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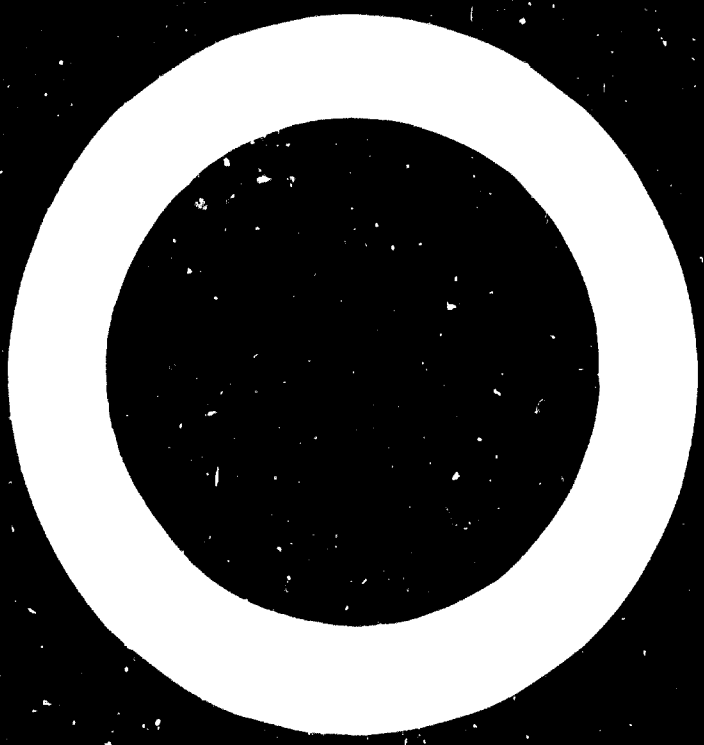
UNIDO MONOGRAPHS ON INDUSTRIAL DEVELOPMENT

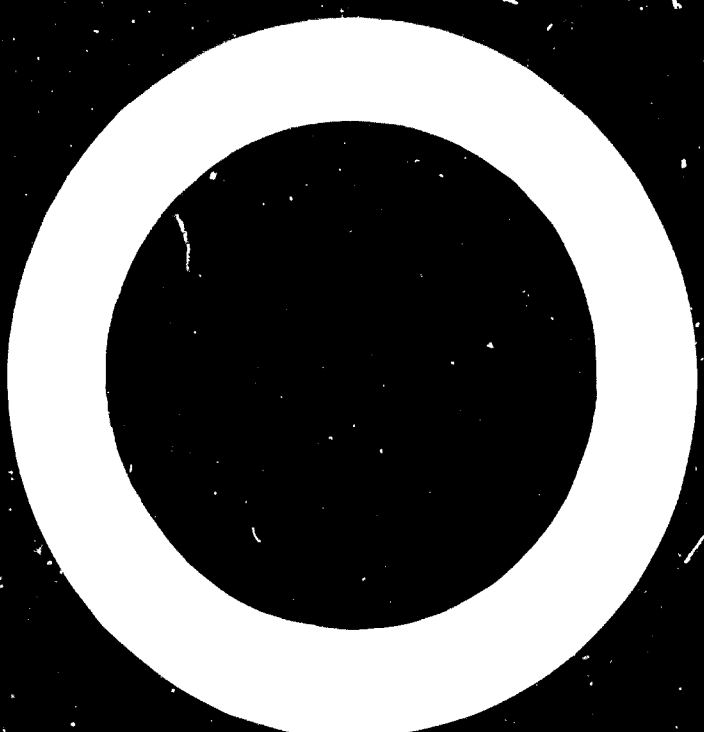
3

Industrialization of Developing Countries: Problems and Prospects

BUILDING MATERIALS INDUSTRY

UNITED NATIONS





BUILDING MATERIALS INDUSTRY

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
VIENNA

UNIDO MONOGRAPHS ON INDUSTRIAL DEVELOPMENT

Industrialization of Developing Countries:
Problems and Prospects

MONOGRAPH NO. 3

BUILDING MATERIALS INDUSTRY

Based on the Proceedings of the International Symposium on Industrial Development (Athens, ~~November–December~~ 1967)

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Foreword

The International Symposium on Industrial Development, convened by UNIDO in Athens in 1967, was the first major international meeting devoted exclusively to the problems of industrialization of the developing countries. It followed a series of regional symposia on problems of industrialization held in Cairo, Manila and Santiago in 1965-1966 under the sponsorship of UNIDO and the United Nations regional economic commissions, and a similar symposium held in Kuwait in 1966 under the sponsorship of UNIDO and the Government of Kuwait.

The Athens Symposium was attended by some 600 delegates from 78 countries and by representatives of various United Nations bodies, international organizations and other interested institutions in the public and private sectors. It provided a forum for discussion and exchange of views on the problems and prospects of the developing countries which are engaged in promoting accelerated industrial development.

The Symposium devoted special attention to possibilities for international action and for co-operative efforts among the developing countries themselves, and explored the scope, means and channels for such efforts.

Studies and papers on a wide range of problems relating to industrialization were presented to the Symposium—by the UNIDO secretariat and by participating Governments, international organizations and observers. An official report, adopted at the Symposium, has been published by UNIDO.[1] Based on this documentation and the discussions in the meeting, the present series of monographs is devoted to the 21 main issues which comprised the agenda of the Symposium. Each monograph includes a chapter on the issues presented, the discussion of the issues,

[1] *Report of the International Symposium on Industrial Development, Athens 1967* (ID/11) (United Nations publication, Sales No.: E. 69. II. B. 7).

and the recommendations approved by the Symposium. Some of the monographs deal with specific industrial sectors; some with matters of general industrial policy; and others with various aspects of international economic co operation. An effort has been made to make the monographs comprehensive and self contained, while the various economic, technological and institutional aspects of the subject matter are treated within the context of the conditions generally prevailing in the developing countries.

Since economic, technological and institutional aspects are described with particular reference to the needs of the developing countries, it is felt that the monographs will make a distinct contribution in their respective areas. They are intended as a source of general information and reference for persons and institutions in developing countries concerned with problems of industrialization, and particularly with problems and issues of international co operation in the field of industrialization. With this in view it was considered that an unduly detailed technical presentation should be avoided while at the same time enough substantive material should be offered to be of value to the prospective reader. For a more elaborate treatment of the subject, the reader is referred to the selected list of documents and publications annexed to each monograph.

The annexes also contain information on the areas in which UNIDO can provide technical assistance to the developing countries on request; a selected list of major UNIDO projects in the respective fields; and a list of meetings recently organized by the United Nations.

It is hoped that the monographs will be particularly useful to Governments in connexion with the technical assistance activities of UNIDO and other United Nations bodies in the field of industrial development.

This monograph has been prepared by the secretariat of UNIDO on the basis of material submitted by Professor D. A. Turin and Mr. T. O'Brien, University College, London.

CONTENTS

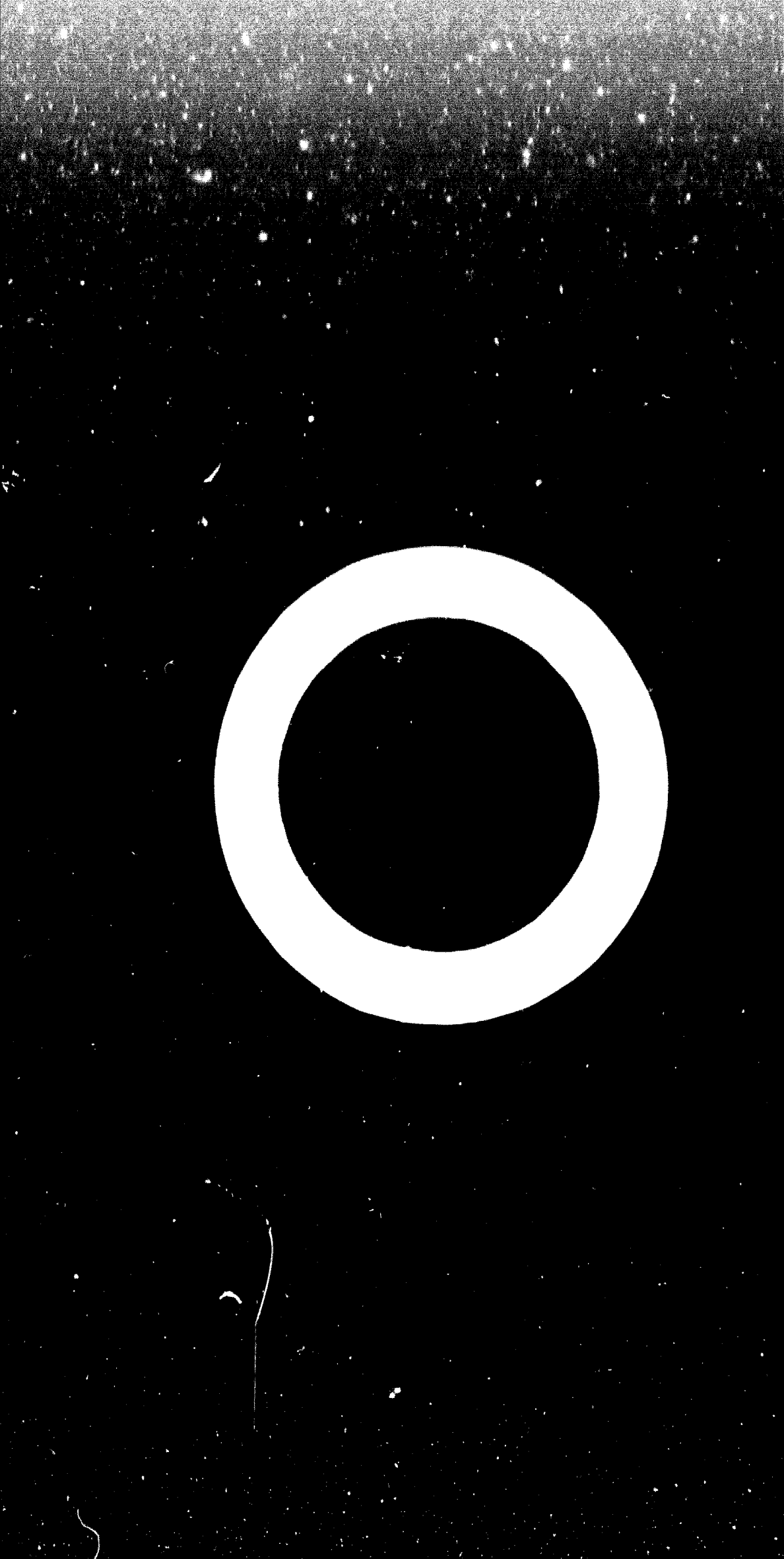
Explanatory notes

Dollar ($) refers to US dollar unless otherwise indicated.

Ton refers to metric ton (1,000 kg) unless otherwise indicated.

The following abbreviations are used in this monograph:

ECA	Economic Commission for Africa
ECAFE	Economic Commission for Asia and the Far East
ECE	Economic Commission for Europe
EEC	European Economic Community
FAO	Food and Agriculture Organization of the United Nations
GDCF	Gross Domestic Capital Formation
GDP	Gross Domestic Product
GNP	Gross National Product
UNIDO	United Nations Industrial Development Organization
UNDP	United Nations Development Programme



INTRODUCTION

Construction is a major component (45 to 60 per cent) of capital formation. Capital formation increases with *per capita* national income, and the share of construction appears to be independent of the stage of economic development. Building materials and components contribute between 50 and 60 per cent of the total value of construction output. The building materials industry is therefore closely connected with the process of development.

This monograph should be read in conjunction with the monograph on the construction industry (Monograph 2 in this series), as the two industries are closely linked. Construction is a complex activity involving the assembly on site of different types of structure, using a range of materials inputs. The construction industry differs essentially from the manufacturing industry in that it is carried out in the place where the end product will be used; it is generally a low technology industry; it involves the assembly of bulky materials; at present the end product is normally sold before it is made; and the industry figures prominently in long term investment decisions. The building materials industry exists only to serve the construction industry.

Chapter 1 points out the difficulty of defining the building materials industry. Some materials are used exclusively in construction; others are used also in other industries. The interrelationship is complex, and the borderline between the building materials and the construction industry is fluid. Some materials, such as cement, steel, timber and bricks, may be described as key materials because they are essential in most construction and because they account for more than 50 per cent of the materials used in many buildings. Other materials are indispensable in the sense that although not used in large amounts, critical shortages of them may seriously impede construction.

The four categories of construction – international modern, national modern, national conventional and traditional – make different demands on the building materials industry. Similarly, the requirements for materials differ between various types of building and between building and

civil engineering. Thus the demand for materials is affected not only by the construction technology used but also by the composition of construction output.

International trade statistics show that in some countries imports of building materials represent a significant percentage of total imports. In addition, such imports may account for a large percentage of the building materials used. A strong incentive for local production is that many such materials can be produced locally, thus saving foreign exchange.

Even when national construction output is fairly constant, considerable fluctuations may occur at the local level, and the demand for building materials will likewise fluctuate. Building materials are not usually transported over great distances, owing to their low value/weight ratio. The production of many building materials tends to be dispersed; local fluctuations in demand therefore result in local fluctuations in production. Only rarely is there sufficient confidence in future demand to permit producers to build up stocks and thus attempt to iron out such trade cycles. The issue of confidence is important if the investment of private and local public capital is to be encouraged.

A few materials must be produced in large scale, centralized plants. In such cases, the main problem, apart from the fluctuation in total demand, is capacity utilization. Under utilization of capacity is endemic in developing countries. It cannot easily be eliminated because demand grows slowly, there are few manufacturing plants, and their capacity can be increased only in discrete stages.

Chapter 2 attempts to evaluate trends in patterns of consumption, in order to determine targets for the levels of production of key building materials. The *per capita* consumption of cement, steel, sawnwood, wood-based panels and plastics is seen to increase as the *per capita* national income rises.

Although the relationship between levels of consumption and national income in any given year cannot automatically be assumed to hold over a period of time, there is evidence to suggest that it is constant for cement, steel and wood based panels. Consumption of sawnwood is decreasing in some countries; the rate at which plastics are substituted for other materials will change the relationships in time.

The consumption of cement and steel in construction does not rise proportionately with increased expenditure on construction, since the percentage of construction expenditure devoted to civil engineering and

building carcase falls as development proceeds. On the other hand, consumption of wood-based panels and plastic tends to rise faster than expenditure on construction. Thus, changes in the relationships between the levels of consumption of key materials and the macro-economic indicators also depend on changes in construction output and on the substitution of one material for another.

Chapter 3 suggests another approach to the problem of assessing consumption of building materials, since more detail is needed for national planning than can be provided by the global analysis described in chapter 2. It is possible to evaluate the materials inputs into new buildings by surveying existing construction. As the quantities of materials vary with the type of building, a representative selection of the most common types must be included. A table, based on a survey in a Western European country, shows alternative materials for each functional element of six types of buildings.

In order to assess total requirements per unit of construction, it is necessary to take into account the possibilities of substitution of materials. There is less scope for substitution in structural materials than in the finishings of a building. In civil engineering, the choice of materials is limited. Apart from cement and steel, the main materials used in civil engineering are local rocks and soils. Local conditions and availabilities are therefore important. Tables are given showing steel requirements for single-storey factories and for bridges.

Chapter 4 describes the characteristics of the building materials industry. Various stages in the industrialization of building materials may be recognized. Walling materials are among the first to be produced industrially, next, roofing and flooring materials; and after these, carcase elements, fittings, finishes and equipment. These stages overlap to an extent that varies from country to country. Modern construction uses relatively small quantities of traditional materials and dependence on cement, steel and timber is world-wide. When production of any building material is industrialized, a number of related subsidiary industries tend to develop. As resources are normally limited, the development of the building materials industry should follow a strategy phasing the production of building elements as well as building materials.

Development plans should take into account not only the levels of output required to enable construction targets to be met, but also a number of production criteria for building materials; production problems may often impose severe limitations on what can be achieved. For

planning purposes, a full chart is given, grading materials according to certain production criteria that are fully evaluated.

Among the factors that must receive detailed examination are the sources of raw materials in relation to plant location. Investigation shows that inputs are normally over 50 per cent of the total output value of building materials. Pre-investment studies evaluating all factors contributing to production costs should pay particular attention to plant maintenance costs. Studies must also be made of labour and capital requirements and of the size of market in relation to the economic size of plant. In arriving at the optimum solution, it will usually be necessary to reach a compromise between market requirements and production factors. The costs of the various choices must be carefully considered.

Chapter 5 deals with the planning and organization of the building materials industry. Difficulties are usually experienced in planning owing to the lack of data on natural resources, current production and consumption and existing patterns of use of materials. The importance of having information on which to base plans and forecasts is evident, and the mechanism for obtaining it must be established.

