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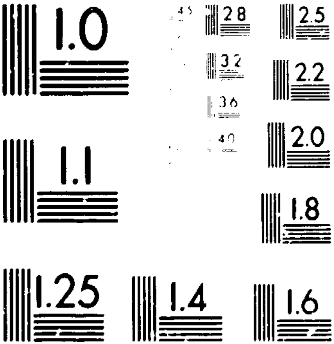

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MEASURES AND ACTIONS TO INCREASE THE PRODUCTION OF INDIGENOUS BUILDING MATERIALS IN THE CONTEXT OF ENHANCED IMPORT SUBSTITUTION *

by

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1.0 INTRODUCTION

1.1 Context of Development

Serious obstacles confront developing countries in the industrialization process, difficulties which have been most evident during the United Nations Third Development Decade. During the 1960s, developing countries exceeded the United Nations 5 percent annual growth target. In the 1970s, however, this rate of growth faltered. Although some middle income developing countries achieved higher real growth rates than the industrialized countries, lower income countries fell further behind as a group. Consequently, developing countries collectively did not fulfill the objectives of the International Development Strategy for the U.N. Second Development Decade.

A number of constraints imposed by changing global economic conditions will continue to hamper developing countries throughout the 1980s and beyond. First, economic stagnation in the developed countries has contracted export markets for the manufactured goods of developing countries. Second, commodity prices are at their lowest levels in three decades. Consequently, world trade levels have declined and the terms of trade for developing countries deteriorated. Depressed world trade and increased competition are primarily responsible for the surge in calls for protectionist legislation in the industralized economies.

A serious outgrowth of the poorer trade market is the problem of financing growing foreign debts. These debts increased sharply in the 1970s to ease the strain on foreign trade balances precipitated by higher prices for fuel and imported manufactured goods. The prolonged world recession reduced the capacity of the industrialized countries to absorb raw materials and industrial exports from developing countries. High interest rates, unfavorable dollar exchange rates and especially the shortening of the terms of debt maturity by private commercial banks have exacerbated the severity of the international debt problem. The current accounts deficits of both oil importing and oil producing countries have skyrocketed, as the debt service ratio of 21 major borrowing countries soared from 50 percent of exports in 1979 to 85 percent in 1982. (1)

In response to their high indebtedness, developing countries have pursued austerity policies, e.g., restricting domestic spending, investments and imports. Investment capital which could have supported development programs has been diverted instead toward financing international debts. The reduced ability of developing countries to borrow in international capital markets will necessarily restrict their capacity to import the machinery, transport equipment, materials and technologies necessary for industrialization. (2)

The revitalization of industrialization will depend on new approaches to the problem of sustaining economic development. Indeed, to avoid structuring developmental strategies which either promote economic growth at the expense of social welfare or redistribute income at the expense of undermining asset expansion, developing countries must devise a strategy permitting both redistribution and growth. A key element of such a strategy is to make poorer groups in society more productive while not sacrificing capital accumulation.

1.2 Role of Construction Industry in Development

The construction industry is central to realizing social welfare and economic development goals. The construction sector provides for basic human needs, including shelter, sanitation and safe drinking water supplies. Construction investment is critical to rural development programs, providing housing, health and educational facilities and small-scale industrial plants. Construction additionally makes significant direct contributions to gross domestic product (GDP), gross fixed capital formation (GFCF) as well as provides employment opportunities and backward and forward linkages with other industries.

1.2.1 The Construction Industry and Economic Growth: GDP and GFCF

The direct contribution of the construction sector to national economic growth can be measured in terms of the value added by the sector as a percentage share of total GDP. The value added is the difference between the gross value of the output of the construction sector and its intermediate consumption. The contribution of construction to GDP typically ranges from 3 to 8 percent in developing countries, with an average near 5 percent. The corresponding average in industrialized countries is 8 percent. (3)

A relationship is apparent between development levels and construction activity, with the proportional contribution of construction to GDP higher in more developed countries. Time series data for several countries show that construction activity rises faster than per capita income growth, as evidenced by construction's increased share of GDP.

While the rate of expansion of construction in developed countries has declined relative to average annual growth rates, the growth of the construction industry in developing countries has exceeded overall economic growth at an accelerating rate (Figure 1.1). Trends between the growth rates of construction activity versus GDP differ with geographical region. In Africa, construction growth rose sharply from an average of 2.2 percent annually in the early 1960s to 12.6 percent in the mid-1970s, but has since fallen to 8.1 percent. Latin America and the Caribbean experienced its peak in the early 1970s, but then declined steadily. Construction growth in Asia reflect the oil boom and its impact on infrastructure and building investment in the Middle East and the rapid industrialization in the Far East in the 1970s. Construction's share in developing countries' GDP collectively increased from 5.3 percent in the early 1960s to 6 percent in the mid-1970s. Table 1.1 provides annual construction growth rates for several developing countries during the 1970s.

