousand DM)	Percentage of Total
Cement-making machinery, erected	5,000	43.5
Refractory material, installed	300	2.6
Electrical equipment, installed	300	2.6
Building, foundation, silos	3,700	32.2
Workshop and laboratory	450	3.9
Quarry equipment	500	4.4
Rail trades, water supply, drainage	400	3.5
Vehicle pool and works roads	450	3.9
Store (spare parts)	400	3.5
Total	11,500	100.0

Source: Otto Labahn, Cement Engineer's Handbook (Berlin, 1960).

The electrical equipment item comprises: motors, starters, distribution boxes, cables in the factory, transformers, high and low voltage installations, lighting. These costs do not include cost of power plant, land, forming the company, investigation of material, and starting up the quarry. The above cost figure was multiplied by the following factors to arrive at the estimated initial investment for the various capacities.<sup>19/</sup>

0.55 for 100 tons per day  
0.84 for 200 tons per day  
1.25 for 400 tons per day  
1.50 for 500 tons per day  
1.70 for 600 tons per day  
2.60 for 1,200 tons per day<sup>20/</sup>

2. United States. Estimates of initial fixed investment were based mainly on the cost of initial investment of 18 new plants built in the United States in the period 1956 to 1960. Case histories for 18 new cement plants constructed during this period were published in Rock Products (May 1958 and May 1959). Initial investment was adjusted to prices in 1960. The index used was based on "Marshall and Stevens Annual Index of Comparative Equipment Costs for Cement Manufacturing" and "Engineering News-Record Index of Heavy Construction Costs".<sup>21/</sup> The price indices are given below (They are weighed 70 per cent for equipment, 30 per cent for construction):

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<sup>19/</sup> See: Otto Labahn, op. cit.

<sup>20/</sup> The factor for 1,200 tons per day was entrapolated.

<sup>21/</sup> Chemical Engineering (March 6, 1961), pp. 115-116.

3. India

Table I-4. Fixed Capital Cost per Ton of Capacity  
for Various Cement Plants in India

Year	(1) Actual or Estimated Investment in Fixed Capital (in million rupees)	(2) Plant Capacity (in thousand tons)	(3) Fixed Investment per Ton (in current rupees)	(4) Inflating Factor Index 1961 = 1.00 <u>a/</u>	(5) Fixed Capital Cost per Ton in 1951 prices (in rupees)
1940	5.6	100	56	2.06	115
1949	9.4	50	189	1.15	217
1949	11.0	115	96	1.15	110
1950	11.9	115	104	1.11	115
1950	13.5 <sup>b/</sup>	115	117	1.11	130
1951	16.8	150	112	1.00	112
1956	7.9 <sup>c/</sup>	100	79	...	...
1956	12.0 <sup>d/</sup>	200	60	...	...

Source:

a/ The index was computed by estimating a weighted average of the "Index for Capital Replacement Cost, 1938-1953: Chemical and Allied Plant" (for machinery) and an index of sales value per ton of output of cement (for building costs). The former was weighted at twice the importance of the latter, based on the balance sheet distribution on fixed assets between machinery and plant. The computed indices are as follows:

Year	Index
1939	100
1940	109
1949	194
1950	202
1951	224

b/ A hypothetical plant.

c/ An actual expansion.

d/ A planned expansion.

These data have not been discussed in the text as information on the nature of the plants involved was not available in sufficient detail to permit analysis.

4. Other countries

The following estimates of capital cost per ton of annual output by the wet process were prepared by a United Nations technical assistance expert for a southeast Asian country. The data relate to 1955.

<u>Capacity</u>	<u>Capital Cost in Pounds Sterling per Ton of Annual Output</u>	
	<u>with power plant</u>	<u>without power plant</u>
200 tons per day(app.65,000 tons per year)	17	16
300 tons per day(app.100,000 tons per year)	14	13
400 tons per day(app.125,000 tons per year)	12	11

It was estimated that dry-process plants with similar capacities would cost between 10 and 20 per cent more. The investment cost for a 300 ton per day wet process plant, at 1955 prices, was as follows:

Table I-5. Fixed Investment, Plant D

Item	Cost (in thousand pounds sterling)
1. All cement-making machinery including reduction gears grinding media,(first charge) and fire backs	350
2. Electric motors with switchgear and starters, etc.	85
3. Generating plant steam turbo alternators or 3a <u>Alternative</u> -transformer station equipment (20KV) (20,000)	155
4. Quarry equipment—drilling machines, one excavator and dumpers, <u>appr.</u>	50
5. Laboratory equipment	5
6. Repair workshop equipment and tools for erection	15
7. Freight by sea (no insurance), <u>appr.</u> :	50
8. Landing charges and duty, <u>appr.</u>	70
9. Transport to site	12
10. Erection (including unloading)	75
11. Civil Engineering work—building, roads,drains,etc.	280
12. Railway Sidings	25
13. Fuel Oil Tanks	9
14. Water Supply installation and lighting	20
15. Supervision, insurances and office expenses	40
16. Contingencies and consulting engineering fees with steam power plant - total	<u>100</u> 1,341
alternative with transformer station - total	1,206

The following tables give details of fixed investment for 6 plants. These data are based on feasibility reports prepared for several developing countries and are based on unpublished materials.

Table I-6. Capital Investment, Plants B and C (Dry Process), 1959 (in thousand dollars)

Item	Plant B 100,000 tons per year	Plant C 66,000 tons per year
<b>Materials (f.o.b.):</b>		
quarry equipment	130	144
kiln	365	480
cement mill	112	144
other mechanical equipment including crushers, mills, etc.	324	416
storage, measuring, and control equipment, laboratories, etc.	639	836
Ocean freight (10 per cent)	157	202
Transport to site (3 per cent)	<u>48</u>	<u>60</u>
Sub-total materials	(1,775)	(2,282)
<b>Erection:</b>		
supervisory and professional labour	174	202
local labour	198	264
erection equipment	<u>57</u>	<u>57</u>
Sub-total erection	(429)	(523)
Buildings, etc.	620	840
Auxiliaries	78	88
Housing for 18 and 15 men	214	228
Design 5.4 per cent and 5.6 per cent	174	214
Contingencies 7.5 per cent	247	313
Interests 6 per cent	<u>212</u>	<u>269</u>
Total fixed capital	3,749	4,757
Working capital	<u>310</u>	<u>420</u>
Total capital	4,059	5,177

Table I-7. Capital Investment, Plant E with Annual Capacity  
of 200,000 Tons (Wet Process)

Item	Estimate cost, f.a.s. port	
	(in thousand dollars)	(in percentage)
<u>Construction cost estimates (1955):</u>		
Quarry and clay pit	86	1.0
Rock crushing	137	1.6
Clay handling	26	0.3
Raw mill	179	2.1
Flotation equipment	144	1.7
Slurry department	75	0.9
Burning and coaling	908	10.5
Coal handling and burning	147	1.7
Clinker grinding and gypsum handling	212	2.5
Cement storage and shipping	130	1.5
General, etc.	385	4.5
Electrical equipment and transmission	<u>379</u>	<u>4.4</u>
Sub-total	(2,808)	(33 )
Power plant and auxiliaries	1,115	12.9
Building material, including housing and railroad	1,522	17.7
Spare parts	232	2.7
Ocean freight and insurance	<u>793</u>	<u>9.2</u>
Sub-total	(3,662)	(42 )
Design of complete plant	391	4.5
Construction and installation of equipment	718	8.3
Technical assistance during start-up and initial operation	<u>42</u>	<u>0.5</u>
Sub-total	(1,151)	(13 )

Table I-7 (Continued)

Item	Estimate cost, f.a.s. port	
	(in thousand dollars)	(in percentage)
Preliminary engineering first and second phase	140	1.6
Preliminary (limestone investigation and analysis)	75	0.9
Supervision and inspection	175	2.0
Construction		
Housing for plant personnel	140	1.6
Utilities for housing area	25	0.3
Access road to plant	20	0.2
Communication facilities	50	0.6
Fence, paving and lighting for lower areas	<u>20</u>	<u>0.2</u>
Construction sub-total	( 255 )	
Logistical support for contractors and field pv.	55	0.6
Contingency for cost variation, etc.	<u>300</u>	<u>3.5</u>
Sub-total	(1,000 )	(11.6)
Grand total	8,621	100.0
Actual expenditures (9 April, 1959)		
Procurement costs:		
Cement machinery and equipment	3,439	
Power plant equipment	1,159	
Spare parts for machinery	363	
General construction material	539	
Cement	226	
Lumber	196	
Reinforcing steel	181	
Structural steel buildings	745	
Construction and erection equipment	173	
Pol supplies	51	
Administrative supplies	<u>51</u>	
Sub-total	7,123	

Table I-7 (Continued)

Item	Estimate cost, f.a.s. port	
	(in thousand dollars)	(in percentage)
<u>Service costs:</u>		
Preliminary Engineering	137	
Design fee	39	
Procurement fee	87	
Procurement services	13	
Construction fee	174	
Construction services	713	
Supervision and inspection	235	
Operational technical assistance	<u>94</u>	
	1,844	
Grand total	8,967	