Implementation of plans may be impeded by inadequate transport networks, lack of technical know-how, lack of skills and lack of finance and incentives. Unless these problems are considered and resolved, at least in part, it may prove impossible to put apparently sound plans into operation.

The production and use of modern building materials requires a higher degree of technical know-how than is generally recognized. As the industrial production of building materials develops, supporting technical institutions must be established, including advisory services for producers and consumers, research laboratories for materials analysis, and an authority that prepares quality standards and codes of practice. Such services will take time to establish owing to the lack of qualified staff. The exact form of the institutions required will vary; in some countries they may be undertaken by a single, central body.

It is often more expensive to produce materials locally than to import them, in spite of high transport costs. In order to develop local industry, it may be necessary to impose import controls until local production costs can be brought down to reasonable levels. Thus Governments may often play a leading part in promoting local materials, both indirectly through fiscal controls and directly by requiring that

imported materials should not be used for government or government-sponsored construction unless specific approval is given. In general, the question of finance and incentives for promoting building materials industries is the same as for any other manufacturing industry.

Chapter 6 deals with the work of the International Symposium on Industrial Development –the issues, the discussion and the recommendations approved.

Chapter 7 describes the action of UNIDO and other United Nations agencies in connexion with the building materials industry.

Chapter 1

THE BUILDING MATERIALS AND COMPONENTS INDUSTRY: A REVIEW OF TRADE AND PRODUCTION

Definition of the industry

It has often been pointed out that there is no generally accepted definition of the building materials and components industry. It is worth repeating this here in order to emphasize the problem of defining the scope of this monograph. The range of materials used in new building, maintenance and civil engineering is very wide. Some materials, such as cement, bricks and gypsum plaster, are produced almost exclusively for use in construction. In other cases, although construction may be a large, or the largest, user of the products of an industry, such as iron and steel products and wood and wood based products and plastics, these products are nevertheless produced for many other users.

Considerable overlap exists between the building materials and the construction industry since many materials are manufactured on site, particularly in the early stages of economic development. The production on-site of materials like concrete blocks is considered as part of the construction process. At later stages of development, such materials are usually produced in factories, and construction becomes an assembly operation. Many material inputs are supplied in a semi processed or simply shaped state, for example, aggregates for concrete. Production of such inputs is not always recognized as a manufacturing industry.

National statistics and development plans do not recognize many branches of the building materials industry, although they sometimes cover branches that develop early and use industrialized production techniques, including key materials, such as cement, steel, wood and ceramics. Construction planning must take account of the whole range of materials required, since critical shortages of small components like screws, even though their value as inputs is slight, would seriously hold up construction output.

Planning for the various sectors of the industry is difficult owing to lack of statistical information. The key materials usually receive attention because data are available from which to draw conclusions.

The variety of materials required in construction may be illustrated by noting six main categories of use:

Load-bearing structure;

External envelope (protection against weather);

Improvement of internal climate;

Hygienic requirements;

International subdivisions;

Aesthetic requirements.

A considerable degree of co-ordination is required among the various parts of the heterogeneous building materials industry in order to produce the various combinations needed. In the early stages of industrialization, this problem is often solved by manufacturing in one place a wide variety of products for a variety of end uses. As economic development progresses, factories become increasingly specialized: they manufacture products for one specific industry or one particular product. Thus, factories formerly producing a range of fabricated metal components tend to specialize and produce metal window frames or structural steel or machinery.

The trend towards transferring the production of building materials from site to factory does not necessarily mean that such production passes out of the hands of construction enterprises. In industrialized countries, contractors are beginning to set up plant manufacturing specific materials such as lightweight aggregates, or to acquire a controlling interest in other industries. In these cases, the products are not used exclusively by the controlling enterprise, but are traded through normal commercial channels. This diversification of interests on the part of large contractors makes the present situation somewhat analogous to that in early stages of development, when control of the construction and building materials industries is more integrated.

Within this trend, however, there is another trend towards "supply and fix", whereby the assembly or application of some specialized materials is carried out on site by a unit of the manufacturing enterprise. This is an example of manufacturers diversifying into construction at the same time that contractors are diversifying into manufacturing. In developing countries, the situation may be confused still further if the Government becomes a major investor in building materials production.

Traditional and modern categories

In most developing countries, the construction industry falls into four categories: the international-modern, the national-modern, the national-conventional and the traditional.[1] Each category makes different demands on the building materials industry. In the first category, the construction enterprises are international in character and tend to purchase the most suitable materials from any source. At the same time, the construction works undertaken may require sophisticated materials such as high-strength steels, materials of particularly uniform quality or materials from particular countries. Such factors militate against the use of local sources, and a large proportion of the materials may be imported.

National-modern construction is found chiefly in urban areas, and the materials and the construction technology are similar in developing and developed countries. It is therefore possible to discuss this category in international terms.

In the traditional and national-conventional categories the situation is different. The differences between regions may be attributed to various factors, for example, the climate, which determines the materials that are readily available for use in building. This has helped to shape local traditions which have governed, in turn, the form and character of traditional, rural construction. A complete classification of climatic zones has been worked out by Köppen and Geiger.[2] Many countries do not fall neatly into one zone. Tropical climates may be divided into the three following zones: warm-humid, hot-dry, and composite.

Organic materials (timber, bamboo, reeds etc.) do not grow well in hot-dry climates, but they flourish under warm-humid conditions. They are therefore used as building materials in countries in the warm humid zone. These organic materials are easy to use for building, particularly for roofs. Limited amounts of inorganic materials, such as earth, are also used in traditional building.

Countries in the second zone are short of organic materials; their traditional building materials are inorganic (e.g. stone, brick, lime and earth). These materials are excellent for walling, but difficult to use for

[1] For further discussion of this subject, see Monograph 2 "Construction Industry" in this series.

[2] Köppen-Geiger, *Klima der Erde* [map], revised by R. Geiger and W. Pohl; Justus Perthes, Darmstadt, 1953.

roofing, for which some organic materials, such as timber, have to be found. Countries in the third zone use a combination of organic and inorganic materials.

The national-conventional category of building is found in semi-urban areas in the subsistence sector of the economy. It is based on traditional methods and uses materials derived from rural building. However, these are supplemented with simply formed products, not necessarily produced industrially, but derived from the modern sector. The best example of this is corrugated iron for roofing, which is particularly useful in countries that are short of suitable roofing materials.

In view of the international character of the modern sectors of the construction and the building materials industry, it might be thought that a study of the input-output tables for the economies of different countries would yield valuable information, particularly about the interrelationships between the various sectors. However, existing tables are not really adequate for this purpose. Many do not even recognize construction as a specific industrial sector.

TRADE IN BUILDING MATERIALS

Trade in building materials is sufficiently important to be identified separately in the foreign trade accounts of many countries, although the volume of trade is small compared with that in consumer goods owing to the low value/weight ratio of building materials and their relatively high transport costs. For some materials the value/weight ratio is high enough to make trade worth while; timber, glass and metal products are examples. Cement is traded, despite its usually low value/weight ratio, because production costs vary sufficiently from one country to another to permit the transport costs to be absorbed. Still, cement plants must export in bulk shipments, and as a rule only plants located at or near ports can be competitive in price.

The development of modern construction calls for building materials that often cannot be produced locally for a small market. The scale of production required for some building materials does not allow economic local manufacture until the local market has expanded considerably. Such a market may be built up by initially importing the materials. In addition, trade sometimes occurs because a particular country lacks some indigenous raw materials; timber is the most obvious example, but there are others, such as asbestos.

The scale on which building materials are imported may be gauged from information covering a number of countries in Africa, Asia and Latin America over various periods between 1955 and 1965. These data show that in most of the countries concerned, the value of imported building materials ranged from 5 to 8 per cent of the total value of imports. Since expenditure on building materials is from 3 to 5 per cent of the gross domestic product (GDP) in developing countries, it is clear that building materials, as compared with inputs for other industries, use up a disproportionate share of foreign exchange.[3]

TABLE 1: BUILDING MATERIALS IMPORTS, AFRICA, 1960

Commodity	*Percentage distribution by value*					*Percentage of consumption imported*
	North Africa	*West Africa*	*Central Africa*	*East Africa*	*Africa*	*Africa*
Cement	5	23	15	5	12	33
Other fabricated building materials	1	4	—	2	2	—
Bricks, tiles and ceramics	3	2	1	5	3	50
Iron and steel products	60	61	74	69	62	87
Sawnwood and wood products	24	2	1	11	13	33
Glass and manufactures	2	2	1	2	2	100
Paints and varnishes	5	6	8	6	6	60
TOTAL	100	100	100	100	100	58

SOURCE: ECA, *Housing in Africa*.

Tables 1 and 2 give the breakdown by main categories of building materials of imports in the regions of the United Nations Economic Commission for Africa (ECA) and the Economic Commission for Asia and the Far East (ECAFE). Both tables show that for the developing countries, metal products form the largest group of imports, followed by timber and cement. In contrast, in the developed countries of Asia and the Far East—Australia, Japan and New Zealand—timber imports account for about 80 per cent of the total. In all regions, a higher proportion of wood production is involved in international trade than is the case with cement because the raw materials for cement production are more

[3] See the Role of Building Materials and Components in the National Economies of the Countries of the ECAFE Region, for full reference see annex 3 under "Economic Commission for Asia and the Far East"; and *Housing in Africa*, for full reference see annex 3 under "Economic Commission for Africa".

TABLE 2: BUILDING MATERIAL IMPORTS, ASIA AND THE FAR EAST, 1964

Building material	*Percentage distribution by value*	
	Developing countries in the ECAFE region[a]	*Australia/ Japan/ New Zealand*
Cement and allied products	18.9	0.4
Stone, sand and gravel	1.5	1.3
Clay and refractory materials	5.7	1.7
Other non-metallic mineral products	3.3	2.8
Glass	4.1	4.2
Wood (rough)	13.4	69.4
Wood (shaped)	4.7	11.6
Veneers and plywood	3.0	0.9
Iron and steel tubes and pipes	25.6	4.1
Structurals—metal	8.8	0.8
Nails, screws, nuts, bolts etc.	4.3	1.6
Sanitary, plumbing and other fittings	6.7	1.2
TOTAL	100.0	100.0

SOURCE: ECAFE, The Role of Building Materials and Components Industries in the National Economies of the Countries of the ECAFE Region.

[a] Excludes seven countries not reporting trade statistics.

uniformly distributed than timber resources. Brazil, Canada, Central America, northern and central European countries, South East Asia and West Africa have an export surplus of timber, whereas the Caribbean, East Asia, the countries of the European Economic Community (EEC) and the Middle East, North Africa, South Africa, southeast South America, the United Kingdom and the United States are importers.

The picture of world trade in building materials is slowly changing. This may be illustrated by reference to data for cement. Figures for cement exports and imports for the years 1955 and 1967 show that there was little tendency for exports to increase significantly. Exports from Western Europe declined from 9.7 to 3.9 per cent of its production. The countries with centrally planned economies only slightly increased their proportion of exports in 1967 as compared with 1955. On the import side, the trend was one of progressively lower imports, implying greater local production. In East and West Africa, for example, the percentage of cement imported decreased considerably, although the level still remained high.[4]

[4] Calculated from data in *Cembureau Statistical Review* (Paris) 1968.

Such statistics demonstrate the efforts of many developing countries to industrialize the production of building materials in order to speed construction (by eliminating delays in delivery) and to reduce the foreign exchange bill. The problems of local production are reviewed briefly below and in more detail in chapter 4.

Production of building materials

National production of building materials presents problems of its own. One of the most important is that construction output may fluctuate considerably, particularly at a local level. The supply of building materials must be adjusted to meet the situation. Normally, fluctuations in demand are accommodated by adjusting the level of output, by stock changes and by importing or exporting. Adjustments of output are often difficult to make owing to the use of capital-intensive production processes requiring high output for economic operation, or to a reluctance or inability to lay off labour. Furthermore, reductions in the labour force may lead to difficulties when there is renewed upsurge in demand. Stock changes are widely used as a regulating device. Stocks of building materials are normally held at a level sufficient for production for from one week to six months, the average ranging from one to eight weeks. Stocking is expensive, however, since space or buildings are required, inventories have to be maintained and extra handling costs are involved. It is relatively easy to import as a means of meeting an excess demand. It is more difficult to export as a means of continuing high output at a time of low demand unless there are established channels and markets.

Countries may be divided into three categories as regards the trend of construction output: those in which the trend shows a slow but steady rate of growth, those in which it shows a more rapid but steady rate of growth, and those in which it fluctuates widely. Countries in the first category are developed countries with relatively stable conditions. Countries in the second category include those that have suffered war damage or have received considerable outside economic aid to assist development. Countries in the third category cover most of the developing world.

Production of key building materials may be expected to follow a similar pattern; the trend in construction output is matched very closely by that in cement production. The recent history of some developing

countries explains the large fluctuations that have occurred in construction output. Data are not available for brick or glass production in most developing countries. In developed countries, brick production has been relatively static or even slightly declining, despite the increase in construction output, while the pattern for glass production has been similar to that of cement. Glass is not widely produced in developing countries, most of which must import the bulk of their requirements.

Developing countries still produce only a small proportion of the world output of building materials, as they account also for only a small proportion of construction output.[5] Statistics show that in 1966/1967, Europe, North America and the Union of Soviet Socialist Republics manufactured 72 per cent of the world cement production. As regards wood products, their combined share of world production was 83 per cent of sawn softwood, 60 per cent of sawn hardwood, 79 per cent of plywood, 85 per cent of fibreboard and 92 per cent of particle board.[6]

In many processes, plant capacity can be increased only in discrete stages, which may be large as a percentage of existing capacity. The capital investment required may also be considerable. The growth in demand for the product may not match such increases in capacity. This leads to a high degree of under-utilization of capacity in the building materials industry in developing countries, where the number of factories is small. During the early stages of development, there is no way of solving this problem, and it must be taken into account in assessing production costs.

The summary of building materials production characteristics in chapter 4 shows that most building materials are bulky and have a low value/weight ratio, so that they are costly to transport. This provides a further reason for producing them locally, provided that the resulting production costs do not completely offset the savings in transport costs. A consideration of all these problems tends to reinforce the conclusion that studies of consumption provide the key to planning in the building materials industry.

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[5] For further discussion of this subject, see Monograph 2 "Construction Industry" in this series.

[6] *Cembureau Statistical Review* (Paris) 1968.

Chapter 2

TRENDS IN CONSUMPTION OF BUILDING MATERIALS

It is useful to be able to forecast the level of consumption of different building materials, but it is not clear how this can be done most effectively and what margins of error are acceptable. Planners in a particular country can make more accurate assessments of local consumption than one who attempts to make a global analysis. However, the analysis presented below may serve to show the over-all trend and to give comparative data to which national planners can refer.

It is possible to analyse only those key materials already referred to in chapter 1. In order to have a common basis of comparison, *per capita* consumption (by weight or volume) has been used as an index. These figures were then compared with the macroeconomic indicators, namely the gross national product (GNP) or the GDP, according to the data available or with the gross domestic capital formation (GDCF) attributable to construction, each expressed in dollars *per capita*. In most cases, the GNP has been used as an index of national income, as it is readily obtainable from the *World Bank Atlas*.[7] For wood products, the GDP had to be used.

CONSUMPTION OF CEMENT, STEEL AND BRICK[8]

Cement

Regression analysis confirms that the relationship between cement consumption (in kilograms *per capita*) and the GNP (in dollars *per capita*) in 1965 was non-linear; the GNP-elasticity of cement consumption

[7] For full reference see annex 3 under "International Bank for Reconstruction and Development".

[8] The analysis given in this chapter is based on original work by Professor O. A. Turin and Mr. Turlagh O'Brien of the Bartlett School of Architecture, University College, London.

decreases with an increasing GNP. It is unity when the GNP is approximately $390 *per capita* and cement consumption stands at 148 kg *per capita*. Below this, cement consumption increases faster, and above this, slower than the GNP.

Cement consumption may be expected to be more closely related to expenditure on construction than to the GNP. Unfortunately, fewer countries have data available on the GDCF in construction. A regression equation derived from data for 1965 for as many countries as possible (42) showed that the construction-elasticity of cement consumption is unity when expenditure on construction in the GDCF is approximately $16 *per capita* and cement consumption stands at 60 kg *per capita*. A discussion of changes in consumption with increasing development will be left to the end of this chapter, as it is relevant to most of the materials considered.

The usefulness of regression equations for purposes of forecasting depends upon their constancy over a period of years. Unfortunately, data on the GDCF for years before 1965 were available for still fewer countries. A check of figures for 1960 covering 26 countries showed no significant difference between the relationships in that year and in 1965. This suggests that the relationship between cement consumption and expenditure on construction is a fairly stable one.

When cement consumption is compared with expenditure on construction, one or two countries show pronounced departures from the general trend, that might be explained by a significant change in the nature of construction output, as for example a large increase in the proportion of civil engineering works.