In all developing countries, construction plays a dominant role in gross fixed capital formation (GFCF). Construction usually accounts for over 50 percent of the total GFCF in developing countries and includes residential and non-residential buildings and infrastructure, communications, waste treatment and industrial plants.

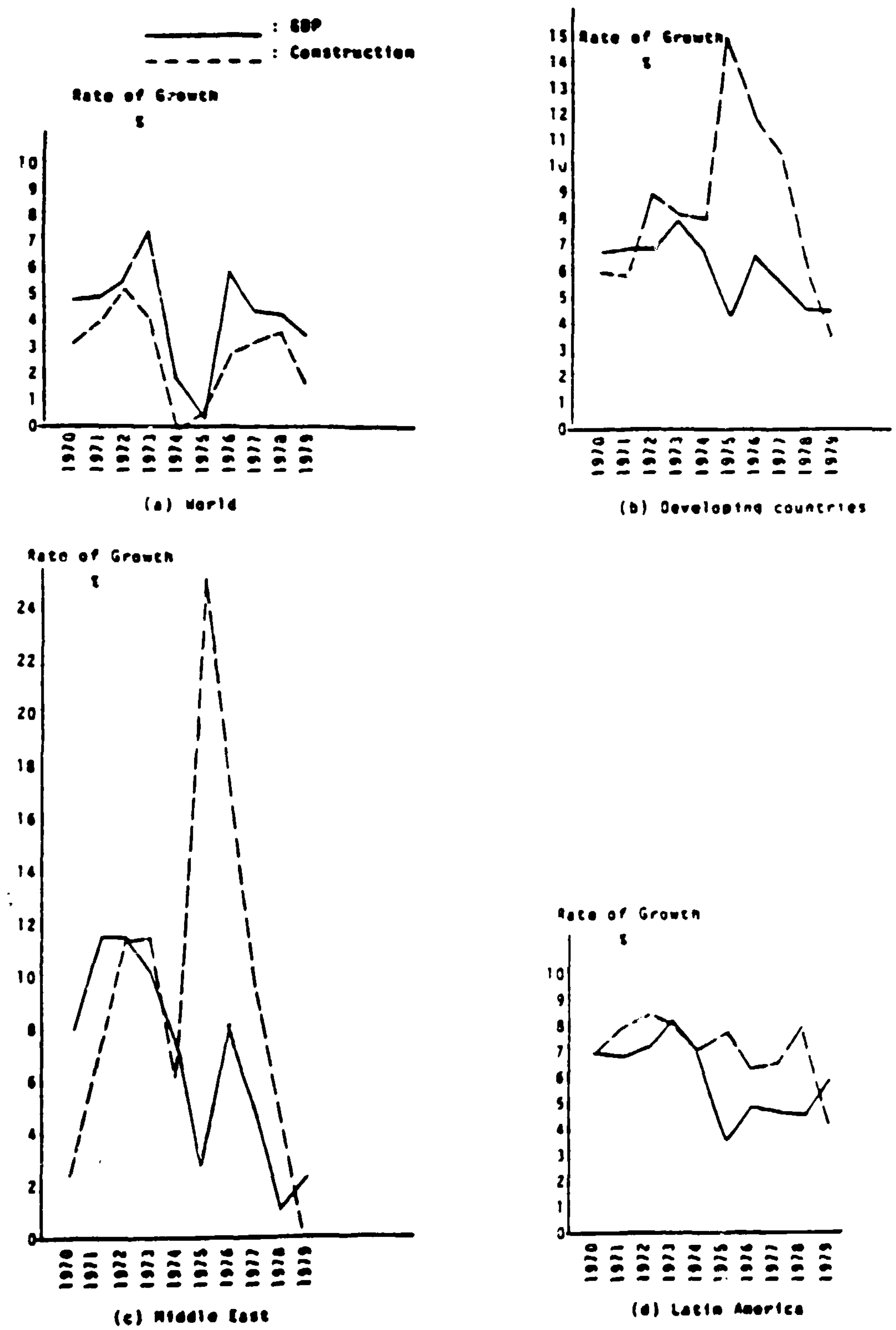
1.2.2 Backward and Forward Linkages

How does investment in the construction sector induce growth in the GDP and promote industrialization? The answer is the linkages created by the construction sector to other industries.

Backward linkages represent products and services purchased from other economic sectors which serve as inputs to the construction sector. Backward linkages, or derived demands, often represent a value exceeding the value added by the construction sector itself. A study of 11 developing countries found the average value

FIGURE 1.1

ANNUAL RATE OF GROWTH OF CONSTRUCTION VERSUS ANNUAL RATE OF GROWTH OF GDP



SOURCE: UN Yearbook of National Accounts Statistics, New York 1982.