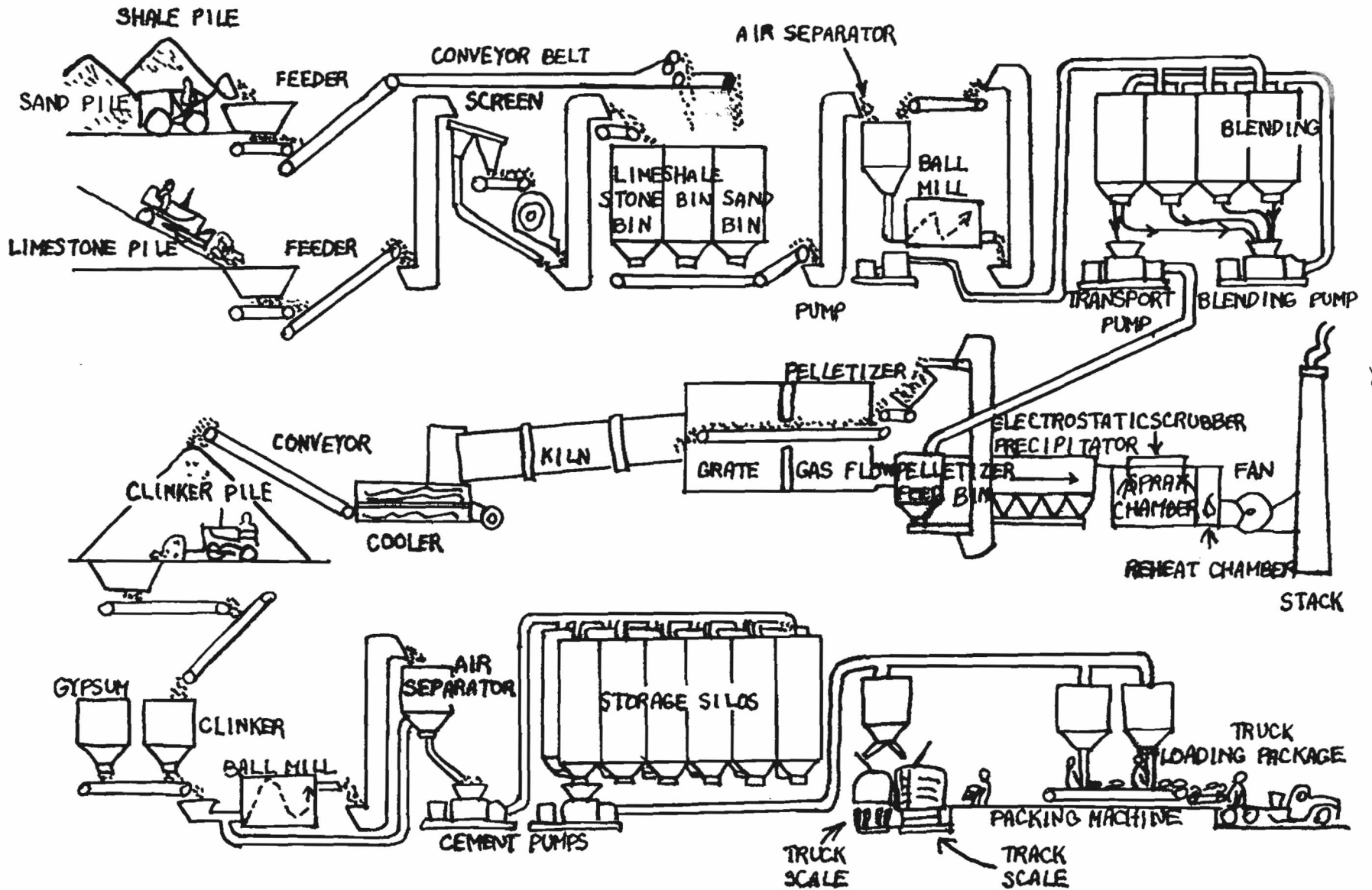
Table I-8. Capital Investment, Plants F, G and H  
(in thousand dollars)

Item	Plant F		Plant G		Plant H	
	335,000 tons annual capacity wet process		400,000 tons annual capacity wet process		400,000 tons annual capacity wet process	
	Foreign currency	Local currency	Foreign currency	Local currency	Foreign currency	Local currency
Quarrying	485	30	485	248	485	248
Raw materials handling and storage	347	216	1,089	519	1,089	519
Milling facilities	1,307	402	1,416	466	1,589	521
Raw meal handling facilities	105	207	115	253	244	220
Burning and cooling	2,388	871	2,464	1,000	2,283	980
Clinker handling	115	111	113	117	113	117
Storage, packing and Loadout	303	592	341	780	341	777
Plant service and buildings b/	262	264	262	284	262	284
Utilities	1,113	699	284	445	264	427
Electric power and distribution c/			1,015	566	1,015	566
Mobile equipment	83	1	151	3	151	3
Site development	34	296	35	282	35	282
Contingencies	<u>601</u>	<u>369</u>	<u>707</u>	<u>499</u>	<u>717</u>	<u>496</u>
Total	7,143	4,058	8,477	5,462	8,588	5,440
Total cost, local plus foreign currency	11,201		13,939		14,028	

Table I-8 (Continued)

- a/ Cost is based on prices from the Federal Republic of Germany, Denmark, and Italy. Quarry equipment and all electrical based on United States prices.
- b/ Building costs are based on structural steel frames and corrugated asbestos roofing and siding for factory building and concrete wall or masonry construction for service and office buildings. Structural steel fabricated and shipped from Europe.
- c/ Since cost of power plant is excluded, this item probably includes electrical equipment, motors and other electrical items for distribution of electricity. In plant F, these items are probably included under utilities.

# FLWSHEET OF A CEMENT PLANT



E. Prospectus of cement plant equipment:

A list of equipment normally used in a modern United States cement plant summarized from case studies is given below:

1. In quarrying:

shovel  
drill  
truck  
primary crusher            )  
secondary crusher        ) (in wet process if hard material used)  
vibrating screen         )  
apron feeder  
conveyors, bucket feeders, travelling crane

2. In Cement Plant

Raw Material:

weighing feeder  
air separator  
ball or ring roll mills  
kiln feeder  
dryer (for dry process)  
apron feeder  
vibrating screen  
conveyors, bucket elevators  
slurry tank equipment (in wet process only)

Clinker:

kiln  
weighing feeder  
air separator  
cement cooler  
ball mills

conveyors, bucket elevator  
vibrating screen  
clinker crusher  
dust collectors  
auxiliary emergency drive for kiln  
coal storage, handling, pulverizing and burning equipment,  
or fuel oil storage, heating, pumping and burning equipment  
clinker storage bin  
gypsum storage bin

3. For storage, packing and shipping:

cement storage bin  
packaging hopper, and machinery

4. Power plant:

standby generating unit

5. Laboratory equipment:

6. Miscellaneous

pumping equipment, water storage, maintenance equipment,  
fire protection equipment.

F. Data on labour input in various countries

1. Federal Republic of Germany:

Table I-9. Labour Requirements<sup>a/</sup> Plant A  
(100,000 tons per year plant)

---

<u>Item</u>	Number of Workers
Quarrying (lime marl)	
production (drilling and blasting)	3
shovel operators	2
dumper drivers	2
fitters and maintenance men	3

---

Table I-9 (Continued)

Quarrying (clay)	
production (drilling and blasting)	2
dragline operators	2
engine drivers	2
fitters, maintenance men, compressor operators	<u>4</u>
	20
Plant	
Preliminary crushing	2 labourers
Raw material grinding	3 mill attendants
Cement grinding	3 " "
Coal grinding	3 " "
Kiln installation	3 burners
Kiln installation	3 helpers
Raw meal silo	3 labourers
Cement silo	3 "
Clinker store	3 crane drivers
Packing plant	3 packers
Packing plant	3 helpers
Laboratory	3 helpers
Store	2 labourers
Artisans	3 fitters
Artisans	3 electricians
General labour	9 helpers
Checkers	<u>3 gate-keepers</u>
	55
Total personnel:	
Salaried	
Works manager	1
Foreman burners	3
Foreman fitter	1
Laboratory technician	1
Bookkeeper	1
Correspondence clerk	<u>1</u>
	8

a/ These figures do not include labour requirement in repair shop.

Source: Otto Labahn, Cement Engineers' Handbook, Berlin, 1960.

To prepare the cost estimates appearing elsewhere in this paper, it has been assumed that the same labour force is needed for smaller plants. The following estimates have been made for labour force requirements for 200,000 tons per year and 400,000 tons per year capacity plants:

	<u>200,000 tons per year</u>	<u>400,000 tons per year</u>
Quarrying	28	36
Plant	62	74
Salaried	10	11
	<hr/>	<hr/>
Total	100	121

2. Japan

Table I-10. Labour Requirements in Japan by Departments and Scale of Operation, 1959

(man-hours<sup>a/</sup> per ton of cement)

Operation or Department <sup>b/</sup>	Scale of Operation in Thousand Tons per Year					
	All Plants Covered	Under 200	200 to 300	300 to 400	400 to 600	600 and Over
<u>Direct Labour</u>						
Drying and Mining	0.24	0.48	0.28	0.25	0.22	0.23
Fuel Handling	0.06	0.10	0.06	0.08	0.05	0.05
Rotary kiln	0.20	0.36	0.23	0.20	0.18	0.18
Finish mill	0.11	0.23	0.13	0.16	0.09	0.08
Sub-total	0.61	1.17	0.70	0.69	0.54	0.54
<u>Indirect Labour</u>						
Material and Fuel Porting	0.12	0.18	0.13	0.12	0.10	0.12
Boiler and Turbine	0.13	0.24	0.13	0.17	0.10	0.12
Power	0.14	0.25	0.18	0.16	0.11	0.12
Repair (by repair shop proper)	0.23	0.49	0.25	0.24	0.24	0.18
Repair (by department crew)	0.16	0.43	0.21	0.13	0.15	0.12
Packing	0.15	0.25	0.13	0.18	0.15	0.13
Sub-total	0.93	1.84	1.03	1.00	0.85	0.79
<u>Total</u>	1.54	3.01	1.73	1.69	1.39	1.33

Source: Japan Ministry of Labour, Yearbook of Labour Statistics, p.72.

a/ Production and related workers only. Excluded, non-production workers that include supervisory and inspection workers not directly engaged in production operations, clerks and technical workers.

b/ Quarrying operations apparently excluded.

Estimates of labour force for different size plants were made on the basis of the above data relating man-hour per ton of output to scale of operation. A man-year of 2,440 hours was assumed. Based on the above data, the following labour force requirements were derived:

<u>Scale of Output</u>	<u>Number of Workers required</u>
100,000 tons	124
250,000 tons	178
350,000 tons	240
500,000 tons	290

### 3. United States

Table I-II. Labour Requirements by Type in Three United States Plants, 1955

(man-hours per ton of cement)

Item	Plant 1 (Wet Process, 84 per cent capacity utilization )	Plant 2 (Dry Process, 97 per cent capacity utilization )	Plant 3 (Dry Process, 91 per cent capacity utilization )
<u>Operation and function:</u>			
<u>Direct:</u>			
Quarrying	0.23	0.05	0.23
Raw material preparation	0.12	0.16	0.16
Coal crushing	0.05	0.05	--
Burning (kiln)	0.17	0.10	0.32
Finish grinding	0.16	0.10	0.07
<u>Indirect:</u>			
Repair	0.16	0.30	0.40
Power	0.09	0.08	0.20
Warehouse	0.02	0.02	--
Packing and shipping	0.20	0.15	0.17
<u>Administrative</u>			
Technical Supervision	0.08	0.12	--
Clerical and Office	0.06	0.22	0.31
Laboratory	0.06	0.05	--
Guards	0.08	0.13	0.25
Total	1.48	1.53	2.11

Source: Onoda Cement Co., Some Data on the Cement Industry, No. 12 (Oct.1961), p.45 (mimeographed, Japanese).