Steel

If the relationship between steel consumption in 1965 (in kilograms *per capita*) and the GNP (in dollars *per capita*) is analysed, as in the case of cement, in terms of a second order polynomial equation, it is seen that the elasticity is unity only when the GNP is about $1,600 *per capita* and steel consumption stands at 480 kg *per capita*. However, unlike cement, only a proportion of steel production is used in construction. There is some evidence that the proportion of steel used in construction is higher in developing than in developed countries. This opinion appears to be supported by statements about the situation in Asia and the

Far East.[9] It has been estimated that construction accounts for between 35 and 50 per cent of steel consumption in developing countries in this region, which is reasonable, since other steel-using industries are usually less well established than modern construction. In Africa, the proportion would appear to be higher still, but precise figures are lacking.[10]

From regression analysis, it would appear that the construction elasticity of steel consumption is less than unity. This means that the rate of growth of steel consumption in construction is less than the rate of growth of expenditure on the GDCF in construction.

Bricks

It is difficult to relate the consumption of bricks to the GNP or expenditure on construction; statistics for developed countries are available, but there are few statistics for developing countries. As bricks are not traded to any significant extent, the production figures may be taken to be equivalent to consumption (ignoring stock changes). It is probable that developing countries show marked fluctuations in consumption, but the pattern in each country is determined either by tradition or current policy. Some countries have found it expedient to promote brick production; others have allowed the industry to languish. The availability of skilled bricklayers may be a contributing factor.

Consumption of sawnwood, wood-based panels and plastics

Sawnwood

Interpretation of the relationship between *per capita* consumption of sawnwood and the GDP is complicated by variations in the timber resources of different countries. The highest consumers are Canada, Northern Europe, the Pacific and the United States, all of which have large reserves of timber and a long tradition of using it, particularly in housing. Not all sawnwood, however, is used in construction. A survey of countries grouped in the subregional classification used by the Food and Agriculture Organization shows that the proportion varies widely—from 40 to 86 per cent.

[9] ECAFE, *op. cit.*
[10] ECA, *op. cit.*

The general trend seems to be towards a very slow increase in *per capita* consumption of sawnwood, with an increasing proportion of it used in construction, the precise amount depending primarily on the country's timber resources.

From the survey of the FAO subregions just mentioned, three patterns may be observed for the percentage of sawnwood consumption used in construction:

For countries with a timber surplus: over 70 per cent;

For countries with an approximate timber balance: 55 to 70 per cent;

For countries with a timber deficit: under 55 per cent.

At the same time, however, there is a trend towards a reduction in the sawnwood content of buildings, particularly houses (see chapter 3).

In developed countries, softwood is used in construction rather than hardwood, but statistics are not available to show what proportion of the total consumption of sawn softwood is used in construction.

Wood-based panels

Wood-based panels include plywood, fibreboard and particle board. Production of wood-based panels is a growing industry in all parts of the world, and *per capita* consumption is expected to rise everywhere. After analysing data for 23 countries over the period 1950 to 1960, FAO reported: "For nearly all countries in the group, a reasonably good linear relationship could be obtained between the logarithm of *per capita* consumption and the logarithm of *per capita* GNP... A striking characteristic was that there seemed to be no effect of income level on the apparent income elasticity. In other words, the relationship between changes in consumption and changes in GNP appeared independent of the magnitude of *per capita* income. This phenomenon is not common to many products. The explanation is that income level is not the sole, and seldom the decisive, factor determining consumption. More important is the substitution of this group of products for sawnwood". Few data are available on the proportion of the consumption of plywood or other panels used in construction. In the United States, the proportion is about 65 per cent. In 1955, the proportion in South East Asia was about 75 per cent; in Europe, the trend has been generally downwards, from

76 per cent in 1951 to 26 per cent in 1959, with a slight recovery to 34 per cent in 1962.[11]

Plastics

Data for the *per capita* consumption of plastics in 1966 were available for 22 countries, but the variability was too high to say that any relationship exists between *per capita* consumption and the *per capita* GNP. In addition, with a new material such as plastics, changes in consumption at different levels of development cannot be expected to show stability. Estimates of future consumption are therefore difficult.

Data on the proportion of plastics production that goes into construction were available only for a few developed countries, namely: Japan—36 per cent; the Federal Republic of Germany—30 per cent; the United States—24 per cent; and the United Kingdom—15 per cent.[12]

Interpretation of trends

It is difficult to draw firm conclusions from an analysis of *per capita* consumption of materials and the *per capita* GNP or expenditure on construction that refers to only one year.

It is probable, however, that the relationships between *per capita* consumption of cement and steel and the *per capita* GNP will not change much over a period of approximately ten years. Cement is used almost exclusively in construction, whereas steel is used in a number of industries. The other steel using industries grow at a faster rate compared with national income than does construction; (this is reflected in the small proportion of total steel consumption which is used in construction in the higher income countries). As a result, the relationships of the use of steel and cement to the GNP are such that use of steel shows a higher income elasticity than use of cement.

It is possible that the trend for wood based panels as a group will be similar to that for cement and steel, but the position of individual products is less clear. Sawnwood and plastics show no trends that are likely to remain constant. In the case of sawnwood, *per capita* consumption

[11] *Plywood and Other Wood-Based Panels;* for full reference see annex 3 under "Food and Agriculture Organization".

[12] Sante and Wulkan; for full reference see annex 3 under "Other sources".

is decreasing in some countries as more economical use is made of this material or as other materials replace it. In the case of plastics, consumption is increasing fast owing to the substitution of plastics for other materials.

It has already been stated that the relationship between *per capita* consumption of building materials and the *per capita* GNP varies so greatly that it is only of very general use to economic planners. An over-all picture of the situation in many countries of the world, however, provides a pattern to which individual countries can refer in developing their plans.

The relationship between consumption of materials and expenditure on construction shows a somewhat different pattern from the relationship between consumption of materials and the GNP. In the case of cement and steel, this is caused by changes in construction output at different levels of development. Both cement and steel are used in civil engineering and the carcase of buildings. Very little is used in finishes. It is shown in the companion monograph on construction that the share of civil engineering in construction decreases with development; furthermore, the proportion of expenditure on building finishes and equipment increases until it accounts for about 50 per cent of the total. Hence, the amount of additional expenditure on cement and steel arising from each additional dollar of expenditure of construction tends to fall as the *per capita* GDCF rises. Although data are not available to verify this, it seems likely that the opposite is true in the case of plastics and wood-based panels, since they are more extensively used in building finishes than in structure.

THE STATISTICAL RESULTS

The data discussed in this chapter have been analysed statistically using a computer programme for polynomial regression. This calculates successively lines of best fit of increasing order until the improvement obtained from a higher order polynomial is not significant. For this exercise only first or second order equations were found to be necessary.

The regression equations are of the form:

$$\log y = a \log x + b$$

or

$$\log y = c \log x - d (\log x)^2 + e.$$

Table 3 shows the results of the regression analysis.

TABLE 3: REGRESSION ANALYSIS FOR TRENDS IN CONSUMPTION OF BUILDING MATERIALS

Dependent variable[a] *y*	*Year*	*Independent variable*[b] *x*	*Number of countries*	*Regression coefficients* for *log x*	*Regression coefficients* for *(log x)²*	*Regression constant*	*Per cent of variances explained*
Cement	1965	GNP	100	1.02	—	—0.58	78
				3.22	—0.43	—3.27	81
Cement	1965	GDCF in construction	42	0.72	—	0.91	87
				1.62	—0.26	0.22	90
Cement	1960	GDCF in construction	26[c]	0.82	—	0.71	90
				1.50	—0.21	0.24	92
Cement	1965	GDCF in construction	26[c]	0.75	—	0.83	90
				1.48	—0.21	0.30	92
Steel (total)	1965	GNP	69	1.42	—	—1.92	87
				3.32	—0.37	—4.31	88
Steel in construction ..	1960	GDCF in construction	20	0.83	—	—0.05	93
Sawnwood	1961	GDP	25[d]	1.21	—	—1.31	86
Sawn softwood .	1965	GNP	73	1.51	—	—2.39	85
Wood panels[e]	1961	GDP	25[d]	1.51	—	—2.26	85
Plastics[e]	1965	GNP	22	1.20	—	—1.23	78

a Materials expressed in kg *per capita* or 1,000 m³ *per capita*.

b Indicators expressed in $ *per capita*.

c Same countries in each analysis.

d Subregions, not countries.

e Equations in form: $\log (10y) = a \log x + b$.

PATTERNS OF USE OF BUILDING MATERIALS

Materials used in buildings

All the separate, although related, indicators that have been discussed in preceding chapters are indispensable for assessing future patterns of demand for building materials and components. It must be appreciated, however, that the statistical information available in most developing countries is rarely adequate to build up reliable and sufficiently disaggregated input/output models. It must also be recognized that general trends in *per capita* consumption of key materials provide by using macroeconomic terms only the roughest guide to forecasting future demands.

It appears necessary, therefore, to proceed to a much more detailed analysis of the specific consumption of individual building materials and components in particular types of construction, with a view to establishing more reliable models for projections. The validity of such an analysis depends on the building types selected, the assumptions underlying the estimates, and how far the technical coefficients used in the survey are likely to apply in future situations when use of materials and/or building technology may have changed.

The assessment in this way of the material inputs of construction output is an established feature of the planning machinery of centrally planned economies, and is becoming increasingly popular in the market economies. In developing countries, although the lack of statistical information is a handicap, the problem is somewhat simplified by the limited size of the modern sector and its concentration around urban centres, by the narrow range of technologies used in the modern sector and by the small number of building types constituting a large percentage of total construction output. It is therefore possible to obtain an acceptably reliable set of ratios from a very limited number of case studies.

Once the basic ratios have been established (and the order of magnitude of the error duly assessed), it becomes possible to modify the model in the light of observed or probable trends in technological changes and to indicate more clearly to planning authorities the effects on the building materials and components industry of different sizes and mixes of construction investment programmes.

Table 4, showing estimated materials usage in new buildings, is based on a study carried out recently in a Western European country. Data are presented for the alternative materials used in each functional element of a building. Six types of building are distinguished. In each case, the table gives the average quantity used per 100 square metres of gross floor area and the percentage of buildings in which the material is used. (The percentages add to more then 100 for roof linings because two or more materials are used in conjunction to perform the function.) It will be evident that table 4 refers to a developed country; corresponding estimates for a developing country would show some significant differences.

Substitution of materials

Roofs

Roofs may be divided into flat, low pitched (5°) and pitched (20° to 35°). Asphalt and roofing felt are relatively interchangeable for flat roofs. If people are to walk on roofs, asphalt must be used. Other sheet materials, such as sheet rubbers, are being developed as substitutes for roofing felt, but they are usually more expensive and are therefore used only in special circumstances. For pitched roofs, sheet metals and asbestos cement may be used. In developing countries, corrugated iron is widely used. The amount required is similar to that given for aluminium in table 4. Sheet plastics are as yet little used, but as they become cheaper and quality is improved they may be expected to find increasing use. The sheet materials are usually fully interchangeable and use depends on price and availability. In some countries clay tiles superseded slates and have now in turn been largely replaced by concrete tiles.

In each building type, one of the three main categories of roof structure materials tends to be used much more than the others; thus, timber is used in houses and low flats, concrete in high flats and steel in factories. A greater variety of roofing materials is used in schools and offices, and steel is often employed in the form of light joists. It is possible

TABLE 4: ESTIMATED MATERIALS USAGE IN NEW BUILDINGS IN A WESTERN EUROPEAN COUNTRY
(Quantities of materials per 100 square metres of gross floor area and percentage of buildings in which they were utilized in 1964)

Functional element of building and alternative materials	*Unit*	*Houses and bungalows*		*Low flats (3 storeys)*		*High flats (12 storeys)*		*Factories (1 storey)*		*Schools (1–2 storeys)*		*Offices (3 storeys)*	
		Quantity	%	*Quantity*	%	*Quantity*	%	*Quantity*	%	*Quantity*	%	*Quantity*	%
Roof													
Cover and finish													
Asphalt	m^2	70.5	*	34.5	8	8.5	55	100	17	66.5	45	40	38
Roofing felt	m^2	70.5	*	34.5	7	8.5	44	95	28	66.5	30	40	56
Aluminium	m^2	70.5	*	36	5	8.5	*	95	*	66.5	*	40	*
Asbestos cement	m^2	86	*	36	*	—	—	95	52	66.5	*	40	5
Concrete tiles	m^2	86	78	39.5	60	—	—	—	—	79	20	47.5	*
Clay tiles	m^2	86	13	39.5	9	—	—	—	—	79	*	47.5	*
Cover support													
Sawnwood	m^2	0.25	96	0.12	75	—	—	3.5	18	2.7	25	1.1	40
Asbestos cement	m^2	—	—	—	—	—	—	95	52	66.5	5	40	10
Metal decking	m^2	—	—	—	—	—	—	95	*	66.5	5	40	10
Strawboard	m^2	82.5	*	36	8	—	—	95	5	66.5	20	40	10
Concrete	m^2	9.5	*	4.3	15	b	100	12	22	6.7	45	43	25
Structure													
Sawnwood	m^3	2.1	100	0.9	90	—	—	c	*	3.5	25	0.45	40
Steel	t	—	—	—	—	—	—	1.1	82	1.1	60	1.1	45
Concrete	m^3	—	—	d	10	b	100	d	16	5.8	15	4.3	15
Insulation													
25 mm glasswool and slagwool	m^2	60	70	34.5	65	—	—	95	45	66.5	45	40	67
12 mm fibreboard	m^2	60	*	34.5	*	—	—	95	40	66.5	5	40	5
Light topping	m^2	5.3	*	1.7	15	0.3	100	9.6	8	7	47	3.5	7.5
Woodwool slabs	m^2	60	*	—	—	—	—	95	8	—	—	40	7.5

Lining													
Plasterboard	m²	60	98	32	98	8.5	20	95	40	66.5	35	35	75
Fibreboard	m²	60	*	32	*	8.5	*	95	40	66.5	10	35	10
Plastering	m²	60	90	32	90	8.5	75	—	—	66.5	45	35	45
Timber boarding	m²	60	*	—	—	—	—	—	—	—	—	35	*
Acoustic tiles	m²	—	—	—	—	—	—	95	*	66.5	*	35	5
Drainage													
Gutters													
Cast iron	m	16.4	24	8.2	35	—	—	c	c	15	60	6.5	45
Asbestos	m	16.4	27	8.2	38	—	—	c	c	15	30	6.5	30
Plastics	m	16.4	47	8.2	23	—	—	c	c	15	5	6.5	10
Aluminium	m	16.4	*	8.2	*	—	—	c	c	15	5	6.5	10
Pipes													
Cast iron	m	6.5	24	2	35	0.7	92	c	c	8	60	4	45
Asbestos	m	6.5	27	2	38	0.7	8	c	c	8	30	4	30
Plastics	m	6.5	47	2	23	—	—	c	c	8	5	4	10
Aluminium	m	6.5	*	2	*	—	—	c	c	8	5	4	10
Main structure													
Timber	m³	c	*	c	*	—	—	—	—	1.1	*	c	*
Steel	t	c	*	c	*	c	*	1.4	80	1.4	42	c	25
Concrete	m³	c	10	c	10	25	99	7	15	1.1	30	6.6	25
Brickwork	m³	c	88	c	88	c	*	c	5	c	26	c	50
Walls													
External walls													
Brickwork	m³	27	85	40	49	37	47	10.5	58	15	49	24	35
Lightweight concrete blocks	m³	27	14	40	49	37	47	10.5	58	15	*	24	*
Timber boarding	m²	93.5	*	25.5	*	23	*	—	—	80	10	72	5
Asbestos	m²	—	—	25.5	*	23	*	36	33	40	*	36	*
Proprietary curtain wall	m²	—	—	—	—	23	*	36	*	40	5	36	10
Concrete	m³	27	*	40	*	37	5	4.5	*	3	20	9.5	20
Infill panels	m²	—	—	—	—	—	—	36	5	40	15	36	10
Stone cladding	m²	—	—	—	—	—	—	—	—	—	—	36	15