TABLE 1.1

ANNUAL GROWTH OF CONSTRUCTION IN DEVELOPING COUNTRIES

Country	Previous 10 Years	Previous 5 Years	Previous Year	Year of Reference
OPEC				
Middle East				
Algeria	--	24.47	20.79	1979
Iran	22.08	53.32	38.64	1977
Iraq	26.26	52.12	288.94	1976
Kuwait	20.53	48.96	4.76	1981
Libya	22.10	20.18	7.64	1978
S. Arabia	44.13	69.27	18.2[illegible]	1979
OTHER				
Ecuador	30.48	26.93	26.45	1981
Gabon	--	2.49	8.35	1979
Indonesia	37.02	29.72	18.27	1981
Nigeria	25.84	27.96	14.77	1977
Venezuela	20.80	13.55	7.84	1981
OTHER DEVELOPING COUNTRIES				
Mexico	27.93	33.22	42.30	1980
Brazil	51.76	68.49	139.91	1980
Argentina	132.90	193.93	125.11	1980
Korea	35.40	37.87	4.10	1981
Thailand	20.54	24.63	19.06	1981
Taiwan	26.54	24.44	31.28	1980
Egypt	19.46	37.00	27.90	1979

SOURCE: Business International Corporation, Worldwide Economic Indicators, 1983 Annual Report.

added by construction accounted for 45 percent of total output value, and intermediate consumption (derived demand) accounted for the remaining 55 percent. (4) Table 1.2 shows the strong backward linkages of the construction industry in Kenya.

Forward linkages represent the consumption resulting from construction output. However, defining the forward linkages is problematic because it is difficult to separate investment in facilities from the value of ongoing activities within these facilities. This task is complicated by national accounting practices which treat construction as a final demand product, thereby not recording construction deliveries to other sectors in national input-output tables.

A recent econometric model testing the productivity of investment in infrastructure by a Cobb-Douglas production function with data for four countries, Singapore, Israel, Malawi and Zambia, suggests a strong impact of infrastructural change on national output in the cases of the two countries at the higher end of the income scale for developing countries, i.e., Singapore and Israel (5). The most pronounced effects register after a lag of approximately two to three years. In the cases of the poorer countries, Malawi and Zambia, the available data suggest that, at best, the net result of infrastructure investment during the past two decades has been negligible. A number of explanations could account for such discrepancies. Infrastructure projects, for example, might be more effective at more advanced levels of development in terms of contribution to other sectors of the economy. Also, national planning procedures may account for the clear advantages of infrastructural construction for economic growth.

TABLE 1.2

EFFECT OF AN INCREASE IN CONSTRUCTION SECTOR GROSS OUTPUT BY 1000 Kenyan Pounds

KENYA 1976

SECTOR	INCREASES IN INTERMEDIATE OUTPUTS, BY SECTOR, IN KENYAN POUNDS
Mining	42
Wood-Furniture	26
Paper/Printing	7
Petroleum Products	92
Rubber Products	7
Paint/Detergents	14
Other Chemicals	17
Nonmetallic Products	86
Metals-Machinery	156
Transport-B & R	14
Electricity-Supply	5
Construction	119
Wholesale-Retail	47
Transport Services	17
Restaurant/Hotel	12
Financial Services	30
Business-Premises	5
Other Intermediate	12
Total Intermediate	713
Wages and Salaries	233
Other Inputs	54
Total Primary Inputs	287
GROSS OUTPUT	1,000

SOURCE: CMT, Role and Contribution of the Construction Industry to Socio-Economic Growth of Developing Countries, November 1980, Revised April 1982.

1.2.3 Employment

The data presented in a recent study suggests that the construction sector in a number of developing countries accounts for 2 to 9 percent of total national employment with a heavy clustering around 4 to 5 percent. (6) These figures do not, however, include employment opportunities created in other industries and sectors with which the construction sector has strong backward linkages. Government plans in a number of cases illustrate the intentions of increasing employment by investment in the construction sectors. The Fifth Tunisian Plan (1971-81) projected that of the 233,700 new jobs to be created by planned investments, 55,000 or 24 percent would be in the construction and public works sector and another 12,000 in the building materials industry. Egypt's recent five year plan (1982-87) projects an overall growth rate of 37 percent in construction sector employment as compared with 18 percent in total employment (7). In the aggregate, the construction sector on average accounts for approximately 5 percent of total employment; 3 percent in Africa, 4 percent in Asia and 6 percent in Latin America.

The large numbers of unskilled workers which the industry employs substantiate the claim that construction has great labor absorptive capacity. Construction thus has the potential to be a skill processor, where relatively unskilled rural workers can be integrated into the urban economy.