4. U.S.S.R.

Table I-12. Labour Requirements by Departments and Size of Plant  
in U.S.S.R., 1957

(man-hours per ton of cement)<sup>a/</sup>

Item	<u>Annual Output Per Plant (in thousand tons)</u>				<u>Average for 66 Plants</u>	
	Under 200	200 to 400	400 to 600	Over 600	Man- hours	Percentage of total
Quarrying <sup>b/</sup>	0.09	0.43	0.25	0.18	0.27	7.3
Production shops (ex. quarry) of which:	(3.21)	(1.88)	(1.52)	(1.06)	(1.50)	(40.3)
Crushing, Milling and Drying	1.83	1.20	1.04	0.71	0.98	26.3
Others <sup>c/</sup>	1.38	0.68	0.48	0.35	0.52	14.0
Auxiliary shops <sup>d/</sup>	3.98	2.61	1.89	1.39	1.95	52.4
Repair shops	--	--	--	--	0.49	13.3
Material Handling, Trucking and Packing	--	--	--	--	1.02	27.3
Other	--	--	--	--	0.44	11.8
Total	7.28	4.92	3.66	2.63	3.72	100.0

Source: Loginov, op. cit., pp. 113, 117 and 122.

a/ Original data in workers per 100,000 tons of output per year, or tons per worker per year was converted to man-hours by assuming an average of 2,280 hours per worker year. (See Krasnov, I.D., Ekonomika stroitel'noi industrii USSR. (Economics of the Construction Industry in the U.S.S.R. (Moscow Gosstroizdat, 1960), p.263. Non-worker personnel (engineering and technical, clerical, guards, etc.) are excluded.

b/ Estimated as residual.

c/ Presumably the kiln department (burning).

d/ The breakdown of "auxiliary shops" labour is estimated from percentages given in Loginov, op.cit., p.117.

U.S.S.R. (Continued)

Table I-13. Labour Requirements by Operation in Typical Plants  
in U.S.S.R.

(man-hours per ton of cement)

Operations	Plant 1	Plant 2	Plant 3	Plant 4
Production of Clinker				
(All operations, including quarrying and burning)	-	0.39	0.31	0.79
Additive drying	0.37	0.23	0.29	0.35
Cement grinding	0.25	0.18	0.22	0.32
Packing and filling	0.07	0.03	0.10	0.15
Repair and auxiliary shops	0.39	0.64	0.79	1.05
Transport-and-storage	0.62	0.45	0.59	0.58
Laboratory	0.06	0.07	--	--
Total	1.76	1.79	2.30	3.24

Source: A. J. Pen'kov, "O tekhniko-ekonomicheskikh pokazatel' iakh po trudu na tsementnykh zavodakh", ("Techno-economic labour indicators for cement plants"), Tsement (Cement), No. 3, 1960, p. 20.

Note: Plant 1 does not produce its own clinker.

Plant 2 has easily quarried chalk deposits as lime source (Loginov, op.cit., p.24).

Plant 3 does not have its own limestone source - buys raw materials and uses metallurgical by-products.

U.S.S.R. (Continued)

Table I-14. Distribution of Labour Force in Plants of a Soviet Cement Combine

(in percentage of total labour requirement)

Operations	Industrial Labour Force
Operation of technological equipment (including intra-shop transport in basic production)	23.2
Quarrying (raw material extraction)	6.1
Raw material transport (truck)	5.3
Repair work - all types	30.2
Cement packing and loading-and-unloading operations	12.8
Building repair and construction shops	4.1
	81.7 <sup>a/</sup>

Source: M. F. Iurov, "Nekotorye voprosy Kompleksnoi mekhanizatsii i avtomatizatsii" ("Some problems of comprehensive mechanization and automation"). Tsement (Cement), No. 6, 1960, pp. 3-6.

<sup>a/</sup> The remaining 18 per cent are presumably non-worker (technical, clerical, etc.) personnel.

Table I-15. Distribution of Labour Force in Soviet Cement Industry, 1957

Item	Labour Force (in percentage of total)
Workers (production and auxiliary) and apprentices	84.2
Engineering and Technical Employees	8.7
Clerical and Office Employees	3.6
Other (Janitors, Watchmen, Firemen, etc.)	3.5
Total Labour Force	100.0

Source: Loginov, op. cit., p. 118

5. Others

Data in Tables I-16 to I-18 are derived from unpublished sources. For additional information see Section D in this Appendix.

Table I-16. Labour Force for Plants B and C  
(number of persons engaged)

Type of Labour	Plant B with 66,000 tons capacity per year		Plant C with 100,000 tons capacity per year	
	Supervisory and Professional (Foreign Employees)	Local Employees	Supervisory and Professional (Foreign Employees)	Local Employees
<u>Quarrying</u>				
Operator		3		3
Driver		4		6
Unskilled Labour		30		40
<u>Plant Production</u>				
Raw material, operator		3		3
Kiln "		3		3
Mills, "		3		3
Packing and shipping, operator		3		3
Maintenance and repair:				
skilled	1	6	2	8
unskilled		3		5
General plant, unskilled		30		40
<u>Administration and Technical</u>				
Laboratory:				
Chemist	1		1	
Assistant	1	1	1	2
Electrical Technician:				
Engineer	1		1	
Supervisor	1		1	
Mechanical Technician:				
Engineer	1		1	
Supervisor	3		3	
Administration:				
Admin. manager		1		1
Technical Manager	1		1	
Clerks	1	2	1	2
Typists, etc.		2		3
Total	11	94	12	122

Table I-17. Labour Force for Plants F, G and H  
(number of persons engaged)

Type of Labour	Plant F <sup>a/</sup> (335,000 tons capacity per year)	Plants G and H <sup>b/</sup> (400,000 tons capacity per year)
<u>Quarrying</u>	21	22
<u>Plant (production)</u>		
Secondary crushing, surge piles, storage	23	3
Raw grinding	18	18 <sup>a/</sup>
Burning and clinker cooling	27	27
Finish grinding	18	18
Silos and Baghouse	89	87
Warehouse	6	6
Maintenance	92	95
Yard Labour	8	19
Sub-total	<u>281</u>	<u>273</u>
<u>Administrative and Technical</u>		
Laboratory	25	25
Technical	15	13
Administration	30	30
Security	25	34
Sub-total	<u>94</u>	<u>102</u>
<u>Miscellaneous</u>	<u>14</u>	<u>36</u>
Total	411	433 <sup>b/</sup>

a/ Wet process.

b/ Plants G (Wet Process) and H (Dry Process) are very similar in design, and the projected staff is the same for both with the exception that Plant H requires an additional 9 men (not shown) in the Raw Grinding Department.

Table I-18. Distribution of Labour Force by Qualification, Plants B and C  
(in percentage of total)

---

Qualification	Plant B	Plant C
Local	89.5	91.0
Unskilled	60.0	63.4
Skilled	29.5	27.6
Supervisory and Professional	10.5	9.0
	<hr/>	<hr/>
	100.0	100.0

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G. Average total cost:

1. Federal Republic of Germany. Average total cost for the various capacities was computed on the basis of information available in Labahn, Cement Engineers' Handbook. In the handbook, calculations were given for 100,000 tons per year dry process plant. The plant uses lime marl and clay as raw material.

Table I-19. Average Total Cost per Ton Related to Capacity, Wet Process

(in DM)

Item	Capacity in thousand tons per year				
	33	66	100	200	400
Salaries	1.93	0.96	0.64	0.45	0.23
Wages <sup>a/</sup>	11.70	5.85	3.97	2.34	1.43
Raw material	2.41	2.41	2.41	2.41	2.41
Fuel <sup>b/</sup>	13.80	13.80	13.80	13.80	13.80
Power <sup>c/</sup>	6.00	6.00	6.00	6.00	6.00
Packing <sup>d/</sup>	5.00	5.00	5.00	5.00	5.00
Maintenance <sup>e/</sup>	3.90	3.00	2.50	2.00	1.60
Overhead	2.00	2.00	2.00	2.00	2.00
Miscellaneous <sup>f/</sup>	<u>11.42</u>	<u>9.34</u>	<u>8.31</u>	<u>7.62</u>	<u>6.94</u>
Total above items	58.16	48.36	44.63	41.62	39.41
Depreciation on fixed capital	18.00	13.64	10.80	9.18	6.98
Interest on fixed capital	<u>12.00</u>	<u>9.10</u>	<u>7.20</u>	<u>6.12</u>	<u>4.65</u>
Total	88.16	71.10	62.63	56.92	51.04

a/ Includes wages in quarrying

b/ Consumption of fuel for a wet process assumed at (1.38 million kilo-calories per ton ) 25 per cent more than dry process.

c/ Consumption of power in a wet process assumed at 85 Kwh per ton, 6 per cent less than dry process.

d/ 100 per cent packed.

e/ Repair shop wages, spare parts, lubricants. Assumed at 2 per cent of initial fixed investment.

f/ Taxes, interest, social security contributions, directors' salaries, profits, bonuses, statutory reserve, etc.. At 15 per cent of average total cost.

2. United States. The United States' experience is based primarily on data from a case history study of 18 new plants mentioned above and experts' opinion. The following table summarizes the experience of the United States:

Table I-20. United States Cement Industry, Capital Requirement, Operating Data Input-Output Coefficients Related to Standard Capacities (Wet Process)

Item	120 (1 kiln 3x122) metrics	210 (1 kiln 3.5x 130 ) metrics	260 (1 kiln 3.66x 137 ) metrics	340 (2 kilns 3.44x 122 ) metrics	430 (2 kilns 3.66x 137 ) metrics	510 (2 kilns 3.5x3.9 x122)a/ metrics	1,000 (2 kilns 5x5.57x 4.88x 140.21a) metrics
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Capital Requirements:  
(in thousand dollars)

1. Fixed Capital <sup>b/</sup>	7,000	11,250	13,200	16,000	19,000	21,000	30,000
2. Working Capital (60 days)	210	320	380	480	580	650	1,040
Total	7,210	11,570	13,580	16,480	19,580	21,650	31,040

Operating Data, through  
Shifts at 90 Per Cent  
Total Capacity:  
(in thousand dollars)

1. Material and Supplies - Total	149	244	285	364	45	511	871
Direct Material							
Limestone <sup>c/</sup>							
Clay <sup>c/</sup>							
Gypsum	22	38	46	60	78	92	180
Bags <sup>d/</sup>	37	66	79	104	135	159	311
Supplies <sup>e/</sup>	90	140	160	200	240	260	380
2. Power, Fuel and Water-							
Total	497	875	1,058	1,378	1,794	2,115	4,137
Power	227	401	485	610	822	963	1,894
Fuel	256	450	544	710	923	1,089	2,130
Water	14	24	29	38	49	58	113
3. Manpower							
(a) Direct Labour	400	510	570	700	780	810	810
(b) Indirect Labour-							
Total	82	116	126	166	166	166	166
Managers and Supervisors	30	48	48	77	77	77	77
Chemists	17	17	17	17	17	17	17
Office	17	27	32	38	38	38	38
Others	19	24	29	34	34	34	34
Miscellaneous and Contingencies <sup>f/</sup>	210	338	396	480	570	630	900
Total Operating Cost	1,339	2,083	2,435	3,088	3,763	4,232	6,884