TABLE 4 *(continued)*

Functional element of building and alternative materials	*Unit*	*Houses and bungalows*		*Low flats (3 storeys)*		*High flats (12 storeys)*		*Factories (1 storey)*		*Schools (1—2 storeys)*		*Offices (3 storeys)*	
		Quantity	%	*Quantity*	%	*Quantity*	%	*Quantity*	%	*Quantity*	%	*Quantity*	%
Windows													
Aluminium	m^2	12	*	18	*	18	25	9	19	30	15	16	15
Galvanized steel	m^2	12	30	18	45	18	35	9	79	30	20	16	79
Wood	m^2	12	69	18	50	18	40	9	*	30	64	16	5
Plastics coated	m^2	—	—	—	—	—	—	—	—	30	*	16	*
External doors													
Wood	m^2	4.5	100	4	97	4	97	[c]	65	2.5	65	[c]	99
Metal	m^2	—	—	4	*	4	*	[c]	35	2.5	35	[c]	*
Internal doors													
Wood	m^2	10 (No)	100	13	100	12	100	[c]	65	18	99	5 (No)	95
Metal	m^2	—	—	—	—	—	—	[c]	30	18	*	5 (No)	5
Wall finish[a]													
Plaster	m^2	93.5	90	127	90	120	80	36	5	40	55	72	50
Plasterboard	m^2	93.5	10	127	10	120	10	36	5	40	30	72	20
Integral	m^2	—	—	—	—	[b]	10	[b]	90	40	10	[b]	30
Asbestos	m^2	—	—	—	—	—	—	—	—	40	5	—	—
Partitions and interior walls													
Brickwork	m^3	15.4	23	14.5	55	—	—	[c]	[c]	5	35	16.5	20
Lightweight concrete blocks	m^3	15.4	70	8.8	45	8.2	48	[c]	[c]	5	50	16.5	45
Prefabricated units	m^2	82.5	*	106	5	101	*	[c]	[c]	35	10	85	30
Concrete	m^3	—	—	—	—	[b]	50	[c]	[c]	—	—	9.2	*
Timber stud	m^2	3.5	*	—	—	—	—	[c]	[c]	35	5	85	*

Partition finish													
Plaster	m²	165	88	127	88	120	50	c	c	70	80	85	50
Plasterboard	m²	165	10	127	10	120	10	c	c	70	10	85	10
Integral	m²	165	*	127	*	120	40	c	c	70	10	85	30
Asbestos	m²	—	—	—	—	—	—	c	c	—	—	35	10
Floors and stairs													
Floor structure													
Wood	m²	1.7	55	1.5	*	—	—	—	—	3.4	20	0.5	5
Concrete	m²	6	45	12	98	b	100	15	99	15	79	15	95
Floor surface													
Concrete	m²	—	—	—	—	—	—	b	60	—	—	20	5
or													
Granolithic	m²	—	—	92.5	5	93.5	5	100	30	98.5	*	95.5	*
or													
Thermoplastic	m²	92.5	35	92.5	75	93.5	74	100	5	98.5	5	95.5	10
or													
Linoleum	m²	92.5	*	92.5	*	93.5	5	100	5	98.5	25	95.5	*
or													
Rubber	m²	92.5	*	92.5	14	93.5	10	100	5	98.5	10	95.5	5
or													
PVC	m²	92.5	*	92.5	14	93.5	10	100	5	98.5	20	95.5	5
or													
Wood	m²	92.5	60	98	5	98.5	5	100	5	98.5	15	95.5	55
Soffits (ceilings)													
Plastics	m²	—	—	—	—	—	—	c	c	—	—	70	*
Fibreboard	m²	—	—	—	—	—	—	c	c	—	—	70	10
Plaster	m²	60	90	63.5	90	90	60	c	c	33.5	60	70	50
Acoustic tiles	m²	—	—	—	—	—	—	c	c	33.5	5	70	5
Plasterboard	m²	60	98	63.5	98	—	—	c	c	33.5	30	70	75
Integral	—	—	—	—	—	b	40	c	c	—	—	—	—

TABLE 4 *(continued)*

Functional element of building and alternative materials	*Unit*	*Houses and bungalows*		*Low flats (3 storeys)*		*High flats (12 storeys)*		*Factories (1 storey)*		*Schools (1—2 storeys)*		*Offices (3 storeys)*	
		Quantity	%	*Quantity*	%	*Quantity*	%	*Quantity*	%	*Quantity*	%	*Quantity*	%
Stairs													
Wood	m^3	0.3	67	0.3	10	—	—	[c]	[c]	0.1	5	0.1	10
Metal	—	—	—	—	—	—	—	[c]	[c]	[c]	35	[c]	5
Concrete	m^3	—	—	0.1	100	[b]	100	[c]	[c]	0.1	60	0.1	85

SOURCE: Cullen, for full reference see annex 3 under "Other sources".

[a] Internal walls and internal surface of external walls.

[b] Included under MAIN STRUCTURE.

[c] No basis for estimating.

[d] Included under ROOF: Cover support.

[e] Included under WALLS and/or FLOORS.

* Less than 5 per cent.

that light steel joists will be used more in houses, but this is unlikely in developing countries until the supply improves considerably. The range of materials for cover support is slightly greater, but a gradual change may be expected, with light boards becoming more widely used, since they provide insulation as well as a solid deck. This will have the effect of reducing the extent to which glasswood or slagwood is used, although as long as they are cheap, their use will be widespread. Obviously, the need for roof insulation varies considerably from one country to another.

Questions of substitution in roof lining materials will be considered with internal linings generally. For roof drainage, the materials listed in table 3 may be regarded as fully interchangeable. However, in developing countries, only asbestos cement and plastics are likely to be widely used. Among the various plastics, polyvinyl chloride and polythene are the most often used.

Main structure *(including load-bearing walls)*

The choice of materials for structural frames is normally limited to timber, steel and concrete. The structural use of aluminium is likely to remain very limited. In practice, the choice for developing countries is between timber and concrete, steel being used only in factories. Data for

TABLE 5: STEEL CONSUMPTION FOR SINGLE-STOREY FACTORIES AND MEDIUM-SPAN BRIDGES

Type of structure	*Range of bay size (m^2)*	*Range of steel consumption (kg/m^2)*
Single-storey factories		
Steel framed (with heavy cranes)	200—350	30—65 (40—120)
Reinforced concrete	100—500	24—36
Pre-stressed concrete	100—800	15—36
Medium-span bridges[a]	*Bridge span (m)*	
Ordinary steel	20—80	175—475
High-tensile steel	35—80	100—370
Reinforcing steel for deck		20—60
Pre-stressed concrete[b]	20—70	40—140
Reinforced concrete[b]	10—50	60—204

SOURCE: ECE, *The Use of Steel in Construction.*

[a] Steel consumption for bridges is expressed as kg/m^2 of deck area for given spans.

[b] Including steel in girders and deck.

the use of steel in factories and bridges are given in table 5. The principal developments regarding structural frames lie in the analytical techniques, which enable more economical structures to be designed. The use of pre-stressed concrete in framed buildings is likely to be limited to special cases where long spans are essential.

For load-bearing walls, the choice lies between the varieties of bricks, blocks and concrete. Although table 4 does not include dense concrete blocks, as they are not used to any great extent in the country concerned, the data may be used for estimating the quantity of blocks required, as it would be similar to the amount of brickwork. For high-rise buildings using load-bearing walls, the pre-eminent position of concrete, either cast *in situ* or pre-cast, is being challenged to a limited extent by calculated load-bearing brickwork. In European countries, the structural costs of the latter can be very low and may be quite competitive with concrete. The slowness of construction and the highly skilled labour required are the main disadvantages of this method

It is possible that the quality of dwellings built on a do-it-yourself basis may be improved by the introduction of moulded plastic bricks, provided that preliminary trials of the material are satisfactory and production costs are sufficiently low to make the price competitive.

Walls *(non-load-bearing and partitions)*

The main categories of materials used for non-load-bearing walls are clad-timber frames, concrete blocks or clay blocks and bricks. A variety of aggregates may be used in blockmaking and a variety of materials may be used for cladding timber frames. The development of synthetic resin- and plastics-based panels will extend the use of clad timber frames. The cheapness of the block wall accounts for its popularity. Blocks have been found in some places to be cheaper than other materials even when relocation of partitions is occasionally required. The various panel systems of partitioning available in developed countries tend to be expensive, and their advantage as regards appearance is more important in office buildings and similar structures than in housing.

The choice of wall, partition and ceiling finishes lies between integral finishes, such as self-finished substrate; wet finishes, such as plaster; and dry finishes, such as plasterboard. The choice depends on the building techniques used and the labour skills available.

Floors

Apart from using timber for floor surfacing in countries in which this is available or in which light (as opposed to solid) floors are customary, the choice for floor finishes is between a range of tiling or sheet materials and various concrete finishes. The use of plastic tiles is widespread in developed countries, and it may be expected to extend to other countries as local plastics industries develop. Until then, plain concrete or concrete tiles will be the most commonly used floor finish.

MATERIALS USED IN CIVIL ENGINEERING

Choice of materials

The range of materials available for use in civil engineering is limited. Cement, steel, bitumen and a variety of aggregates and filling materials are the main materials. For structural purposes involving spanning a distance, steel or concrete are usually alternative materials, as they are for piling. For the general run of civil engineering works, plain or reinforced concrete is used in conjunction with filling materials. For roads, bitumen may be used as a binder in place of cement (this produces what are sometimes called "flexible pavements").

The high investment in civil engineering works that often occurs during the early stages of development tends to encourage the establishment of a local cement industry. Although steel is also required, local steel production is not greatly stimulated, possibly because it is more difficult on the completion of major engineering works to divert steel products, other than steel reinforcing rods, to building.

Quantities of materials required

Detailed studies on the quantity of materials required for civil engineering works do not seem to have been carried out, with the exception of a study on the use of steel in Europe.[13] The major difficulty is to express the quantities in some standardized form that makes it possible to compare one custom-built structure with another.

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[13] *The Use of Steel in Construction;* for full reference see annex 3 under "Economic Commission for Europe".

Table 4 shows the estimated quantities of steel used in single-storey factories and medium-span bridges. It is based on the results of the international survey in Europe mentioned above. Owing to the difficulties of collecting data by this method, the estimates must be treated with caution. Reference should be made to the source document for detailed qualifications. It will be seen, however, that the consumption index (kg/m^2) increases quite rapidly with bay size for factories and with span for bridges. Similar data are not available for concrete bridges. It has been found, however, that for a selection of medium-span bridges of various structural designs, the quantity of concrete used varied between 67 and 85 $m^3/100m^2$ of deck area. This information must also be treated as indicative only.

Chapter 4

CHARACTERISTICS OF THE BUILDING MATERIALS INDUSTRY

In this chapter, the problems of the building materials industry itself will be considered in the light of the analysis of the use of building materials that has been made in the preceding chapters.

Stages of industrialization of building materials and components

Pattern of industrialization

There is no single pattern for the industrial development of the building materials and components sector that would be applicable to all countries. Like many other manufacturing industries, the choice depends largely on the availability of local resources and is conditioned by local traditions. However, the impact of local conditions should not be unduly exaggerated; when allowance is made for differences in the speed of development and in the rate at which modern technologies are introduced, it is remarkable how different countries follow similar trends and eventually reach a similar stage in building technology.

It is even possible to suggest a "scenario" of stages in the industrial production of building materials and components in which these materials are related to their functional use. The most likely sequence, followed by most developing countries, starts with the industrial production of walling materials, followed by roofing and flooring which together provide the essential elements of the carcase of buildings of any type. Finishes and equipment normally follow at a later stage, with the production of joinery (doors, windows, built-in furniture etc.), services (starting with pipes and conduits and proceeding subsequently to fittings and accessories), and more sophisticated types of electrical and mechanical equipment. Structural components may be manufactured at early stages in this sequence if they are a by-product of other major industries; if not, their manufacture may not be introduced until much later. Some of

the reasons for this general sequence of development are summarized below; other equally valid considerations such as economies of scale, capital intensity, economic levels of production and other technical and economic factors are discussed later in this chapter.

Building elements

Walling materials exist almost everywhere. They are required to act in compression and to have a certain degree of solidity. Either inorganic or organic materials may be used. Industrial production is relatively easy and may be modified as development proceeds; concrete blocks and clay bricks, for example, may be produced by simple processes and by processes requiring various degrees of mechanization.

Since roofing materials cannot be dispensed with and are expensive in foreign exchange, pressure for early local production is justified. A distinction must be made, however, between structural materials and semi-structural cladding and non-structural cladding. As the first two categories must act in bending, the requirements for mechanical properties are stringent; semi-structural cladding includes various complex sheet materials discussed in the section on roofs in chapter 3. But a good case can be made for local production of non-structural claddings (tiles, felts etc.) that are fairly easy to produce and have relatively low value/weight ratios.

Flooring materials are usually very primitive in early stages. When a knowledge of the technology of concrete production is acquired, floor tiles or *in situ* concrete may be used for this purpose Countries with a tradition of clay building materials may use clay tiles for floors.

Joinery may be produced in small workshops using simple methods. Industrialized production may therefore be postponed. Metal and plastic pipes are essential for modern building, but sophisticated technology is required to produce them. Concrete and clay pipes may be produced locally at an early stage, but they cannot replace metal and plastic pipes.

Structural components are normally manufactured relatively late in the development of industrialized building materials industries. Successful production depends on dimensional standardization and an adequate market. It is easy to produce wood components in areas with a tradition of timber construction. Concrete components may be manufactured next, if problems of transport can be overcome. Metal and plastic components follow much later.

Equipment and finishes are regarded as luxuries at early stages of development. However, they later become essential accessories. Sanitary and electrical fittings are necessary of equipment above certain levels of development.

Prefabrication normally represents the last stage in the process of industrialization, a stage that has been reached in developed countries only recently. In some developing countries, however, there are moves to introduce prefabrication at an early stage. A wide measure of integration of materials is required and the consistent application of standardization. Prefabrication does not necessarily involve significant advances in production technology as compared with on-site assembly operations. The real benefits of prefabrication are achieved only when the market becomes sufficiently large to enable high outputs to be maintained.

A survey of specific building materials

The exact course of industrialization depends on the traditional materials employed, but the use of cement, steel and timber as industrial building products is world-wide.

When cement is introduced into a country, it tends progressively to replace other materials, owing to its versatility, ease of handling and durability, although the technology of production is relatively sophisticated. The establishment of a cement industry may promote a number of subsidiary industries manufacturing asbestos cement, concrete blocks and concrete products that give added impetus to industrial development.

In most countries, cement is a strong competitor to clay products. Their manufacture continues and is worth expanding only in areas with a long tradition of using them. Similarly, the use of limes often declines owing to competition from cement. However, there are likely to be renewed efforts to bring back limes and "natural" cements as cheap alternatives to manufactured cement for many purposes such as mortars for block walls. Lime may also be used in some forms of light-weight concrete blocks and sand-lime bricks that are widely employed in a few countries.

If raw materials are available, gypsum products are useful building materials. In dry climates, gypsum blocks may be employed. More generally, gypsum products are used for the lining and finishes, that, as mentioned above, become essentials at later stages of development.

Whether stone is used as a primary walling material depends on its availability, but it is nowadays traded for this purpose only in small local markets. It is used in developed countries as a cladding material.

There is a trend towards greater economy in the use of timber: roundwood is replaced by suitable types of sawnwood; wood-based panels, such as plywood, have quality facings, but the cores are made of lower-quality timber; wood residues from sawmilling and plywood production are used in fibreboard and particle board. Useful lining materials can be produced in this way.

In the early stages of development, reinforcing rods can be easily made from scrap metal. Flat sheets can be turned into corrugated sheets for roofing. Window frames may be assembled by relatively simple operations, from rolled steel sections that are normally imported until local steel production has made considerable progress, although fabrication of structural steel is fairly simple. Metal accessories (nails, screws, bolts) are also not difficult to make, but they are not usually manufactured at an early stage of industrial development.

The main advantage of using aluminium as a building material is its durability. It is more expensive than steel, and, for window frames, the assembly of extruded sections is more difficult. Corrugated aluminium roofing is useful as a substitute for steel. Rolling mills and extruding presses are installed normally at a late stage of development, but they might be introduced earlier if the building materials industry should become more concerned with durability than it is at present.

Plastics have great potential as building materials in developing countries. The stage at which they are introduced is likely to vary more widely than is the case for many other materials. The first plastic components to be manufactured are pipes for cold water and waste disposal. Plastic floor coverings, equipment and accessories are generally introduced later. Experiments in housing systems using plastics have been carried out. The use of plastics in this way might prove very useful if provisional estimates of the economics of such systems are confirmed by subsequent experience.

Of the other materials not covered so far, paints and glass should be mentioned. Local manufacture of paints is usually introduced at an early stage because they are easy to produce on a small scale. Glass is very widely used, and competition from transparent plastics is not as yet serious. It requires, however, a fairly large market for economic production.

PRODUCTION CHARACTERISTICS OF BUILDING MATERIALS

In a given country, production problems may limit the amount of a particular building material that can be produced so that this amount is quite unrelated to the potential demand. In planning the levels of investment in factories producing different materials, account must be taken of production problems as well as of the level of demand and other national economic considerations, such as the saving of foreign exchange. In this section, the principal limitations imposed by production technologies will be reviewed. They will vary considerably in effect in different areas.

Tables of building materials graded according to selected production criteria

In order to evaluate production problems, it is useful to measure the degree to which a number of selected criteria affect the production of certain common building materials. For this purpose, sixteen criteria

TABLE 6: DEFINITION OF PRODUCTION CRITERIA AND GRADES USED IN TABLE 7

Production criterion	*Grade*		
	A	*B*	*C*
1. Raw materials source			
The optimum distance from source to factory	less than 8 km	8—160 km	more than 160 km
2. Water requirement			
The volume of water consumed to manufacture $2,400 of product	more than 13,500 litres	4,500— 13,500 litres	less than 4,500 litres
3. Fuel costs			
The total fuel costs as a percentage of production costs	more than 10	5—10	less than 5
4. Electricity requirement			
Electricity cost as a percentage of fuel costs	more than 90	50—90	less than 50
5. Minimum size of market			
The minimum value of annual output that would justify capital costs (thousands of $)	more than 1,200	240—1,200	less than 240

TABLE 6: *(continued)*

Production criterion	*Grade*		
	A	*B*	*C*
6. Capital for storage Outlay on storage facilities at all stages of manufacture expressed as a percentage of capital costs	more than 15	5—15	less than 5
7. Reliability of process The length of time the basic process has been used commercially	less than 10 years	10—30 years	more than 30 years
8. Adjustability of process How easily the process can be adjusted to market demand	continuous process	intermittent but regular	adjustable to demand
9. Plant maintenance The percentage of production time lost through maintenance	10	5	nil
10. Supervision/quality control The ratio of supervisors to total labour force and proportion of their time spent on supervisory duties	10% continuous	5% continuous	only intermittent supervision
11. Skilled labour The ratio of fully skilled operatives to the total labour force	more than 50%	10%—50%	less than 10%
12. Production per man-hour The value of product per man-hour worked	less than $4	$4—$10	more than $10
13. Packaging The percentage of costs added for packaging	10	5	nil
14. Value/weight ratio The sale value per ton of product	less than $30	$30—$150	more than $150
15. Handling for delivery The equipment required for loading and unloading transport vehicles	cranes	hoists, lifts etc.	no equipment
16. Cost of delivery The addition to works costs for delivery cost	more than 10% in 50 mile radius	5% —10% any distance	less than 5% any distance

have been selected. Table 6 shows the definition of each criterion and of the three grades into which building materials may be placed with reference to it.

The sixteen criteria may be grouped into five categories. The criteria as regards input are raw materials source, fuel costs, water and electricity requirements. In certain circumstances, inadequate supplies of fuel and raw materials may limit potential production.

With some processes there is a threshold capacity, below which it is uneconomic to manufacture. This obviously varies considerably, as the definition of economic production can be framed only in relative terms by comparing t. e cost on site of local materials with that of equivalent imported ones. The criterion selected is defined as the minimum size of market required. This is approximately equivalent to the minimum capital investment needed, although the actual money values used for grading purposes in table 5 would vary in each specific case. The indicator of capital invested per employee has not been selected as a criterion because of the wide variations observed in the production of the same material. Further details will be found in the following section as regards cement production.

Criteria relating to process technology are defined under the headings "reliability of process", "adaptability of process" and "plant maintenance". If the principal processes have been employed for many years in various countries, fewer difficulties may be expected when they are adapted for use in developing countries. The rate at which technology develops is also important, since the rate of obsolescence of equipment is likely to be faster for newer processes. Some production plants using high temperatures must be operated continuously, as it is uneconomic to stop and start a plant repeatedly. This is further discussed below in relation to the size of plants. Complicated machinery may require extensive maintenance, and lack of trained maintenance staff may reduce output.

Criteria relating to labour are defined by the ratio of supervisors and skilled workers to total staff and the value of production per man-hour. The last figure may vary widely and the ranges given for grading are tentative. The variations do not appear to be quite so great, however, as for investment per employee. Value of production per man-hour is an index of productivity and is therefore likely to increase as improvements are made in a plant.

The ease with which materials are transported is most often defined by the value/weight ratio. Criteria relating to packaging, methods of

TABLE 7: CLASSIFIED BUILDING MATERIALS GRADED ACCORDING TO SELECTED PRODUCTION CRITERIA
(see table 6 for definitions of criteria)

Materials / Production criteria	*Raw materials source*	*Water requirement*	*Fuel costs*	*Electricity requirement*	*Minimum market size*	*Capital for storage*	*Age of process*	*Continuity of process*	*Plant maintenance*	*Supervision and quality control*	*Skilled labour*	*Production per man-hour*	*Packaging*	*Value/weight ratio*	*Handling for delivery*	*Cost of delivery*
1. Building stone (sedimentary)[a]	A	C	B	BC	C	C	C	C	C	C	AB	A	C	AB	BC	A
2. Building stone (igneous & metamorphic)[b]	C	B	B	B	B	C	C	C	C	C	B	B	C	B	BC	B
3. Natural aggregates	A	A	B	BC	C	B	C	C	B	C	C	BC	C	A	BC	A
4. Synthetic aggregates	A	A	A	B	B	B	A	AB	A	A	C	B	C	A	BC	A
5. Portland cements[c]	A	AB	A	C	AB	B	B	A	A	A	B	AB	AB	A	C	A
6. Limes[c]	A	C	A	C	C	C	C	AB	B	C	C	A	B	A	C	B
7. Gypsum plasters[c]	B	B	B	C	AB	C	C	C	B	B	AB	B	B	A	C	A
8. Plasterboard	B	A	B	C	A	B	C	C	B	B	AB	B	C	B	C	B
9. Glass sheet	B	A	A	C	A	A	BC	A	B	B	B	A	B	B	BC	B
10. Concrete blocks	B	AB	C	C	BC	AB	C	C	B	B	C	AB	C	A	BC	A
11. Concrete tiles	B	B	C	C	B	B	B	C	C	B	C	B	C	A	C	A
12. Concrete pipes[d]	B	A	C	B	BC	A	B	B	A	B	C	C	C	B	AB	A
13. Sand-lime bricks	AB	C	B	C	C	BC	C	BC	C	C	C	A	C	A	C	A
14. Asbestos-cement products	C	A	C	B	B	B	C	A	A	B	BC	AB	C	B	C	B
15. Pre-cast concrete units	B	B	B	C	BC	A	B	B	AB	AB	BC	AB	C	A	AB	A
16. Pre-stressed concrete units[e]	B	B	C	B	B	B	A	A	B	B	B	BC	C	A	A	A
17. Woodwool slabs[f]	C	A	C	BC	BC	C	C	C	C	B	C	B	C	B	C	B
18. Clay bricks/blocks[g]	A	A	AB	C	BC	C	C	A	C	B	C	A	BC	A	BC	A
19. Clay tiles	C	B	B	C	B	C	C	C	C	B	B	A	B	BC	BC	B
20. Ceramic and stoneware pipes	B	B	B	C	B	C	C	C	C	C	B	A	B	B	BC	B
21. Ceramic sanitary ware	C	C	B	C	C	A	C	B	B	B	B	A	B	C	C	C
22. Sawnwood	BC	C	C	C	C	C	C	C	C	B	BC	AB	C	BC	C	B
23. Plywood panels	C	C	C	B	B	B	C	C	C	B	AB	AB	C	B	B	C
24. Chipboard units	B	C	A	C	B	C	B	AB	C	B	C	B	C	B	B	B

25. Timber window frames	C	C	C	A	C	A	C	C	C	B	B	BC	C	C	C	C
26. Timber flush doors	C	C	C	B	B	B	B	C	B	B	B	B	C	C	C	C
27. Plastics panels[h]	C	C	B	B	B	A	B	C	C	A	A	A	C	C	C	C
28. Plastics fabrication[i]	C	B	B	B	B	C	A	B	B	A	B	B	C	C	C	C
29. Roofing felts	C	C	C	C	C	C	C	A	B	B	B	*	C	B	C	C
30. Paints and varnishes	C	C	B	B	C	B	B	C	C	A	B	B	A	A	C	C
31. Joint sealants and mastics	C	C	C	B	B	B	B	C	C	A	C	B	A	A	C	C
32. Reinforcing bars[j]	B	C	C	A	C	A	B	B	A	B	B	C	C	C	BC	C
33. Rolled steel sections[k]	AB	A	A	C	A	A	B	A	B	B	A	B	C	B	A	B
34. Structural steel fabrication	C	B	C	A	C	A	B	C	C	B	B	A	C	C	A	B
35. Steel pipes	B	*	B	C	A	B	B	C	B	B	B	*	C	B	AB	B
36. Cast-iron pipes	B	A	B	C	A	B	C	B	B	*	B	B	C	B	AB	B
37. Steel window frames	B	C	C	B	B	B	B	B	C	B	B	*	C	B	C	C
38. Stainless steel sheet[l]	C	A	B	C	A	C	B	A	B	B	B	C	C	C	B	C
39. Aluminium sheet/extrusions[m]	C	C	C	C	C	C	B	B	C	A	A	*	C	C	BC	C
40. Aluminium window frames	C	B	C	A	B	B	A	C	C	B	B	C	C	C	C	B
41. Copper/brass pipes	C	*	B	C	A	B	B	A	B	B	B	*	C	C	AB	B

[a] Including quarrying and processing.
[b] Excluding quarrying.
[c] Excluding extraction of raw materials.
[d] Including production of ancillary items such as man-holes, inspection chambers etc.
[e] Production in highly mechanized plants.
[f] Production on an industrialized scale.
[g] Production by modern plant.
[h] Production of purpose-made products.
[i] Including a variety of processes, of which the most important are injection moulding and extrusion.
[j] Excluding rolling bars, but including cutting, bending etc.
[k] Including smelting iron and steel and the rolling processes.
[l] Including production of sheet from steel slab.
[m] Production from ingot.
* Not available.

handling the finished product and delivery costs must also be taken into account.

It will be evident by reference to table 6 that grade C indicates relative ease of production, whereas grade A implies difficulties.

When the production criteria have been defined, a complete chart may be built up. Table 7 shows 41 building materials, in eight groups graded by the selected criteria. It is possible to manufacture some materials or components by different methods; occasionally, several products may be produced by one factory. Cases such as these are covered by the appearance in the appropriate column of two gradings. No attempt is made in table 7 to indicate the relative importance of the sixteen selected criteria. Some are clearly more important than others; the main ones are further discussed in the following section.

FURTHER CONSIDERATION OF THE MOST IMPORTANT PRODUCTION CRITERIA

Raw materials and plant location

The raw materials required to manufacture building materials are heavy and bulky. Their transport costs are high, particularly if they come from relatively inaccessible places and if they have to be transferred from one form of transport to another. For many building materials, the location of factories near the source of raw materials is a prime consideration. This ideal cannot always be attained for various reasons, such as lack of raw materials within the country, difficulty of attracting labour to factories situated far from places of habitation and inter-dependence with other industries.

Examples of raw materials found in relatively few places are asbestos, metals and decorative stones. Most countries have to import them from the few countries with an export surplus. Other materials, such as timber, gypsum and bitumen, although quite widely distributed, are not found in many countries. Raw materials such as clays, limestones, sand and concrete aggregates are widely distributed; most countries have deposits of some sort, although the quantity and quality are uneven.

At the early stages of industrialization, local production of building materials will probably be confined to heavy walling materials, such as cement, lime, aggregates, bricks and blocks. For these products it is particularly desirable to locate the factories close to raw materials, but

this causes difficulties in delivery to markets. In some countries these difficulties are overcome by dividing the production process; thus, cement clinker may be produced near the deposits of clay and limestone and transported for grinding to a plant near the markets. This technique is likely to become increasingly important in developing countries, where there are considerable distances between the sources of raw materials and the centres of population, but it can be applied only to a limited number of materials. Clay bricks, for example, cannot be produced in this way.

Industries dependent on imports of materials such as timber and steel will tend to be located close to ports, particularly at the early stages of development, when transport networks are still under construction. The possibilities of exporting products to neighbouring countries will reinforce this tendency. Subregional trade groupings of countries will probably also influence the location of factories.

Another group of building materials depends on other industries for its raw material: for example, cement or aggregate production uses slag from blast furnaces, and aggregates and lightweight concrete blocks use pulverized ash from coal burning power stations. The production of several building materials may be integrated; thus, the plant manufacturing asbestos-cement products may be adjacent to the cement works, and sawmilling may be integrated with the production of plywood or other wood based sheets. In making national economic plans, careful consideration must be given to whether such concentration of production facilities is desirable; from the viewpoint of a particular industry, there may be certain advantages.

Size of market

Lack of markets of suitable size inhibits the establishment of building materials factories. The problem arises not only from inadequate total size, but also from poor distribution in relation to transport facilities. The minimum size of plant for economic production varies according to the type of material and the production technology. It is fairly easy to define the limitations imposed by production processes, but it is more difficult to reconcile the conflicting criteria for factory investment and location.

Large plants are required for steel, for many other metal extraction processes and for petrochemicals, including plastics. These, however, are

not strictly building materials industries, although some of their products may be processed to produce building materials. For economic production, metal-processing plants are usually large, and rolling mills for sections, plate and sheet, extrusions presses and pipe-forming plants require high outputs. Products from small-scale plants generally cannot compete with imported products unless protected by tariffs.

Of the products manufactured almost exclusively for the building industry, sheet glass requires the greatest concentration of production. Even in developed countries the output of flat glass is concentrated in very few plants. In view of the special situation of the sheet-glass trade, it would be difficult to establish factories to supply even subregional markets without the assistance of one of the major producers. This is partly because it is technically difficult to produce sheet glass of reasonable quality and partly because the principal manufacturing techniques are covered by international patents.

Wide variations may be observed in the capital costs involved in producing the same materials in different countries and in different plants. From an international survey of five selected countries, it appears that in cement production the capital invested per employee varies from $1,800 to $117,000, as shown in table 8.

TABLE 8: CAPITAL INVESTED PER EMPLOYEE FOR CEMENT PRODUCTION

	Number of plants	*Plant investment/employee (thousands of dollars)*
France	2	72—75
India	5	1.8—16
Israel	2	63—117
Yugoslavia	3	11—25

SOURCE: UNIDO, *Profiles of Manufacturing Establishments.*

Cement production is becoming increasingly concentrated and the average size of new works significantly larger. It has become evident, however, that high-cost, small-scale production of cement close to the construction site may turn out to be cheaper than low-cost, large-scale production far from the construction site if transport costs are high. It may, therefore, be economic in certain countries to establish small cement works in spite of their high production costs.


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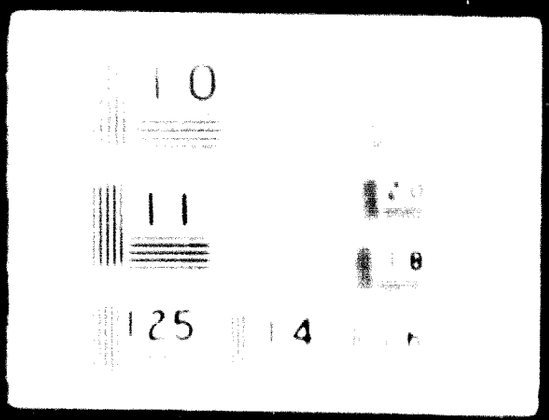


The materials discussed so far are manufactured by processes requiring high temperatures. Capital costs are high, and an intensive, three-shift operation is required, since it is uneconomic to start up furnaces every day. Limes and clay bricks also require high temperatures for their manufacture. With limes, small-scale production is possible only by accepting a variable quality of product and a relatively wasteful use of fuel. If more modern equipment is used, production becomes capital-intensive. Modern brick plants also involve high capital costs and high output compared with traditional brickworks, where greater variability of product is accepted. High investment and high output are required in new plants using high-temperature processes. Production on a reduced scale is feasible only if a variable quality of product is acceptable or if there is protection from cheaper imports. Since competition is usually limited in the brick market owing to high transport costs, high-cost brickworks may be able to survive.

The group of building materials including fibre-board, gypsum plaster, sand-lime bricks and aerated concrete blocks and units, involves heating, often by steam, to temperatures of just over 100 C. Production is feasible in plant of middle range capacity, but any expansion of plant entails duplication of existing facilities (brick presses, autoclaves, steam presses etc.). The advantage of larger-scale production lies in spreading the costs of services, such as steam-generating equipment.

Low-pressure steam heating is also used for curing plasterboard sheets. It is not essential, but it is normally employed in plant sufficiently large for economic production of boards of a uniform quality. For other products, such as asbestos cement, concrete blocks and pre-cast concrete units, steam curing is an optional process usually employed in larger plants where it is desirable to reduce the space used for curing.

The economic scale of production for other building materials depends on the complexity of equipment used (other than the heating units). Heat is required to manufacture plastics by injection moulding or extrusion, but is usually produced electrically and no reduction in costs is obtained by increasing the number of machines. Each machine operates relatively independently and outputs may vary considerably, but it is easy to increase capacity by adding extra machines, with little disruption to production. In large plants, mechanical handling may be introduced. The same conditions apply to other processes of manufacturing plastics, except glass fibre reinforced plastics, where moulding is usually done by hand but may be mechanized for repetitive work. Although the manufacture of plastics is apparently flexible, expensive

machines are required, and a fairly large output of mass-produced products is necessary for economic production.