Table I-20 (Continued)

	<u>120</u>	<u>210</u>	<u>260</u>	<u>340</u>	<u>430</u>	<u>510</u>	<u>1,000</u>
<u>Physical Inputs and</u>							
<u>Coefficients Per Ton</u>							
<u>of Output:</u>							
Limestone (in tons)	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Clay (in tons)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Bags (number of bags)	23	23	23	23	23	23	23
Power (in kwh)	115	115	115	115	115	115	115
Fuel (in million b.t.u.)	5.85	5.85	5.85	5.85	5.85	5.85	5.85
Water (in cubic meters)	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Gypsum (in kilograms) per cent of weight	40	40	40	40	40	40	40
<u>Manpower (number):</u>							
Direct Labour							
Skilled	15	19	21	26	29	30	30
Semi-skilled	15	19	21	26	29	30	30
Unskilled	45	57	63	78	87	90	90
Total	75	95	105	130	145	150	150
Indirect Labour							
Managers and supervisors	3	5	5	5	5	5	5
Chemists	2	2	2	2	2	2	2
Office	3	5	6	7	7	7	7
Others	4	5	6	7	7	7	7
Total	12	17	19	21	21	21	21
<u>Economic Coefficients, Three</u>							
<u>Shifts at 90 Per Cent of Total</u>							
<u>Capacity (in dollars per ton):</u>							
Direct Labour	3.70	2.68	2.48	2.33	2.00	1.76	0.90
Direct Material and Water	0.67	0.67	0.67	0.67	0.67	0.67	0.67
Power	2.10	2.10	2.10	2.10	2.10	2.10	2.10
Fuel	2.37	2.37	2.37	2.37	2.37	2.37	2.37
Indirect Labour and Overhead							
Cost <sup>h/</sup>	3.37	3.13	2.97	2.82	2.50	2.30	1.61
Depreciation of fixed capital	4.93	4.50	4.36	4.05	3.70	3.47	2.53
Interest on fixed capital	3.89	3.55	3.44	3.20	2.92	2.74	2.00
Average Total Cost	21.03	19.00	18.39	17.54	16.26	15.41	12.18

Source: Table calculated from data supplied by experts and data given in case history study of 18 new plants issued in Rock Product (May 1958, May 1959).

- a/ Dumbbelltype of kilns. Instead of one uniform diameter, they have two or more diameters extending over certain lengths of the kilns.
- b/ Includes plant and quarry equipment, building and storage, land, excavation, foundation and installation costs.
- c/ Included in land depreciation.
- d/ 20 per cent of production packaged.
- e/ Refractories, bricks, clay and cement, maintenance and repair parts, lubricants, hand tools, and maintenance insurance.
- f/ Includes insurance, interest, sales cost, office supplies, auditing and legal services.
- g/ Includes labour in quarry.
- h/ Includes supplies and miscellaneous.

H. Automatic shaft kiln plants:

The standard capacity for this type of plant is 100,000 tons per year, with two kilns of 150 tons per day each. The upper limit is attained with four technological lines, giving 200,000 tons per year capacity. A cement plant with a capacity as small as 25,000 tons per year is possible with one 75 ton per day kiln. These plants may be designed for easy installation, making them adaptable for remote locations. Another advantage is the possibility of relocation of such plants, provided that they are designed with that purpose in mind. It is claimed that between 80 and 90 per cent of initial investment is recoverable.

Fixed investment is about 20 per cent lower than for an equivalent dry rotary kiln plant, according to Labahn. No data are available on over-all labour requirements. According to German and Swiss experience, fuel consumption is 0.85 to 1.20 million kilo-calories per ton of clinker.

There are several important limitations of the use of automatic shaft kilns. They are adapted only to the dry process. Raw material specifications as to plasticity and uniformity must be relatively high; a lower water content is presumably also desirable as in other dry processes. Only "lean" fuels with a small volatile material content, such as metallurgical coke or anthracite, can be used in the process. One manufacturer of the kilns has recently announced a successful experiment with either oil or gas firing. The limited maximum capacity of plants equipped with shaft kilns is another consideration, particularly where market conditions show promise of exceeding the 200,000 tons per year limit.

Furthermore, cement produced by shaft kilns has been of inferior quality (less uniform) as compared to products of rotary kilns. Several manufacturers of shaft kilns, however, seem to have overcome this problem, largely through improvements in raw material and fuel preparation equipment and techniques. There is good reason to believe that a greater degree of technical know-how and operator skills is required than with rotary kilns. The more complex technology may be an important drawback to the use of shaft kilns in developing countries.<sup>1/</sup>

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1/ Sources on automatic shaft kilns:

- i) Otto Labahn, Cement Engineers' Handbook.
- ii) Herbert Hughes, "The De Roll Vertical Kiln", Mining Engineering (Dec. 1956)
- iii) Steven Gottlieb, "Shaft Kilns Solve Fuel Problems in Australia", Rock Products, (October 1959).
- iv) Nathan C. Rockwood, "Uniform Cement from Vertical Kilns in Australia", Rock Products, (March 1959).

APPENDIX II

Trends in Production, Consumption and Trade

This appendix presents background statistical data on cement covering mainly the post-war period, although data for the pre-war years 1937-1938 are given for reference purposes. The following is a summary of the trends as derived from the available data.

Since 1947, world production of cement has been steadily increasing at the rate of 9.2 per cent per annum; a lower rate of growth, 7.9 per cent annually, has obtained, however, in the last decade. The fastest growing rates are shown by the Asian countries, the centrally planned economies, and the countries of the Middle East; North America registered the slowest growth. These differentials in rates of growth resulted in changes in the pattern of cement production and in the share of various regions in total world production. Although North America and Western Europe together still account for the greater part of world total output, their share has decreased from 72.1 per cent in 1947 to 51.0 per cent in 1960.

The substantial increase in world production of cement is reflected in the level of per capita consumption. Table II-4 shows the level of per capita consumption and the historical trend of this magnitude for a selected number of countries.

Western Europe has been the most active region in international trade. It has been predominant in the export market and maintained its relatively high share of total world imports. The trend, however, has been towards a decrease in this share.

Despite the increase in local production of cement in developing regions of the world, they remained most active in the import market, except for Latin America which has consistently reduced its share of total world imports, from 37.7 per cent in 1947 to a low of 4.7 per cent in 1960. Africa remained a major importer of cement although its share in the total shows a slightly declining trend. On the other hand, Asia, the Middle East and the countries of centrally planned economies show an increasing trend for their share of total world imports. On the export side, the share of the developing countries of the world has increased from about 4 per cent in 1947 to about 27 per cent in 1960. Countries of centrally planned economies recorded also a high increase in their share of the export market.

The share of North American countries in world trade, despite their high share in world production, has been relatively low.

Net trade as depicted by net exports and net imports by regions (see Chart II-2) show that western Europe and countries of centrally planned economies have been net exporting regions. Since 1952, however, the volume of net exports of the former region shows a declining trend.

Africa, the Middle East and Latin America have been net importing regions, with the latter region achieving gradually a position of self-sufficiency. Since 1951, Africa recorded a slow downward trend in the volume of net imports.

Asia has been on the average a net importer, after the war, although since 1955, the region has been approaching self-sufficiency.

In the years immediately after the war the North American countries were net exporters, after which followed a period of self-sufficiency, a situation of net imports since 1953.

World trade comprises a small share of total world production, and has indicated a moderate downward trend (see Charts II-3 and II-4). This downward trend is explained mainly by the increase in the production capacity of developing countries and consequently the share of local output in total demand has increased while that of imports has declined. This is indicated by the significant decrease in the ratio of imports to production in Latin America, Africa and Asia.

Table II-1. World Cement Production, 1937, 1938 and 1947 to 1960

(in thousand tons and percentages)

Area	1937	1938	1947	1948	1949	1950	1951	1952
<u>AFRICA</u>								
Actual	1211	1295	1968	2115	2238	3116	3493	3754
Percentage	(1.5)	(1.5)	(2.2)	(2.1)	(1.9)	(2.4)	(2.3)	(2.3)
<u>NORTH AMERICA</u>								
Actual	21113	19166	34253	37844	38902	41928	45269	46019
Percentage	(25.9)	(21.9)	(39.7)	(36.7)	(33.7)	(31.7)	(30.2)	(28.8)
<u>LATIN AMERICA</u>								
Actual	2333	3199	5028	5344	6364	7225	7913	8892
Percentage	(2.9)	(3.7)	(5.8)	(5.2)	(5.5)	(5.5)	(5.3)	(5.6)
<u>ASIA</u>								
Actual	8731	8959	3593	4416	6748	8627	11684	12830
Percentage	(10.7)	(10.2)	(4.2)	(4.3)	(5.8)	(6.5)	(7.8)	(8.0)
<u>MIDDLE EAST</u>								
Actual	794	761	1247	1344	1511	1836	2053	1999
Percentage	(1.0)	(0.9)	(1.4)	(1.3)	(1.3)	(1.4)	(1.4)	(1.2)
<u>OCEANIA</u>								
Actual	975	1075	1180	1275	1325	1530	1390	1620
Percentage	(1.2)	(1.2)	(1.4)	(1.2)	(1.1)	(1.2)	(0.9)	(1.0)
<u>WESTERN EUROPE</u>								
Actual	36472 <sup>a/</sup>	40725 <sup>a/</sup>	27932	36038	41726	48252	53249	56992
Percentage	(44.8)	(46.5)	(32.4)	(35.0)	(36.1)	(36.4)	(35.5)	(35.6)
<u>CENTRALLY PLANNED ECONOMIES</u> <sup>b/</sup>								
Actual	9660	10385	10149	13390	16750	19765	20718	25369
Percentage	(11.9)	(11.9)	(11.8)	(13.0)	(14.5)	(14.9)	(13.8)	(15.9)
<u>CHINA (MAINLAND)</u> <sup>c/</sup>								
<u>NORTH KOREA</u>								
Actual	...	2290	749	...	660	...	2490	2862
Percentage	...	(2.6)	(0.9)	...	(0.6)	...	(1.7)	(1.8)
<u>WORLD TOTAL</u>								
Actual	81400	87500	86250	103000	115600	132400	150000	160000
Percentage	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)

Source: United Nations, Statistical Yearbook

- <sup>a/</sup> Including Eastern Germany  
<sup>b/</sup> Excluding China (Mainland) and North Korea  
<sup>c/</sup> Beginning 1951 including North Korea

Table II-1 (continued). World Cement Production, 1937, 1938 and 1947 to 1960  
(in thousand tons and percentages)

Area	1953	1954	1955	1956	1957	1958	1959	1960
<u>AFRICA</u>								
Actual	4192	4731	5347	5669	6037	6474	6622	6891
Percentage	(2.4)	(2.5)	(2.5)	(2.4)	(2.4)	(2.5)	(2.3)	(2.2)
<u>NORTH AMERICA</u>								
Actual	49184	50639	57705	61512	59182	61389	66372	62330
Percentage	(27.6)	(26.2)	(26.6)	(26.2)	(24.0)	(23.3)	(22.6)	(19.8)
<u>LATIN AMERICA</u>								
Actual	9766	10727	11967	13407	14851	15293	15772	16784
Percentage	(5.5)	(5.6)	(5.5)	(5.7)	(6.0)	(5.8)	(5.4)	(5.3)
<u>ASIA</u>								
Actual	15027	17857	18075	20989	24305	25669	29140	35750
Percentage	(8.4)	(9.3)	(8.3)	(8.9)	(9.8)	(9.8)	(9.9)	(11.4)
<u>MIDDLE EAST</u>								
Actual	2339	2654	3289	3701	4234	4538	5307	5664
Percentage	(1.3)	(1.4)	(1.5)	(1.6)	(1.7)	(1.7)	(1.8)	(1.8)
<u>OCEANIA</u>								
Actual	1880	2250	2400	2590	2862	3017	3018	3210
Percentage	(1.1)	(1.2)	(1.1)	(1.1)	(1.2)	(1.1)	(1.0)	(1.0)
<u>WESTERN EUROPE</u>								
Actual	62726	67081	75333	78793	80893	82582	92247	97929
Percentage	(35.2)	(34.8)	(34.7)	(33.5)	(32.8)	(31.4)	(31.4)	(31.2)
<u>CENTRALLY PLANNED ECONOMIES <sup>b/</sup></u>								
Actual	28971	32230	37705	40882	46801	52890	61057	70886
Percentage	(16.3)	(16.7)	(17.4)	(17.4)	(18.9)	(20.1)	(20.8)	(22.6)
<u>CHINA (MAINLAND) <sup>c/</sup></u>								
<u>NORTH KOREA</u>								
Actual	3904	4831	4863	6990	7755	10543	14196	14785
Percentage	(2.2)	(2.5)	(2.2)	(3.0)	(3.1)	(4.0)	(4.8)	(4.7)
<u>WORLD TOTAL</u>								
Actual	178000	193000	217000	235000	247000	263000	294000	314000
Percentage	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)

Source: United Nations, Statistical Yearbook

- <sup>a/</sup> Including Eastern Germany  
<sup>b/</sup> Excluding China (Mainland) and North Korea  
<sup>c/</sup> Beginning 1951 including North Korea

Table II-2 Rate of Growth in Cement Production by Regions

(Percentage per annum)

Area	1947-1960	1950-1960
Africa	9.0	7.2
North America	4.3	3.6
Central and South America	8.6	7.6
Asia	16.4	12.9
Middle East	10.8	10.2
Oceania	7.2	6.7
Western Europe	9.0	6.4
Centrally Planned Economies <sup>a/</sup>	13.9	11.6
World Average	9.2	7.9

Source: Calculated from Table II-1.

a/ Excluding China (Mainland) and North Korea

TABLE II-3 - World Trade in Cement, 1937, 1938 and 1947-1960 <sup>a/</sup>  
(in thousand tons and percentages)

Area	1937	1938	1947	1948	1949
<u>AFRICA</u>					
Import - Actual	1068	995	865	1617	2036
Imports as percentages of total imports	(18.8)	(19.7)	(19.7)	(27.0)	(26.5)
Export - Actual	30	24	20	20	28
Exports as percentages of total exports	(0.5)	(0.5)	(0.4)	(0.3)	(0.4)
<u>NORTH AMERICA</u>					
Import - Actual	328	310	199	225	383
Imports as percentages of total imports	(5.8)	(6.1)	(4.5)	(3.8)	(5.0)
Export - Actual	78	111	1168	1022	781
Exports as percentages of total exports	(1.3)	(2.2)	(26.1)	(16.2)	(10.0)
<u>LATIN AMERICA</u>					
Import - Actual	925	828	1658	1750	1755
Imports as percentages of total imports	(16.3)	(16.4)	(37.7)	(29.2)	(22.8)
Export - Actual	1	2	60	135	115
Exports as percentages of total exports	(-)	(-)	(1.3)	(2.1)	(1.5)
<u>ASIA</u>					
Import - Actual	1230	1070	367	680	1081
Imports as percentages of total imports	(21.6)	(21.2)	(8.3)	(11.3)	(14.1)
Export - Actual	1725	953	89	202	565
Exports as percentages of total exports	(28.7)	(18.8)	(2.0)	(3.2)	(7.2)
<u>MIDDLE EAST</u>					
Import - Actual	484	354	229	337	405
Imports as percentages of total imports	(8.5)	(7.0)	(5.2)	(5.6)	(5.3)
Export - Actual	76	66	1	7	17
Exports as percentages of total exports	(1.3)	(1.3)	(-)	(0.1)	(0.2)
<u>OCEANIA</u>					
Import - Actual	13	12	25	34	103
Imports as percentages of total imports	(0.2)	(0.2)	(0.6)	(0.6)	(1.3)
Export - Actual	3	3	25	8	10
Exports as percentages of total exports	(0.1)	(0.1)	(0.6)	(0.1)	(0.1)
<u>WESTERN EUROPE</u>					
Import - Actual	1245 <sup>b/</sup>	1315 <sup>b/</sup>	600	1090	1655
Imports as percentages of total imports	(21.9)	(26.0)	(13.6)	(18.2)	(21.5)
Export - Actual	3810	3600	2415	4340	5355
Exports as percentages of total exports	(63.3)	(71.0)	(54.0)	(68.9)	(68.4)
<u>CENTRALLY PLANNED ECONOMIES<sup>c/</sup></u>					
Import - Actual	402	173	455	(268)	274
Imports as percentages of total imports	(7.1)	(3.4)	(10.3)	(4.5)	(3.6)
Export - Actual	292	319	694	(567)	962
Exports as percentages of total exports	(4.9)	(6.3)	(15.5)	(9.0)	(12.3)
<u>WORLD TOTAL</u>					
Import - Actual	5700	5050	4400	6000	7700
Imports as percentages of total imports	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)
Export - Actual	6000	5100	4450	6300	7850
Exports as percentages of total exports	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)



TABLE II-3 (contd.) - World Trade in Cement, 1937, 1938 and 1947-1960 <sup>a/</sup>  
(in thousand tons and percentages)

area	1956	1957	1958	1959	1960
<u>AFRICA</u>					
Import - Actual	2275	2298	2266	2400	2848
Imports as percentages of total imports	(18.1)	(18.4)	(20.2)	(21.0)	(24.2)
Export - Actual	272	340	260	317	253
Exports as percentages of total exports	(2.1)	(2.7)	(2.3)	(2.6)	(2.4)
<u>NORTH AMERICA</u>					
Import - Actual	1304	839	616	925	719
Imports as percentages of total imports	(10.4)	(6.7)	(5.5)	(8.1)	(6.1)
Export - Actual	451	534	237	322	196
Exports as percentages of total exports	(3.5)	(4.2)	(2.1)	(2.7)	(1.9)
<u>LATIN AMERICA</u>					
Import - Actual	905	994	687	677	555
Imports as percentages of total imports	(7.2)	(7.9)	(6.1)	(5.9)	(4.7)
Export - Actual	333	219	258	337	338
Exports as percentages of total exports	(2.6)	(1.7)	(2.3)	(2.8)	(3.2)
<u>ASIA</u>					
Import - Actual	2089	2269	2226	2118	1935
Imports as percentages of total imports	(16.7)	(18.1)	(19.9)	(18.5)	(16.5)
Export - Actual	2236	2417	2192	1857	1813
Exports as percentages of total exports	(17.1)	(18.9)	(19.7)	(15.4)	(17.1)
<u>MIDDLE EAST</u>					
Import - Actual	1185	1121	1129	1328	1311
Imports as percentages of total imports	(9.4)	(9.0)	(10.1)	(11.6)	(11.2)
Export - Actual	234	498	415	897	435
Exports as percentages of total exports	(1.8)	(3.9)	(3.7)	(7.4)	(4.1)
<u>OCEANIA</u>					
Import - Actual	113	97	91	94	72
Imports as percentages of total imports	(0.9)	(0.8)	(0.8)	(0.8)	(0.6)
Export - Actual	9	31	22	19	15
Exports as percentages of total exports	(0.1)	(0.2)	(0.2)	(0.2)	(0.1)
<u>WESTERN EUROPE</u>					
Import - Actual	2662	2677	1994	2201	2560
Imports as percentages of total imports	(21.2)	(21.4)	(17.8)	(19.2)	(21.8)
Export - Actual	6699	6134	5073	5563	5196
Exports as percentages of total exports	(51.3)	(47.9)	(45.5)	(46.2)	(49.0)
<u>CENTRALLY PLANNED ECONOMIES<sup>c/</sup></u>					
Import - Actual	1998	2224	2224	1671	1745
Imports as percentages of total imports	(15.9)	(17.8)	(19.9)	(14.6)	(14.9)
Export - Actual	2800	2594	2792	2735	2321
Exports as percentages of total exports	(21.5)	(20.3)	(25.0)	(22.7)	(21.9)
<u>WORLD TOTAL</u>					
Import - Actual	12550	12550	11200	11450	11750
Imports as percentages of total imports	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)
Export - Actual	13050	12800	11150	12050	10600
Exports as percentages of total exports	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)

TABLE II-3 (contd.)

Source: The Cement Statistical and Technical Association, World Cement Market in Figures, 1913-1956 (Malmö, Sweden).  
United Nations, Trade Yearbook  
For individual countries appropriate national trade statistics publications were used.

a/ Export and import include intra-regional trade.

b/ Including Eastern Germany.

c/ Excluding China (Mainland) and North Korea.