Timber processing is a very old industry; it has therefore usually been carried out in small works. The size of the plant is increasing, but the average is still small in comparison with other industries. Larger sawmills are able to install kilns for seasoning, which improves the product. Wood-based sheet materials are relatively new, but production is growing fast. Prices for wood products in international trade are tending to fall owing to over-capacity in some developed countries. Although medium-scale production is technically feasible, it will be difficult for producers in developing countries to be competitive unless the developed countries have a smaller surplus to export as a result of their consumption growing faster than their production.

Joinery works can survive as small operations in many countries because there is no particular advantage in large-scale production until products become highly standardized. The same consideration applies to the assembly of light metal products such as steel window frames. Operations of this type are particularly suitable for developing countries because they may be started on a small scale and progressively expanded without large capital outlays and with little disruption of production.

The foregoing discussion has not covered all building materials, particularly those used for finishes and fittings, but enough has been said to indicate the characteristics that determine the size of market and the type of production unit required for economic production.

Labour skills

Most workers in the building materials industry are semi-skilled. Some materials, such as cement, are produced in highly automated plants in which only a few men are required to keep the machines operating correctly. In other cases, the process itself may be automated, but moving the material from one operation to another may be done by hand and for this unskilled labour may be employed.

Traditional materials, such as stone and wood, require craft skills, which are still required in modern production. New skills required for new materials, as in the case of plastics and wood-based sheets, are usually quickly learned on the job.

Most tasks in the manufacture of concrete products are often regarded as unskilled, since they are concerned with the mixing, transport and

placing of heavy material. It is becoming recognized, however, that the production of concrete of consistent quality requires a certain degree of skill and that such workers should be more carefully trained in concrete mixing and placing.

The training of labour to produce building materials does not present a major problem, provided that sufficient instructors can be found. There is sometimes a shortage of a few key skilled workmen such as carpenters, welders and mechanics. As regards supervisory, technical and managerial staff, however, the situation is usually less satisfactory. Developing countries must often rely upon expatriate staff to fill these posts while they undertake urgent training programmes. Lack of technical skills often results in considerable increases in the costs of bringing new plant into production.

Value added by the building materials industry

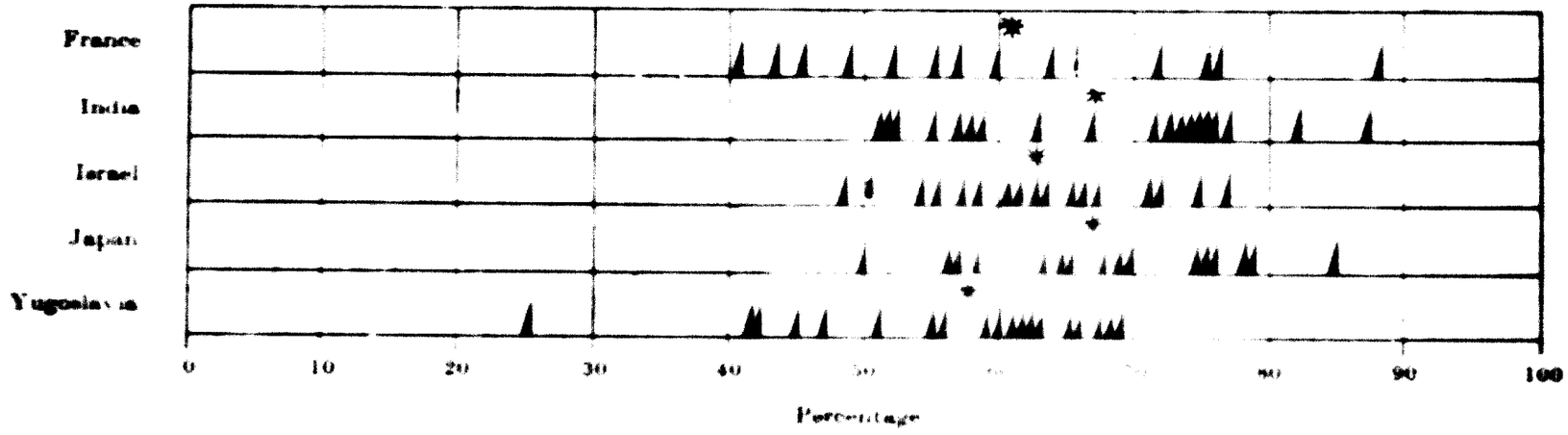
The international survey previously referred to provides an analysis of inputs and output for building materials plants in France, India, Israel, Japan and Yugoslavia.[14] The data are used in table 9 to show total inputs as a percentage by value of output in each country for building materials as a group.

Differences between countries in the composition of the output value of the same product make it difficult to interpret the information, and there are wide variations in the relative proportions of inputs and value added. Table 10 shows for selected groups of building materials the proportion of output value attributable to inputs and to value added. Value added tends to contribute a smaller proportion to output value than do inputs. The proportion of value added to output value exceeded 50 per cent in only 13 per cent of the examples analysed. From table 10 it may be seen that:

> Metal products manufactured by the more mechanized processes tend to have a low value added; only the production of structural steel and the assembly of metal frames show a value added similar to that for other important building products, although in both cases it varies widely;

[14] *Profiles of Manufacturing Establishments*, for full reference see annex 3 under "United Nations Industrial Development Organization".

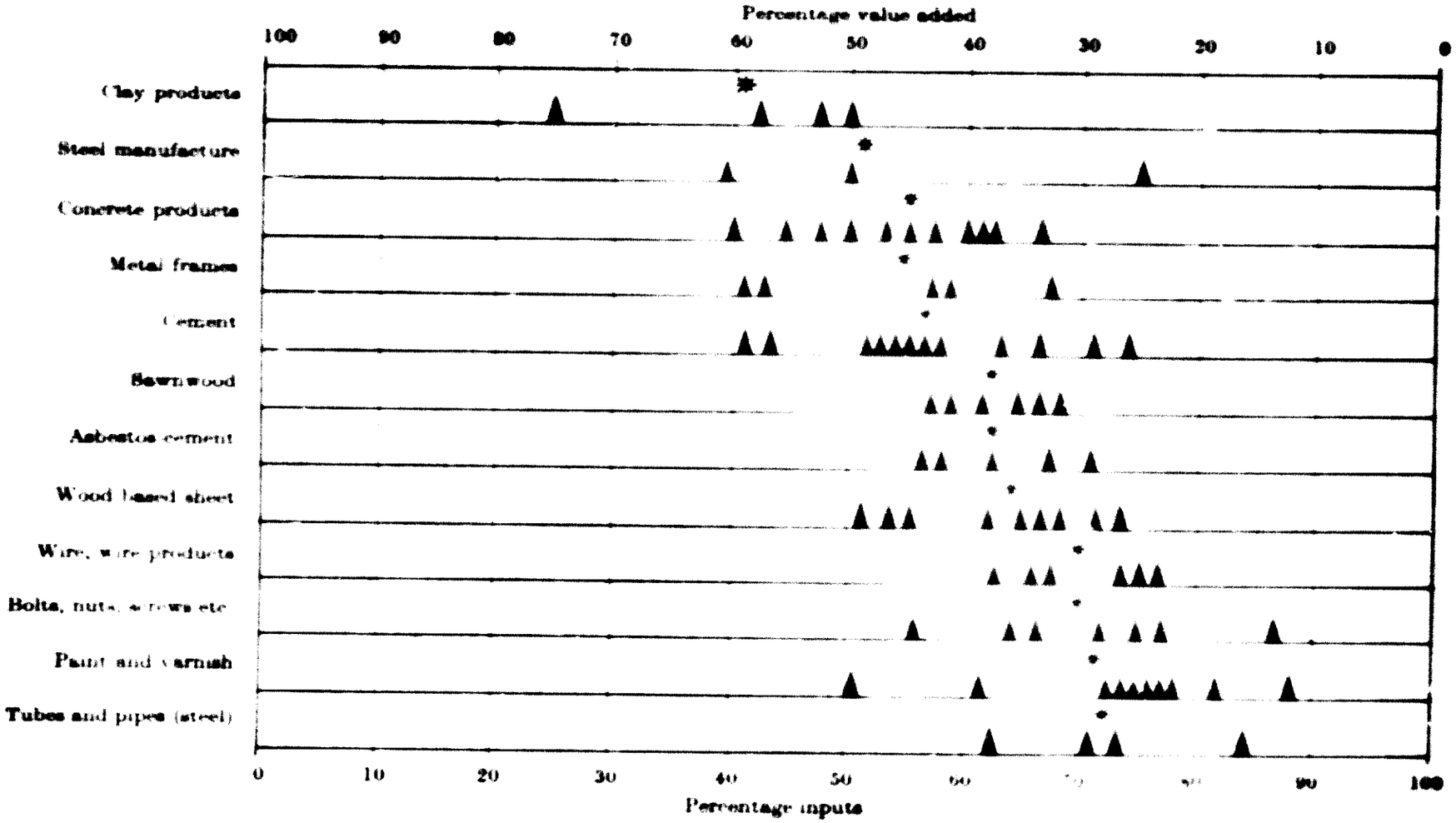
TABLE 9: TOTAL INPUTS AS A PERCENTAGE BY VALUE OF OUTPUT OF BUILDING MATERIALS IN SELECTED COUNTRIES



SOURCE: UNIDO, *Profiles of Manufacturing Establishments*.

NOTE: * represents the average percentage for each country.

TABLE 10. INPUTS AND VALUE ADDED AS A PERCENTAGE OF OUTPUT FOR SELECTED GROUPS OF BUILDING MATERIALS



SOURCE: UNIDO *Profiles of Manufacturing Establishments*.

NOTE: * represents the average percentage for each group of building materials.

The only other materials where the value added is in the same range as for metal products are paint and varnish;

The materials with the highest value added are clay bricks and concrete products.

These observations merely confirm that value added is a higher percentage of output value when production is labour intensive. Metal manufacture and assembly processes have high value added, whereas the more automated production of tubes and pipes have a low value added. The manufacture of clay products is also labour intensive and has high value added. However, to this relatively simple relationship must be added the complication of labour intensive production using expensive, imported raw materials. Referring again to table 10, it will be seen that the value added for asbestos-cement products is a smaller percentage of output than is the case with concrete products. This is because an expensive raw material—asbestos—has to be imported, whereas concrete products do not suffer from this drawback.

PLANNING AND ORGANIZATION OF THE BUILDING MATERIALS INDUSTRY

In attempting to plan the building materials industry at a national level, the first difficulty is usually lack of data on natural resources, on the scale and location of existing production units, and on current consumption and the efficient use of materials. If it proves possible to obtain the information so that production targets may be established and suitable sites selected for production units, the problem becomes one of implementation. This raises the difficulties of unsuitable transport networks, lack of know how and skills, and lack of finance and incentives. A detailed plan must take all these difficulties into account and put forward proposals to overcome them.

In the case of the building materials industry, plans must cover the requirements of all four categories of the construction industry, namely, the international-modern, the national-modern, the national-conventional and the traditional. As a short-term expedient, subsistence level housing may have to be subsidized. Small-scale industry must be promoted and mass-production facilities established.

The following special factors must be considered:

Range of materials. Many different building materials are required in modern construction. Planning must cover all the principal materials in order to ensure that the total supply is adequate, having due regard to the possibilities of interchangeability.

Relationship with other industries. The estimates of total demand must make allowance for the fact that some products used in construction have other end-uses.

Overlapping with construction. In national industrial statistics, some production facilities may be classified under construction because they are owned and run by contracting enterprises. These must be included in plans for developing the building materials industry.

Scale of operations. Few building materials are manufactured on a large scale; many are produced efficiently on a relatively small scale. The industry is usually characterized by a large number of small producers.

Markets. Owing to their low value/weight ratio, building materials in market economies may be exposed only to limited local competition. This sometimes means there is a lack of incentive to modernize production and thus lower production costs.

Demand. At the local level, the demand for materials may fluctuate widely as construction output varies. There is often little incentive to use stocks to even out the supply situation, as stocking ties up capital and there is often a lack of confidence in the level of future demand.

To these problems must be added the limitations imposed by the nature, production processes and handling characteristics of the materials.

THE INFORMATION REQUIRED FOR PLANNING

Data on natural resources

Information is required about deposits of clay, limestone, mineral ores, sand etc. Clearly it is neither possible nor desirable to make a detailed survey of all these resources at the same time. It is more economical to make a series of surveys in increasing detail as particular areas are shown to be possible sources of some useful raw material. In the final stage, when a choice of deposits is being studied with a view to extraction operations, detailed studies must be made in order to collect information on the workable area, the average thickness of overburden, the average thickness of deposits and their yield, the total overburden and deposits, and the position of the water table. In general, the raw materials for building materials are found close to the surface, with the possible exception of natural gypsum. It is therefore relatively simple to compile a map of building materials resources, since deep exploration is not required as in the case of some other industries.

The conducting of surveys is an operation requiring expert technical assistance, and the advice of international agencies should be sought.

Local sources of raw materials are not important for all building materials: timber may be imported as roundwood or sawnwood; plastics as polymer chips or powder; asbestos in slightly purified form after

mining, and metals as crude ingot or primary products. Building materials particularly dependent on local raw materials are cement, bricks, concrete products (for aggregates) and glass.

Data about production and consumption

It is difficult to obtain and keep up to date information about the building materials industry owing to its fragmented and ill-defined nature. Although data about mass-produced materials, such as cement and glass, are readily available, it would be necessary to collect many statistics in order to keep track of the manufacture of concrete products. Some check, however, must be kept on the main producers in each sector of the building materials industry so that attempts can be made to prevent critical shortages of materials. It is preferable to develop an existing structure rather than to create a completely new industry. Systems from other countries should not be introduced unless they are appropriate to local conditions.

The general information given in the previous chapter should not be used for planning purposes in all countries without checking specific points. Investment figures for various production levels of particular materials may vary widely. For example, the distance from port to factory site will affect the cost of imported machinery. The net output per man is also likely to be subject to wide variations.

In addition to a review of the level and distribution of consumption of building materials, an inquiry should be made into how economically they are used.[15] It has been observed in many countries that expensive materials are used wastefully. This may indicate the need for a programme to promote the more efficient use of building materials in construction design and to eliminate waste on site.

The national level of consumption of the materials covered in chapter 2 should be compared with the data given for other countries. Ideally, however, information is required on the consumption of a wider range of materials. If studies of production and consumption were carried out with international technical assistance through bodies such as UNIDO, the data collected would be of considerable value throughout the developing world.

[15] Report of the Seminar on the Development of Building Materials; for full reference see annex 3 under "Economic Commission for Asia and the Far East".

Forecasting demand and production

In considering trends of future consumption it is important to recognize the difference between key materials (cement, steel, timber), which are irreplaceable in any national construction programme, and others that are useful but interchangeable. The key materials are, fortunately, those for which good statistics are available. Cement and steel estimates for Africa may be found in documents relating to this region.[16] Figures for Asia and the Far East are also available.[17] Few data are available for Arab countries. In the case of timber, detailed forecasts of consumption are available.[18]

In estimating the demand for other building materials, account must be taken of:

The present breakdown of building materials inputs, which has been influenced by national climate, geography, history, tradition and the pattern of construction output;

The changes in the breakdown that will probably occur as a result of changes in the pattern of construction output, in the technology of construction (including rationalization of the use of materials), in the availability and price of materials, in fashions, and in government policies.

Tables (such as table 3 in this monograph) giving the consumption in particular countries of building materials in different types of construction are very useful, although the actual figures will not be directly applicable in other countries. Such tables enable better estimates to be made of the effects on total consumption of changes in the composition of construction output and show the possibilities of interchanging materials. Continued growth in the national-modern category will increase the demand for industrialized materials faster than the increase in total construction output would suggest. Similarly, a change in the international-modern category might significantly alter the volume of imported building materials.

The role of the Government as a client should also be considered. The commissioning of major defence or engineering works may alter completely the character of demand for building materials; these works may either require heavy imports or severely retard other construction

[16] ECA, *op. cit.*

[17] *Industrial Development in Asia and the Far East*, Vol. IV.; for full reference see annex 3 under "Economic Commission for Asia and the Far East".

[18] See publications listed in annex 3 under "Food and Agriculture Organization".

works by creating shortages of materials. In developing countries, the Government may often be able to regulate demand in a way that is not feasible in developed countries by programming its own works.

Transport costs of both raw materials and finished products play an important part in determining the prices of building materials. Factors affecting transport, therefore, also affect building materials. Thus, a new road link between areas may radically change the previous supply position for building materials. An industry enjoying a market hitherto cut off by transport difficulties from other sources of supply may suddenly have to become competitive. Unless it is able to react to the change, it may find that its costs are too high and it loses business. As a result, the supply of building materials may be disrupted.

The measures required for implementing the plans

Provision of the appropriate industrial services

Adequate technical knowledge in the production of building materials is indispensable; if it is not available locally, it must be imported with the assistance of international agencies, such as UNIDO.