Table II-4 - Apparent per capita cement consumption. Selected Countries, 1937, 1938 and 1947-1960

(in kilogrammes)

Area	1937	1938	1947	1948	1949	1950	1951	1952
<u>AFRICA</u>								
Kenya	...	...	5.6	11.7	22.6	31.8	34.4	40.5
Morocco	...	...	38.8	60.4	64.4	72.6	103.3	117.2
United Arab Republic	22.2	25.2	34.2	39.5	44.7	50.3	54.7	44.1
<u>AMERICA</u>								
Argentina	86.4	95.8	92.3	97.9	98.8	118.0	113.0	112.4
Bolivia	9.3	8.2	14.0	13.4	14.0	12.7	13.7	13.4
Brazil	16.7	17.0	26.0	29.7	33.8	34.4	39.7	44.8
Canada	86.6	77.4	164.6	181.4	216.4	209.4	220.7	234.5
Chile	64.8	74.1	104.9	92.6	83.4	83.2	99.1	123.6
Dominican Republic	21.2	10.0	34.7	43.8	24.6	35.1	49.6	60.6
Ecuador	11.2	11.6	14.7	14.9	21.0	20.5	24.3	26.5
Mexico	19.1	20.3	34.1	34.4	49.7	57.6	62.5	66.4
United States	154.9	143.5	216.3	234.1	233.4	258.8	267.1	272.9
Venezuela	48.3	50.4	116.8	144.2	184.5	167.1	168.1	174.4
<u>ASIA AND THE F.A.R. EAST</u>								
India	3.9	4.7	5.1	4.9	6.9	7.5	8.9	9.6
Iran	13.0	...	3.0	3.7	4.2	6.1	5.7	2.9
Japan	70.8	78.4	15.0	21.6	34.7	48.0	67.9	75.3
Pakistan	...	...	...	4.5	5.8	5.9	7.5	7.3
<u>EUROPE</u>								
Czechoslovakia	88.2	80.1	112.1	132.2	134.5	146.9	159.1	168.7
Poland	37.1	47.8	46.7	63.7	71.2	121.9	87.3	86.1
Yugoslavia	27.2	33.1	54.4	57.8	62.8	56.4	49.2	60.9

Source: Computation based on data obtained from the same sources as Tables II-1 and II-3.

a/ Provisional data

Table II-4 (continued) - Apparent per capita cement consumption.  
Selected countries, 1937, 1938 and 1947-1960

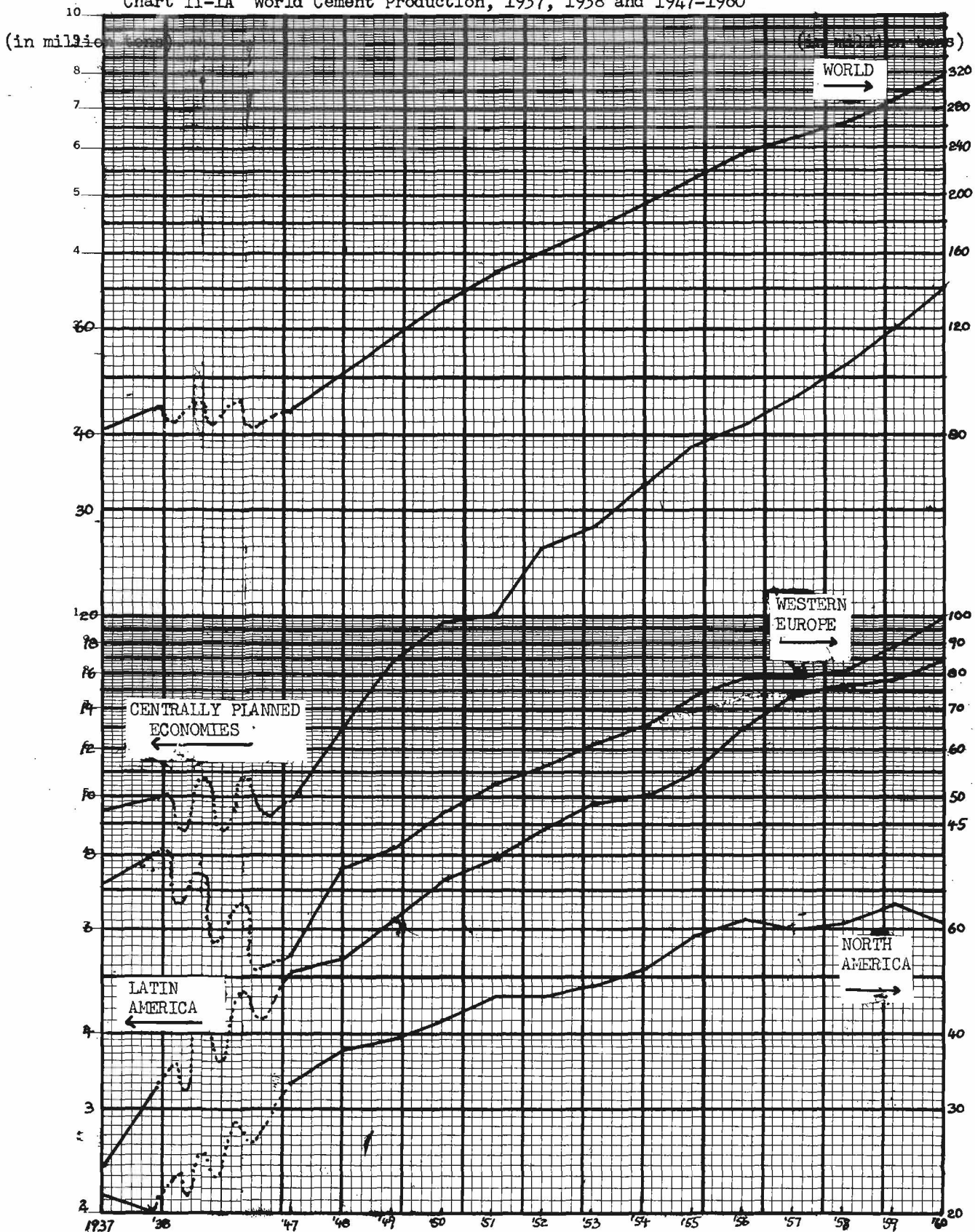
(in kilogrammes)

Area	1953	1954	1955	1956	1957	1958	1959	1960 <sup>a/</sup>
<u>AFRICA</u>								
Kenya	31.4	30.1	42.0	45.6	45.0	43.2	45.7	42.2
Morocco	106.0	96.8	88.3	77.9	57.2	45.5	35.4	60.2
United Arab Republic	44.8	48.4	58.1	59.7	52.4	52.6	53.2	60.6
<u>AMERICA</u>								
Argentina	90.0	104.2	107.9	108.4	121.4	124.5	117.3	134.5
Bolivia	11.9	10.7	12.4	11.0	9.4	9.6	9.5	8.1
Brazil	54.3	49.3	50.7	55.3	55.6	60.4	60.6	62.8
Canada	265.0	257.5	274.7	315.2	328.3	330.8	312.1	291.6
Chile	116.2	117.8	119.1	110.9	102.0	98.7	111.7	113.5
Dominican Republic	55.0	54.9	62.2	66.2	80.2	84.9	59.8	39.2
Ecuador	26.3	32.1	40.4	40.4	39.8	39.8	37.9	46.8
Mexico	64.5	63.1	69.1	76.9	83.1	79.6	81.3	88.2
United States	279.1	316.3	318.3	327.2	300.0	212.3	337.6	307.4
Venezuela	185.8	220.8	224.9	250.9	315.0	267.0	298.0	223.1
<u>ASIA AND THE FAR EAST</u>								
India	10.2	11.6	11.7	13.2	15.2	15.6	16.8	17.9
Iran	4.4	7.2	10.8	13.3	17.9	23.1	31.6	41.0
Japan	92.0	111.0	105.1	121.2	142.6	145.5	170.1	224.3
Pakistan	8.3	9.1	9.4	9.0	12.1	13.9	12.6	14.4
<u>EUROPE</u>								
Czechoslovakia	175.1	186.2	205.6	217.2	254.3	284.6	370.0	349.8
Poland	103.7	106.7	115.0	124.9	153.5	167.0	173.0	212.9
Yugoslavia	68.5	67.1	72.6	62.6	80.9	88.9	93.8	117.0

Source: Computation based on data obtained from the same sources as Tables II-1 and II-3.

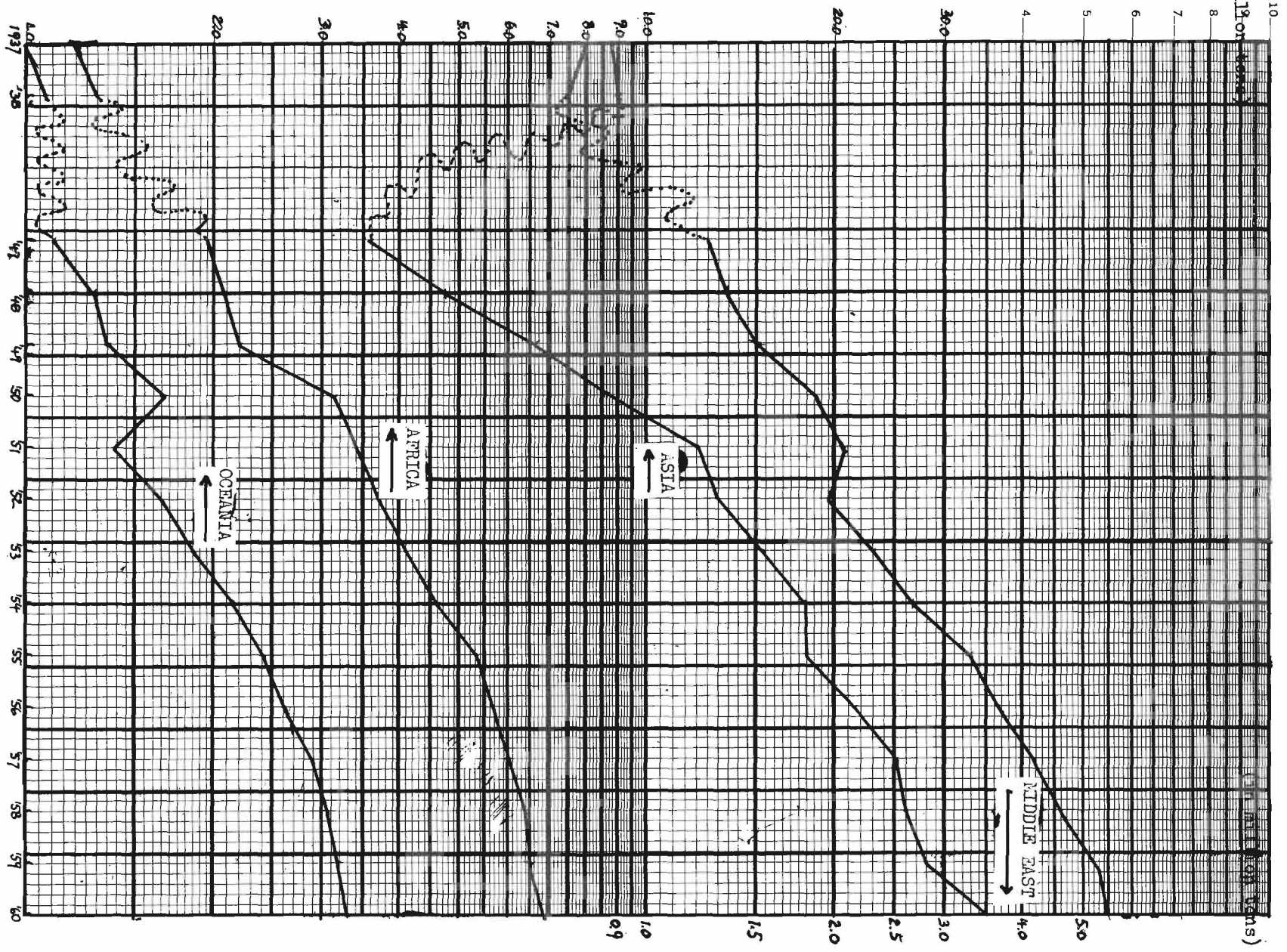
<sup>a/</sup> Provisional data.

Chart II-1A World Cement Production, 1937, 1938 and 1947-1960



Source: Table II-1

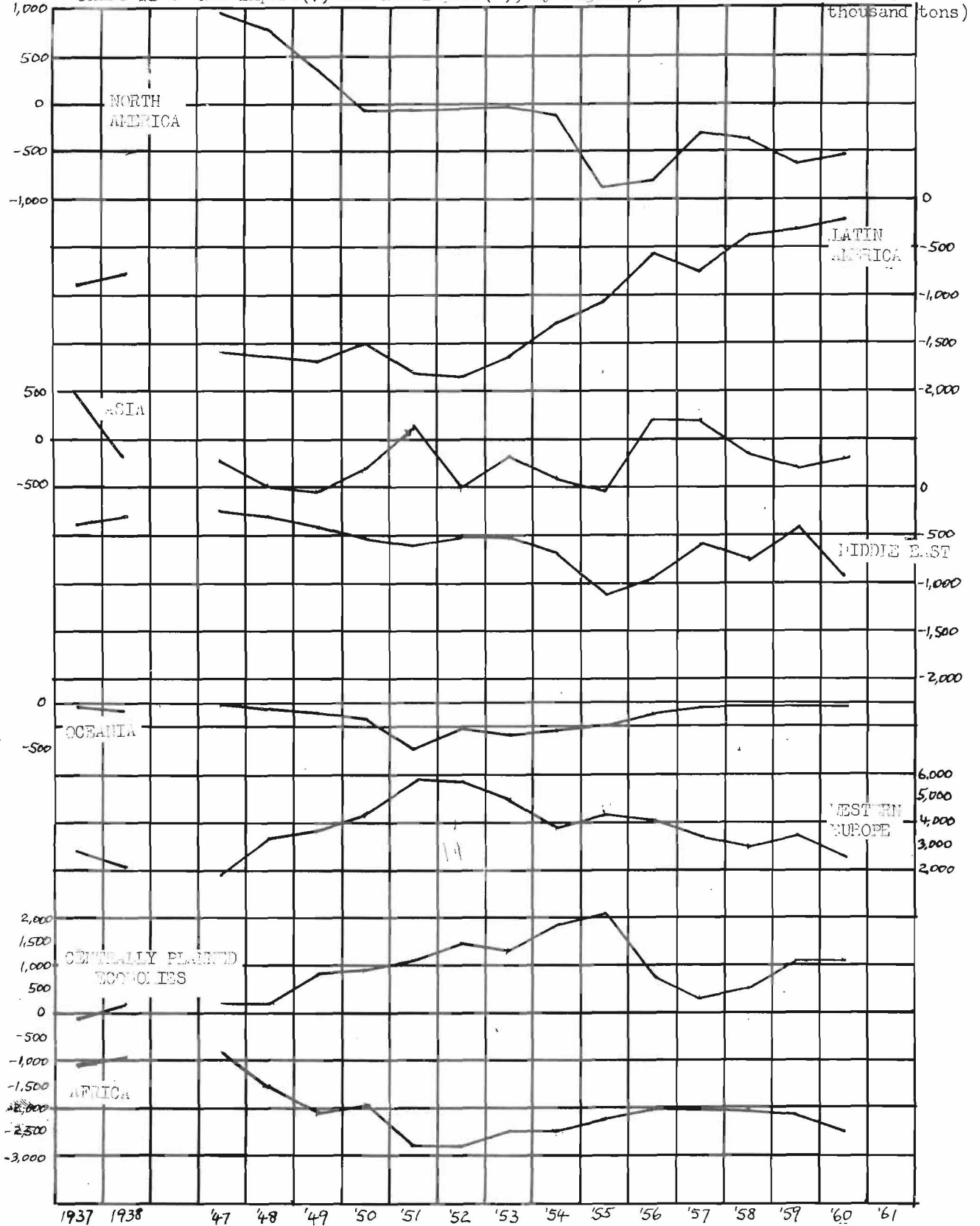
(In million tons) (In million tons)



Source: Table II-1

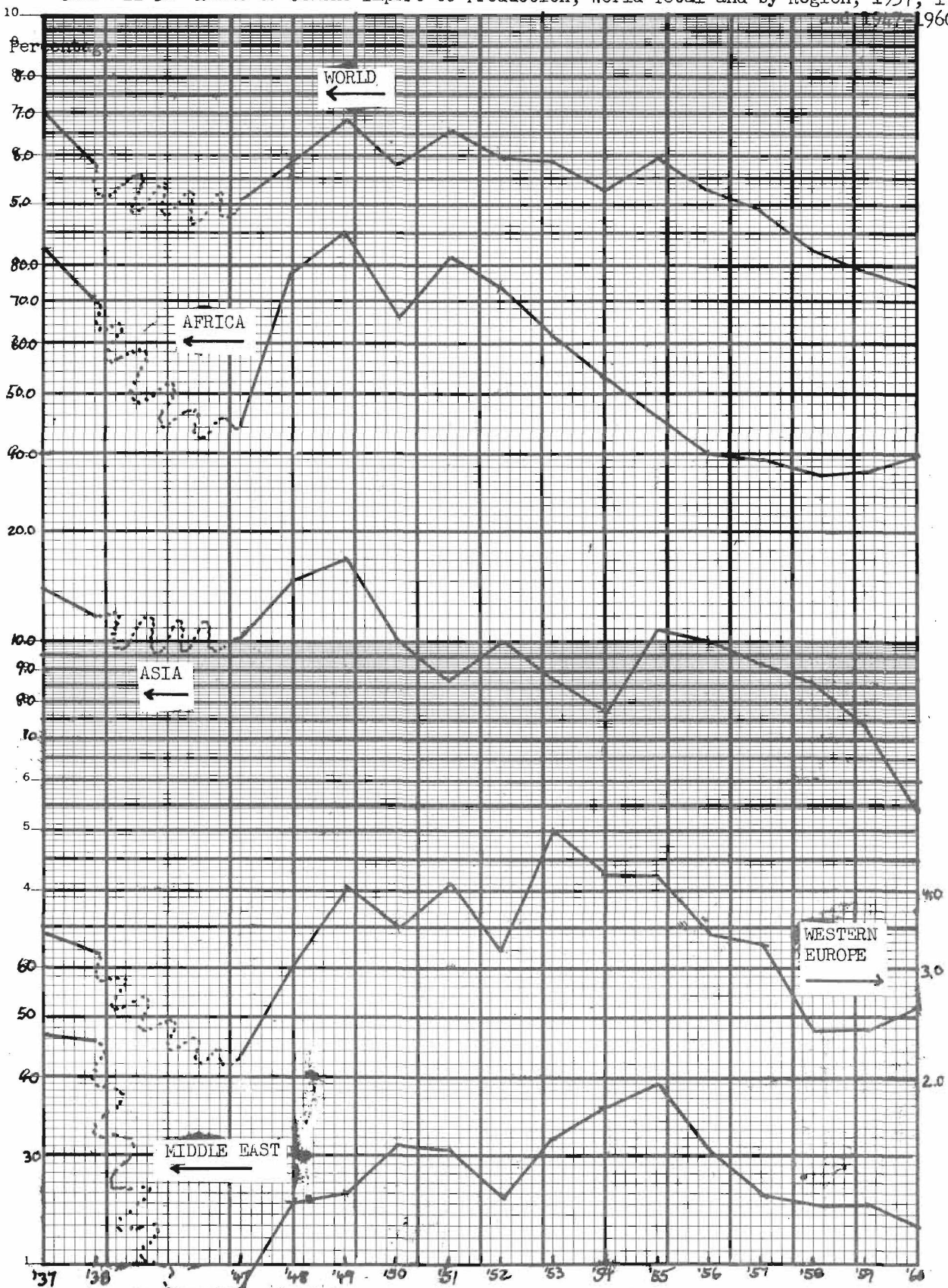
in thousand  
tons

Chart II-2 Net Export(+) and Net Import(-), by regions, 1937-1938 and 1947-1960(in thousand tons)