The shortage of technical expertise in developing countries makes it essential to use what is available as efficiently as possible. It is therefore suggested that one central institution be established, covering both the construction and the building materials industry, to serve as an advisory and research body responsible for standards and testing, thus combining functions that are discharged by a number of separate bodies in developed countries.

The functions that such an institution should undertake may be summarized as follows:

To serve as the national clearing-house for technical assistance provided by international agencies;

To assist in surveys of natural resources, particularly by carrying out sample analysis;

To assist government agencies in preparing plans for the development of the building materials industry by carrying out surveys and studies on the use of materials;

To provide technical advice to industrial enterprises on producing materials and to users on the selection and performance of materials;

To undertake research on subjects related to the production and use of building materials;

To adapt published standards for use under local conditions.

To assist in the development of proposals for dimensional co ordination.

This is a formidable list of functions and they cannot all be undertaken immediately. They indicate however the range of services required by a modern building materials industry for which some provision must be made at an early stage of development. The technically qualified personnel required as a minimum to staff the building materials section of a central institution would include

Materials analyst (to supervise analytical work)

Production process technologists (covering four sectors: cement lime/gypsum, concrete products, metal products and wood products).

Advisers on the use of building materials (two covering different ranges of products)

Data analyser (to organize surveys and fact finding programmes).

Standards officer (to adapt standards to local conditions).

Officer for dimensional co ordination (who may be attached to a government department rather than to the central institution).

Director of materials section

It may well prove difficult to recruit eleven people with the qualifications listed above: the possibility of seeking international assistance should be considered. As soon as it has been decided to proceed with the central institution a programme for the development of the organization should be drawn up. Although it will be government financed the body should be given as much independence as possible so that it acquires an identity and a reputation of its own.

The research work undertaken in developing countries should not be concentrated on building materials for modern construction. In some countries significant improvements have been obtained through a small expenditure on research on the performance of traditional materials. Thus it has been reported from Burma that impregnation of bamboo, at a cost of about 30 per cent of its value, increased its expected life from five to fifteen years.

The research work being carried out in other countries should be carefully studied in order to avoid duplication of effort. This may be difficult unless international co operation is established. The sharing of research projects with neighbouring countries is also a possibility worth investigating. It will be found however that at early stages of development, the most profitable research will consist of practical efforts to improve the efficiency with which raw materials are employed in the

manufacture of building materials and to obtain greater economy in the use of building materials in construction.

The importance of quality control cannot be overemphasized. There are many examples of international contractors engaged in modern construction who prefer to use imported materials of known and uniform quality rather than variable local products. This is clearly an unsatisfactory situation. For most users, a known minimum standard of quality, even if quite low, is better than no standard at all, since it encourages a degree of confidence in locally produced materials.[19]

Financial incentives

At early stages of development, the building materials and components industry requires considerable government assistance. In addition to short-term measures such as import tariffs, certain long-term measures have been proposed, for example [20]

Long-term loans at low interest;

Exemption from income tax or from other local taxes and duties and permission for rapid depreciation rates for an agreed period;

Development of industrial estates and infrastructure and the provision of cheap land suitably located;

Use of locally produced building materials in all government or government-sponsored construction programmes;

Special advice and assistance to industries to develop exports of products in the manufacture and marketing of which the country has real advantages;

Special training grants for managerial and skilled personnel;

Reduced transport rates for industries located in developing regions;

Subsidies for the rent of land or buildings for a period of five to ten years or a grant of part of the cost of building factory premises.

Such measures apply not only to building materials but to most industries. Since resources are limited, an order of priorities must be established, and the role of the building materials industry within the national economy must be more precisely defined than it has generally been in the past.

[19] For further discussion on this subject, see Monograph 12 "Standardization" in this series.

[20] "Development of the Building Materials and Components Sector"; for full reference see annex 3 under "Economic Commission for Europe".

THE INTERNATIONAL SYMPOSIUM ON INDUSTRIAL DEVELOPMENT: ISSUES, DISCUSSION AND RECOMMENDATIONS

The issues, the discussion, and the recommendations approved by the Symposium are presented in this chapter.

THE ISSUES [21]

The building materials and components industry is closely connected with the construction industry. The objective of both industries in developing countries is to provide the facilities necessary for the economic development and well-being of the people. The share of the gross national product (GNP) contributed by the building materials and components sector, including transport, increases rapidly with economic development, from about 5 per cent for the less developed countries to nearly 13 per cent of the GNP for the most advanced countries. The annual *per capita* expenditure on building materials and components, including their transport to building sites, may be estimated at about $6 in countries at an early stage of development (with an average *per capita* GNP of $127) while in the next group of countries (with an average *per capita* GNP of $315) the corresponding annual expenditure of GNP on building materials and components may be estimated at about $23. In the most advanced countries, no less than $104 *per capita* is estimated to be used annually for the purchase and transport of building materials and components.

Although based on rather uncertain data from a somewhat arbitrarily selected list of countries representing different economic conditions, it seems reasonable to conclude that on-site expenditure on building materials and components increased about three times faster than the GNP *per capita*. This adds particular significance to the discussion of the issues

[21] From Issues for Discussion: Building Materials and Components Industries, 1967 (ID/CONF. 1/A. 11) (mimeo.).

related to this industry. The changing pattern of this industry in industrial development is illustrated by the steady transfer of operations from building and construction sites to factories.

Forecasting future needs and establishing long-term targets

Few countries have yet adopted a comprehensive policy for co-ordinated efforts in the development of the building materials and components industries. It is apparent that there is a need to establish long-term targets for these industries on the basis of long-term plans for the construction industry. Such targets should be based on surveys of raw materials suitable for the production of building materials, components and equipment.

It would seem that long-term programming of construction activities provides a suitable basis for the forecasting of the future demand for various building materials and components. More research is required, however, to provide the necessary basic information.

Local materials and techniques

Building materials and components produced by organized industries are sometimes more expensive than local goods produced non-industrially. While every effort should continue to be made to encourage increased industrial production of materials such as cement or steel and milled timber, equal importance should be attached to the improvement of local materials and techniques. Lime may be taken as an example. Lime has been universally used for thousands of years, but its application in the construction industry has dwindled in the past century. A more extensive use of lime could be encouraged by disseminating information on its possible application in building and the savings resulting from its use. Manufacture of clay bricks and production of all-clay lightweight blocks should be contemplated in areas where cement is costly. The manufacture of this type of product could be considered in conjunction with a brick plant when equipment and kilns are available. The manufacture of substitute cements such as *puzzolana* may also be considered. Traditional mortars of this type can still have an important place as building materials. The Regional Symposium on Industrial Development in Africa recommended that emphasis be directed to the development of traditional and new building materials based on local resources such as building stones, clays, lime, sand, gypsum, bamboo and timber, as well as agricultural and industrial waste products.

Small-scale manufacture

The encouragement of traditional materials should go along with a policy of promoting the establishment of small-scale industrial manufacturing units. Thus, small sawmills and joinery workshops or small modern brickworks or concrete-block plants may exist side by side with the use of round wood and sun-dried bricks. Specifically, small-scale production of Portland cement could be established and should be encouraged. The Asian Regional Conference on Industrialization recommended that countries with adequate resources of coke, anthracite or petroleum coke whose consumption of cement is low (of the order of 30 000 to 60 000 tons per annum) adopt the shaft kiln process, and the wet or dry process for higher capacities.

Modern techniques and regional sharing of markets

Although traditional techniques play an accepted role in building materials production, it must be emphasized that in each country there are sectors of construction that require quality materials produced under the most advanced technological conditions and that these sectors will grow in importance. Thus, capital-intensive, advanced-technology industries producing materials such as cement, iron and steel are appropriate where the size of the market and availability of raw materials permit. The establishment of such industries does not replace but supplements existing industries at a lower technological level and represents a desirable investment for scarce capital. By replacing imports, not only do they help considerably in saving foreign exchange, but they also tend to have a linkage with other industries and thus play a pivotal role in stimulating the establishment of ancillary facilities.

There are, however, serious difficulties and obstacles. The cost of establishing manufacturing plants in developing countries tends to be greater than in the more developed countries, mainly because of higher costs of transport, construction and installation. The running-in costs of the factory are also generally higher than in more developed countries because of the lack of trained staff. These factors can result in higher production costs per unit than world market prices, and special measures may be required — at least in the initial stage — to protect the domestic industry from the competition of imported products. For these reasons, many developing countries are considering regional sharing of markets for building materials, although this development still appears to be remote.

Standardization[12]

In the early stages of a country's development, the demand for building materials and some components is met to a large extent by imports from developed countries. This often leads to the use of various patterns, sizes and scales of the same material or component. Attempts to standardize products and dimensions are sometimes resisted by traders who have a vested interest in the *status quo*. As long as building materials are imported there is a certain danger in enforcing standardization, since this might give preference to materials of a certain mark or to materials imported from a certain country. As soon as domestic production is envisaged, it is important to introduce standardization of products, involving dimensions, composition, quality, performance, methods of manufacture and testing. Quality standards may prove to have a favourable effect upon productivity, even for such simple items as stone aggregates. Dimensional standardization is of primary importance in the early stages of economic development. At a more advanced stage, when industrially manufactured and fabricated building components are being increasingly used, dimensional co-ordination becomes imperative. To promote acceptance of the standards, consideration should be given to adopting existing international or regional standards. There may, however, be good reasons to deviate from standards adopted in other countries, for instance, to achieve closer compliance with the real needs and conditions in the country. Hence, the standardization of each item should be carefully studied in each country. It is evident that the developing countries have an unusual opportunity to elaborate and apply, at an early stage of development, a coherent system of standards, regulating the dimensions and properties of building materials and components, as well as methods of testing and quality control, and thus are in a position to make a considerable short-cut in technical development.

Testing and research institutes; control of quality standards

The setting up of testing and research institutes and the establishment and control of quality standards are vital necessities in developing countries and might be recommended as a significant field for expanded technical assistance. Such institutes may also be responsible for the survey of existing resources of raw materials for building and the laying down of specifications for the quality and properties of all building. It is highly desirable to have an early linking-up with testing stations in other countries, particularly within the same climatic and geological

[12] See Monograph 12 "Standardization" in this series.

regions. Manufacturers in developing countries are often ignorant of the experience of other countries which have gone through a similar period of development. It is therefore important that information on successes as well as failures of industrial undertakings in developing countries be systematically gathered and disseminated, preferably through international organizations.

As a general rule, standardization, testing and quality control of materials and components, education and the provision of information represent primary activities in developing countries, while research and development work are to be considered as secondary activities. This means that standardization, material testing, quality control, educational and informational activities should be organized in the first instance, while independent research and development work should start at a later stage, on the basis of the progress made in the primary activities and in order to develop them. Furthermore, research should concentrate on the particular problems of the country and on adaptation of research results achieved in other countries. Thus, the Regional Symposium on Industrial Development in Africa recommended that an African building materials industry development research centre be established to work in co-operation with national and subregional building research organizations, existing or planned, in order to facilitate the exchange of information and experience among African countries.

Transport costs and location

Transport costs of building materials constitute an important part of on-site costs. Savings can generally be achieved through a reduction in the bulkiness and weight of materials, a shortening of transport distances, or an improvement of transport facilities, singly or in combination. Measures of this kind give high returns and have perhaps constituted the most important means of improving capacity and productivity in the production of building materials in the last decade. Extensive research into building materials and construction methods has considerably reduced the consumption of materials per unit, for instance, through the introduction of high-quality steel, pre-stressed concrete, prefabricated concrete, hollow bricks etc. Alongside the more economic use of traditional building materials, savings on transport costs have been made also through the introduction and increasing use of concrete, metal and plastics of light weight. Transport costs are a potent factor in the location of modern building materials industries, and modern techniques offer a great variety of solutions, which should be made available to the developing countries.

THE DISCUSSION[23]

The discussion on this subject was concerned primarily with building materials that are mainly used for construction. Since other materials, such as steel and plastics, were discussed under their respective industry sectors, there was little opportunity to review the complex problem of interrelationships between industries. It was considered that building materials were an important industry, which, like construction, had often been neglected in development plans; that neglect had seriously impeded the growth of the industry and was particularly unfortunate in view of the opportunities existing for import substitution, which might achieve significant savings in foreign exchange.

It was stressed that waste materials should be used where possible. Nevertheless, the role of composite building materials based on waste products (rice husks, coconut fibres, groundnut shells, date palm etc.) remained controversial. Many trial schemes had been tried but without great success. Research was continuing and there were reports of success on a laboratory or small pilot scale. The Symposium did not include in its discussion any consideration of how such composite building materials would compare in price and performance with more usual products. It was stressed that, where possible, building materials industries should be based on locally available materials. In that connexion, it was necessary to distinguish between locally produced modern and traditional materials; only negligible quantities of the latter were produced industrially. The international character of most modern materials was not brought out, except in the case of cement and steel.

In view of the complexity of the topic, the discussion did not go deeply into levels of consumption. The only materials singled out for special mention were cement and wood based products, and attention was centred on ways of using these materials rather than on the quantities required.

The role of wood products in construction was also considered controversial. Arguments were cited both for and against their promotion as a primary material for house construction. There was general agreement that economical use must be made of the products employed, but their precise role must be determined in each country, having regard to the raw materials available, their cost and characteristics.

[23] From *Report of the International Symposium on Industrial Development, Athens 1967* (ID/11) (United Nations publication, Sales No.: 69. II. B. 7).

The discussion of the use of prefabricated components covered speed of construction, quality and dimensional co-ordination. The problems of labour requirements and costs were used as arguments both for and against prefabrication, but the Symposium reached no conclusion as to the stage of general industrial development that should be reached before prefabrication was contemplated. The concept of prefabrication, though attractive at first glance, required detailed examination, and caution should be used to avoid wasteful and unsuccessful projects. Transport problems were mentioned in general terms, but it was observed that the centralized production of components in factories requiring a high output for economical production called for well-developed services and facilities.

Attention was drawn to the difficult problems of choice of materials, since materials could be substituted for one another to quite a large extent in buildings. There was usually less range of alternatives in developing countries than in developed ones. Each country would have to determine for itself the extent to which choice should be encouraged.

The importance of adapting the technologies of producing and using building materials to local conditions was emphasized. An example given was the problem of producing concrete components in tropical countries. As the exact nature and quality of raw materials differed in different countries, adaptation was obviously essential. It would be illogical to import processes that depended on imported raw materials when alternative processes could make use of local materials.

Attention was given to the issue of capital investment versus labour requirements, already mentioned in connexion with prefabrication, which was considered to apply to most investment decisions affecting building materials production. However, even if low capital intensity processes were adopted where possible, the total level of investment required in building materials production would still remain high. The necessity for examining detailed production costs, which applied to all products, was particularly important in the case of cement. In assessing costs, capacity utilization must be considered. It was suggested that UNIDO assist in providing guidelines for new uses of products in order to utilize the full capacity of factories. A thorough study of capacity utilization and associated problems would be required in order to establish such guidelines.

Another issue raised at the Symposium with regard to production was that of plant maintenance, and it was stressed that in planning

capital investment in plant particular attention should be paid to the maintenance services in order to ensure minimum delays to production.

Cement was considered to be the key material in the industrialization of the building materials industry, although a number of other materials were also involved. Particular interest was shown in the question of small scale manufacture of cement. The size of cement factories must be considered in relation to the current rate and anticipated growth of consumption, the distribution of markets, the transport required, the price of imported cement and raw materials, production costs and a number of other technical considerations.

The long-term forecasting of requirements of building materials attracted considerable attention. It was stressed that surveys provided a necessary background for the preparation of long-term plans for the development of the building materials and component industries. It was realized, however, that long-term plans and forecasts of needs were not sufficient on their own to determine investments in new factories. Feasibility studies must be carried out for each project, otherwise misinvestment, high production costs and idle capacity might result. In this connexion, it was suggested that each country study carefully its own resources of raw materials rather than rely uncritically on building materials of foreign origin. It was also noted that direct cost comparisons between various materials could be misleading if durability and other requirements were not taken into account.

Much emphasis was placed on the need for surveys of natural resources. Local raw materials were to be preferred in developing the building materials industry, and raw materials for building were generally formed in shallow deposits that were not difficult to survey. Nevertheless, priority was often given to surveys to locate valuable raw materials that could be exported while little attention was given to surveys of raw materials for building. Assistance was needed in making such raw materials surveys.

International assistance would be particularly useful in establishing technical infrastructure; this issue was the subject of extensive discussion, and stress was put on the necessity of having comprehensive services, including technical training centres, research facilities, pilot and demonstration plants and bodies to promote quality and dimensional standards. It was proposed that these issues be dealt with at the regional level.

Recommendations approved[24]

Developing countries should, where appropriate, give higher priority to the development of the building materials industries in order to achieve greater efficiency in their construction activities, better utilization of local raw material resources and savings in foreign currency.

UNIDO, on request, should assist in drawing up national and regional long-term programmes for the production of building materials having regard to plans for their construction industries and surveys of their relevant natural resources.

UNIDO, on request and in co-operation with other organizations, should promote studies and collect and distribute information on the economics and production techniques of competitive building materials, having regard to the function and durability of the constructions.

UNIDO, on request and in co-operation with other organizations, should assist in the development of production techniques based on the use of local raw materials, including agricultural and industrial waste products, by promoting the establishment of pilot and demonstration plants in different regions and by other measures.

UNIDO should assist in the establishment of testing and training centres for a more efficient use of traditional and modern building materials and the setting up of research facilities to promote the application of modern production techniques to specific climatic conditions (as, for example, in concrete products handled in large quantities).

UNIDO should examine the feasibility of smaller scale local cement plants having regard to high transport costs for imported cement.

UNIDO was asked to promote the implementation of projects based upon pre-investment studies already available either on regional or national bases.

UNIDO, in co-operation with other bodies, should assist in the development of co-ordinated systems of standards relating to the dimensions and properties of building materials and components as well as to methods of testing and quality control.

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[24] From *Report of the International Symposium on Industrial Development, Athens 1967* (ID/11) (United Nations publication, Sales No.: 69. II. B. 7).

ACTION OF UNIDO AND OTHER UNITED NATIONS ORGANS TO PROMOTE THE BUILDING MATERIALS INDUSTRY IN DEVELOPING COUNTRIES

International organizations are in a good position to study problems of general interest throughout the world. They have access to a range of information and experience that is often invaluable. As the characteristics of building materials industries are virtually the same everywhere, they provide worth-while subjects for international study and research.

UNIDO ACTION

The programme of UNIDO for promotion of the building materials industry is financed under various United Nations operational programmes in which UNIDO participates. These programmes are: the Regular Programme of technical assistance devoted to industry and financed from the United Nations budget; the Special Fund component of the United Nations Development Programme (UNDP/SF); and the Technical Assistance component of the United Nations Development Programme (UNDP/TA). UNIDO receives, in addition, voluntary contributions from Governments for the financing of the Special Industrial Services programme (SIS), a programme limited largely to urgent short-term missions. Some projects may also be financed from funds in trust, deposited by Governments for specific projects, or other direct voluntary contributions. In all these programmes assistance is given only at the request of the Government concerned.

Considerable work has already been undertaken by UNIDO in the field of building materials. A list of selected technical assistance projects and of areas relating to the development of the building materials industry in which UNIDO can provide technical assistance is given in annex 1.

Technical assistance provided by UNIDO has extended to the cement and allied industries, ceramics, bricks, glass and refractories,

mineral deposits and general building and construction materials industries. Some forty technical assistance projects have been financed by UNDP SF, UNDP TA or SIS. The majority of technical assistance projects in recent years have been connected with the establishment or modernization of particular building materials plants. Not many projects have dealt with wider planning issues. But the situation is likely to change slowly. concern was expressed at the Symposium over the lack of technical infrastructure in developing countries, although few requests have been made as yet for assistance in this area.

As regards cement, the work of UNIDO has focused and will continue to concentrate on the rehabilitation and modernization of existing plants as well as on feasibility studies and market surveys for new installations. Particular attention is being paid to the economics and design of cement plants so as to meet the needs of developing countries where markets are often small and fuel supplies limited and expensive. Stress is laid on the importance of co-operation on a subregional basis as regards cement production.

In view of the shortage in some developing countries of local resources for asbestos, plans for technical assistance will cover the use of alternative materials.

UNIDO plans to expand its technical assistance activities in ceramics, bricks, glass and refractory industries. Such industries are of considerable importance to many developing countries, but they are frequently operated on a scale and with techniques unsuited to local needs and conditions.

A number of field surveys will be carried out on the possible industrial uses of mineral deposits including asbestos, gypsum, sands, clays and other ceramic producing materials. General surveys of building materials industries already executed with technical assistance have proved valuable in promoting these industries in developing countries. It is anticipated that more projects of this nature will be undertaken in the future.

As regards new areas for UNIDO activity, technical assistance with prefabrication in construction is already planned. Prefabrication is a natural development in countries that are industrializing their building industries and are becoming more aware of the need for greater productivity. Plastics is another area in which technical assistance will probably be given. UNIDO feels that it should be possible in developing countries to combine the use of plastics with local materials to provide

efficient low-cost construction, although in industrialized countries the technique employed so far is rather sophisticated and expensive.

Major operational projects in which UNIDO has participated include the setting up of housing and construction centres under Special Fund projects or with financing from other sources. Such centres may have a significant impact on the building materials industries. New Special Fund projects are also under consideration. In these projects UNIDO is co-operating with the United Nations Centre for Housing, Building and Planning.

In support of operational activities, UNIDO organizes, in close co-operation with other international bodies, technical meetings on a wide range of subjects. A list of meetings organized by UNIDO is given in annex 2. In addition to facilitating valuable personal contacts, such meetings often provide the starting point for the preparation of studies and reports that are subsequently widely circulated and used in many countries for years afterwards. A study is being prepared on small-scale production of Portland cement, a subject that attracted much attention at the Symposium. At the Workshop on Organizational and Technical Measures for the Development of Building Materials, held in Moscow in 1968, studies were presented on "*Puzzolana* cements", "Building lime: its properties, uses and manufacture", the manufacture of "Sanitary ware from common clay and the brick and tile industries".[25] Further research on some of these topics will be conducted in continuing study programmes, and other subjects may be added.

Work of the United Nations regional economic commissions

The secretariats of the United Nations regional economic commissions have already carried out various studies on the building materials industry. It is proposed to continue these studies for which UNIDO can offer assistance as regards scope, content and methodology. By contributing to regional and subregional studies, UNIDO will be able to supplement its work in commissioning general reports.

The studies will cover a survey of the trends in the use of building materials and components by sectors of the construction industry, including trends in production technology, capital and manpower requirements and forecasts of likely development in the regions. It is

[25] These papers are not as yet available for general distribution.

clear that much of this information is also required for national planning and some of the data may already be available. Studies of the following sectors might be prepared:

Cement, asbestos cement, lime and concrete products (including aggregates);

Clay building materials;

Plastics for building purposes (including paints and varnishes);

Steel in construction;

Non-ferrous metals for building purposes;

Miscellaneous building materials (gypsum, glass etc.);

Services equipment in buildings.

Further consideration should also be given to the role of wood products; some studies have already been made on this subject.

Annex 1

UNIDO ASSISTANCE IN THE BUILDING MATERIALS INDUSTRY

A. Areas relating to the development of the building materials industry in which UNIDO is in a position to provide technical assistance

Standardization of building materials and components;

Materials testing and research;

Pre-investment projects, pilot and demonstration plants, and the establishment and initial operation of industrial plants producing building materials, at least to the extent of proving their commercial viability;

Training;

Promotion (developing, implementing, evaluation) of manufacturing industry projects;

Expansion and modernization of existing facilities;

Techno-economic evaluation of competitive processes and changing technology, adaptation of technology to requirements of developing areas;

Development planning on a national and regional level;

New and traditional raw materials for the building industries (e.g. clay, stone, sand, plastics, wood, metal etc.);

Manufacture of products and components for building industries (e.g. cement, ceramics, glass, bricks, tiles, concrete and concrete products, plastic, wood and metal components, plaster and board of various compositions etc.);

Testing and research institutions in the above field.

B. Selected major technical assistance projects

The projects listed below relate to the activities of the United Nations Industrial Development Organization since its establishment in 1967. The list excludes projects carried out under the predecessor organizations of UNIDO

(the former Division of Industrial Development up to 1962 and the Centre for Industrial Development up to 1967). Since the projects are listed for illustrative purposes, the names of countries have been omitted. The respective programmes under which the projects are implemented are shown as:

SIS	Special Industrial Services of UNIDO
UNDP/TA	United Nations Development Programme Technical Assistance Component
UNDP/SF	United Nations Development Programme Special Fund Component
RP	Regular Programme

(1) *Projects implemented or under implementation by UNIDO in areas related to the development of the building materials industry*

AFRICA

Technical assistance to brickworks (SIS)
Establishment of a cement industry (SIS)
Glass industry expert (SIS)
Consultant in the test-run of a cement factory (SIS)
Investigation of glass industry (SIS)
Feasibility study of the cement industry (SIS)
Feasibility study for a cement plant (SIS)
Specialist in the technology and commercialization of marble (SIS)

THE AMERICAS

Pilot asbestos processing plant (UNDP/SF)
Development of ceramics industry (SIS)
Establishment of a flat glass industry (SIS)
Establishment of the refractory products industry (SIS)

ASIA AND THE FAR EAST

Ceramic research and training centre (UNDP/TA)
Development of the production technology used in the glass works (UNDP/TA)
Assistance to Ceramics-Corporation (UNDP/TA)
Building and construction materials expert (UNDP/TA)
Expert in mining of decorative building stones (SIS)
Feasibility of manufacture of precast concrete products (UNDP/TA)

EUROPE AND THE MIDDLE EAST

Centre for industrial research (ceramics and glass) (UNDP/SF)
Assistance to asbestos-cement processing factory (SIS)
Assistance to glass factory (SIS)
Asbestos pipe plant project (SIS)
Assistance to cement factories (UNDP/TA)
Slag granulation expert (UNDP/TA)
Assistance to the Building Research Institute (SIS)

(2) *Projects in preparation or under discussion with Governments in areas related to the development of the building materials industry*

AFRICA

Clay products survey (SIS)
Exploitation of marble (SIS)
Establishment of asbestos-cement industry (SIS)
Assistance to glassware factory (SIS)
Use of plastics in conjunction with local raw materials in building (UNDP/TA)

THE AMERICAS

Establishment of lime industry (SIS)
Prefabrication in the building industry (UNDP/TA)

ASIA AND THE FAR EAST

Pilot plant for building and construction materials (UNDP/SF)
Rationalization of clay building materials (UNDP/TA)
Pilot plant for production of plastic/wood structure by irradiation techniques (UNDP/SF)

EUROPE AND THE MIDDLE EAST

Assistance to cement plant (SIS)
Polysand (conglomerate) pipes (UNDP/SF)
Establishment of a glass factory (SIS)
Fibro-cement composites (UNDP/TA)
Survey on raw materials for the manufacture of building materials (UNDP/TA)
Centre for Development of Housing and Construction (UNDP/SF)

Annex 2

MEETINGS, SEMINARS AND WORKING GROUPS ORGANIZED BY UNIDO

	Location	*Date*
Interregional Seminar on the Development of Clay Building Materials Industries in Developing Countries	Copenhagen	August 1968
Expert Working Group Meeting on Fibro-Cement Composites	Vienna	October 1969
		Proposed date
Regional Seminar on Prefabrication in the Building Industries in Africa (in co-operation with ECA and the UN Centre for Housing, Building and Planning)	Denmark or Africa	1970
Regional Workshop on the Development of Clay Building Materials Industries in Africa (in co-operation with ECA and the UN Centre for Housing, Building and Planning)	Denmark or Africa	1970
Meeting of the Heads of Building Materials Research and Development Organizations of the ECAFE region (in collaboration with ECAFE)	Bangkok	1970
Seminar on Cement Manufacture (in co-operation with the UN Centre for Housing, Building and Planning)		1971

Annex 3

SELECTED LIST OF DOCUMENTS AND PUBLICATIONS[1] ON BUILDING MATERIALS INDUSTRY

UNITED NATIONS

Department of Economic and Social Affairs

Soil-Cement: Its Use in Building (Sales No.: 64. IV. 6).

Modular Coordination in Building, Asia, Europe and the Americas (Sales No.: 66. IV. 4)

Centre for Industrial Development (predecessor of UNIDO)

Studies in Economics of Industry. 1. Cement/Nitrogenous Fertilizers Based on Natural Gas (ST/ECA/75) (Sales No.: 63. II. B. 3).

Plastics as Construction Materials for Developing Countries, by A. P. Lien, 1964—reproduced in *Studies in Petrochemicals*, pp. 538—565 (ST/CID/4) (Sales No.: 67. II. B. 2).

Report of the Interregional Seminar on the Cement Industry, held in Denmark from 2 to 16 May 1964 (ST/TAO/SER. C/71) (mimeo.).

United Nations Industrial Development Organization

"A Sectoral Study on Silicate Industries" in *Industrial Development in Asia and the Far East. Vol. 4. Development of Key Industries*, pp. 349—406. (ID/CONF. 1/R.B P./2) (Sales No.: 66. II. B. 22).

Industrial Development in the Arab Countries (ID/CONF. 1/R.B.P./6) (Sales No.: 66. II. B. 23).

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[1] Symbols and Sales Numbers of United Nations documents and publications are given in parentheses after the titles.

Industrial Development in the Arab Countries (ID/CONF. 1/R.B.P./6).

"A Review of the Building Materials Industry in Africa and the Possibilities for a Rapid Expansion" in *Industrial Development in Africa*, pp. 51—74 (ID/CONF. 1/R.B.P./1) (Sales No.: 66. II. B. 24).

Profiles of Manufacturing Establishments, 2 vols. (ID/SER. E/4 and 5) (Sales Nos.: 67. II. B. 17 and 68. II. B. 13).

The Development of Clay Building Materials Industries in Developing Countries (ID/28) (Sales No.: 69. II. B. 18).

The Establishment of the Brick and Tile Industry in Developing Countries (ID/15) (Sales Nos.: 69. II. B. 19).

Sectoral Studies Prepared for the Symposium: Building Material Industries Including Wood Products, 1967 (ID/CONF. 1/23) (mimeo.).

Economic Commission for Africa

Housing in Africa (Sales No.: 66. II. K. 4).

Economic Commission for Asia and the Far East

Industrial Development in Asia and the Far East. Vol. IV. Development of Key Industries (Sales No.: 66. II. B. 22).

The Role of Building Materials and Components Industries in the National Economies of the Countries of the ECAFE Region, 1967 (Document I & NR/BM/25) (mimeo.).

Report of the Seminar on the Development of Building Materials, 1968 (E/CN 11/1 & NR/BM/L. 3) (mimeo.).

Economic Commission for Europe

Annual Bulletin of Housing and Building Statistics for Europe, published annually by the Statistical Office of the United Nations.

The Use of Steel in Construction (Sales No.: 64 II. E/Mim.24).

Development of the Building Materials and Components Sector, 1968 (Document HOU/W.P. 208) (mimeo.).

Economic Commission for Latin America

Housing and Building Materials Industry, Central American Economic Integration Programme, 1960 (ST. SOA/41).

Food and Agricultural Organization

Timber Trends and Prospects in the Asia-Pacific Region, prepared by FAO and ECAFE, 1961.

Latin American Timber Trends and Prospects, prepared by FAO and ECLA (Sales No.: 63.II.G.1).

Plywood and Other Wood-Based Panels. Report on an international consultation on plywood and other wood-based panels, Rome 8–19 July 1963, 1967.

European Timber Trends and Prospects. A new appraisal 1950–1975, prepared by FAO and ECE (Sales No.: 64.II.E.4).

Timber Trends and Prospects in Africa, prepared by FAO and ECA, 1967.

Wood: World Trends and Prospects, 1967 (Freedom from Hunger Campaign Study No. 16).

International Bank for Reconstruction and Development

World Bank Atlas: Population and per capita Product, 3 vols., Washington, D.C.

OTHER SOURCES

Cembureau Statistical Review (Paris) 1968.

Cullen, B. D. "Materials Usage in New Buildings", *Building* Vol. 212, January 1967.

Köppen-Geiger. *Klima der Erde* [map], revised by R. Geiger and W. Pohl; Justus Perthes, Darmstadt, 1953.

Sante, F. J. van and E. K. H. Wulkan, *Plastics in Building*, Bouwcentrum, Rotterdam, 1967.

UNIDO MONOGRAPHS ON INDUSTRIALIZATION OF DEVELOPING COUNTRIES: PROBLEMS AND PROSPECTS

No. 1. Non-ferrous metals industry
No. 2. Construction industry
No. 3. Building materials industry
No. 4. Engineering industry
No. 5. Iron and steel industry
No. 6. Fertilizer industry
No. 7. Textile industry
No. 8. Chemical industry
No. 9. Food-processing industry
No. 10. Industrial research
No. 11. Small-scale industry
No. 12. Standardization
No. 13. Industrial information
No. 14. Manpower for industry
No. 15. Administrative machinery
No. 16. Domestic and external financing
No. 17. Industrial planning
No. 18. Regional co-operation in industry
No. 19. Promotion of export-oriented industries
No. 20. General issues of industrial policy
No. 21. Technical co-operation in industry

Printed in Austria

Price: $U.S. 0.50 (or equivalent in other currencies)

United Nations publication

69-3101—April 1970—4,600

Sales No.: E. 69. II. B. 39, Vol. 3

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6. 7. 72