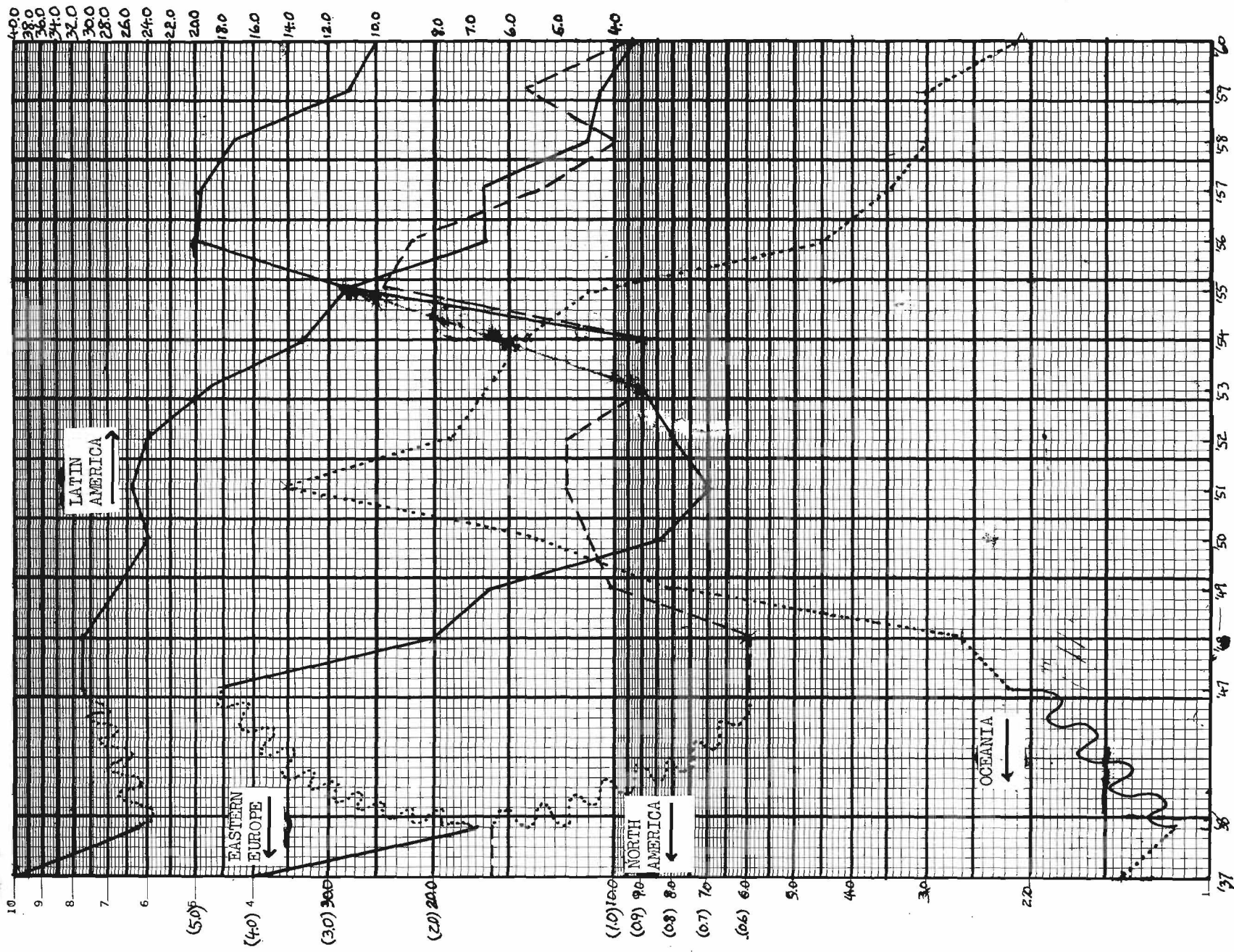


Source: Figures computed from Table II-3

Chart II-3A Ratio of Cement Import to Production, World Total and by Region, 1937, 1938 and 1947-1960.

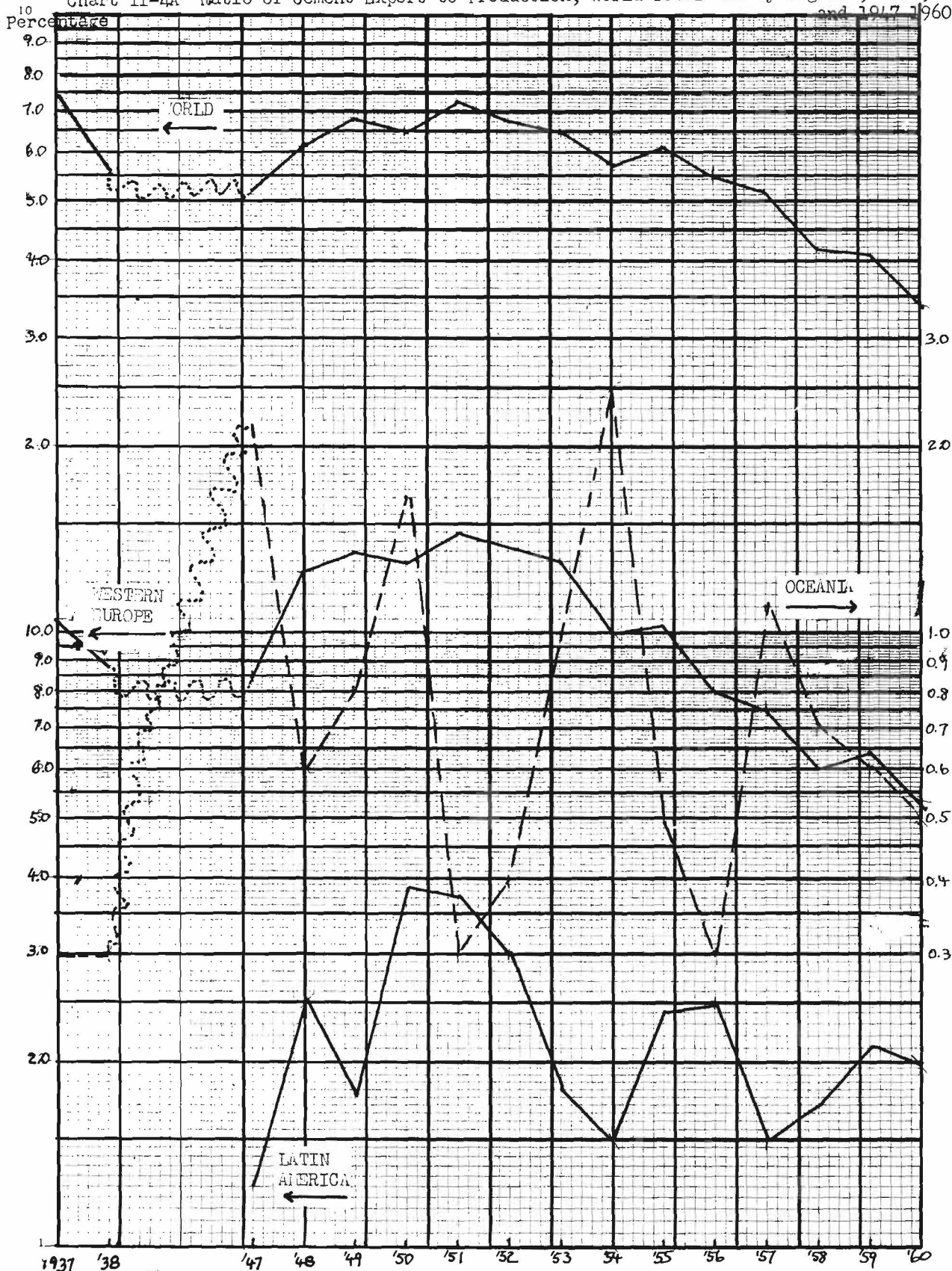


Source: Tables II-1 and II-3.



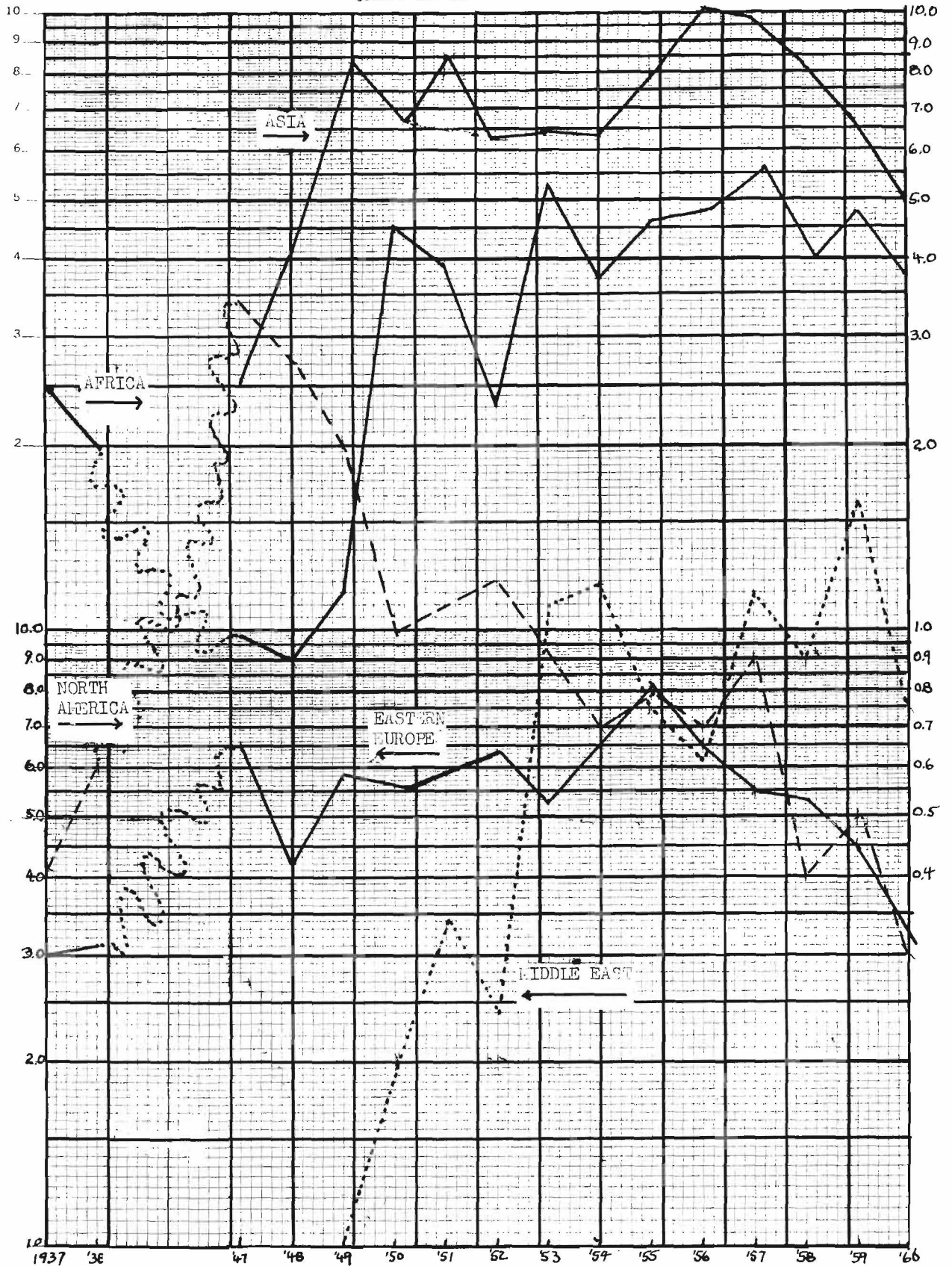
Source: Tables II-1 and II-3

Chart II-4A Ratio of Cement Export to Production, World Total and by Regions, 1937, 1938 and 1947-1960.



Source: Tables II-1 and II-3

Chart II-4B



Source: Tables II-1 and II-3