1.3 Demand for Construction

The demand for construction is somewhat irregular given the sector's nature. The specialized character of each product, the seasonality of the work, and the industry's susceptability to economic fluctuations and demographic influences make construction demand inherently unstable. The need to reduce such uncertainty is evident given the importance of effective planning.

It is evident new shelters must be erected on a grand scale to accommodate projected population growth by the year 2000, when total world population is expected to exceed six billion. Global models suggest nearly 79 percent of this population will be concentrated in less developed regions (8). Urien estimates that during the next 25 years, as much building will have to be completed as ever has been previously initiated. (9) In India the National Building Organizaton has estimated the housing deficit in 1983 to be 22.5 million units. Over the next 20 years, the housing requirement is calculated to rise by 20.4 million units in urban areas and 30.6 million in rural, merely to accommodate population growth. (10)

1.3.1 <u>The Structure of Demand</u>

We have seen that as development proceeds and GDP increases, the demand for construction rises at higher rates. Future growth in population, gross national product, and per capita income, will result in an increase in demand for construction in the next two decades. Although global models diverge over its magnitude, depending on projected economic growth rates and the elasticity attributed to each sector, substantial growth can be expected. (11)

In the past several decades, the strategies for social and economic development of the developing countries have relied heavily on the construction sector. However, the composition and structure of construction demand depend significantly on the options countries choose for capital or labor intensive development, investment in civil engineering projects to foster economic growth or in residential construction to satisfy basic human needs and social welfare, or promotion of rural versus urban development. Typically, construction output in a developing country is distributed 35-40 percent in residential dwellings, 22-27 percent in non-residential buildings, and 35-3[illegible] percent in civil works; as a rule, the share of non-residential buildings tends to rise as development proceeds.

A broader macroeconomic factor influencing demand for construction is the application of national income for capital formation and investment. This is an important variable because the average share of construction in global investment for most economies is quite high, varying from 20 to 40 percent. Since government demand accounts for 63 to 90 percent of total construction demand, public investment substantially affects construction output and especially infrastructure.

A second component is corporate savings. The willingess of corporations to reinvest profits so as to increase capital formation is important to understanding how private sector investment influences demand for construction, especially non-residential buildings. Business investment propels industrial expansion which, in turn, creates a demand for factories, offices, stores, hotels and institutional buildings.

Energy costs and mounting foreign debts, have also affected construction demand. Oil revenues have stimulated construction booms in high income oil exporting countries. In countries lacking petroleum, but with sufficient means and large energy requirements, the changing structure of world energy patterns may create new demands for large-scale, complex, alternative energy production facilities such as hydroelectric or nuclear power plants.

The economic dislocations caused by the debt service burden of the developing countries analyzed above constitutes an important constraint on construction demand growth. The expenditure of increasing domestic resources to meet loan interest and repayment schedules has depressed construction demand in debtor countries. How developing countries cope with their debts will shape the future pace of demand for construction activity. Which sectors receive priority may determine the compositon of that demand.

1.4 Supply of Construction

Indigenous construction firms performing various types of construction of varying degrees of technological complexity are an important resource. Domestic capability in various methods allows a country flexibility in choosing from among competing technologies where one objective is to avoid dependence on foreign firms.

For the construction industry, the most important resource constraints are labor, financing, and building materials. Construction labor forces in developing countries are generally less skilled than their counterparts in the developed nations and skilled craftsmen are frequently in short supply. Constraints on the supply of qualified labor, including semi-skilled and supervisory personnel, in turn, impinges on the ability of the construction sector to provide an adequate supply of construction facilities. Financing also presents a serious constraint for indigenous contractors, especially given the underdeveloped capital markets in most developing countries. Exacerbating this structural difficulty, many commercial banks are unwilling to lend to domestic construction firms, especially those without established records. The indigenous construction sector in the least developing countries satisfies almost 100 percent of its construction equipment need through costly importation. Moreover, the effects of carrying too much equipment can be detrimental. Too much or too large equipment, purchased for a grand-scale job, may have little further use.

1.5 Structure of the Report

This report will examine the role of building materials in the construction industries of developing countries. The emphasis of analysis is on the indigenous capabilities of developing countries to satisfy internal demand for building materials through appropriate technological adaptation and financial and institutional means.

Chapter 2 will examine the role of building materials in the construction industry. Chapter 3 will look at the economics of production in the developing world with an emphasis on labor-capital substitution and small-scale industry. Chapter 4 considers the technologies of materials, including an analysis of indigenous materials. Finally, Chapter 5 contains conclusions and recommendations.

2.0 ROLE OF BUILDING MATERIALS

Building materials are the most important construction resource, determining the technology and relative levels of capital and labor which can be employed in construction. Survey research in a number of developing countries shows that the intermediate consumption of materials and supplies ranged from 37 percent to 55 percent of the total value of construction output while wages and labor accounted for 19 percent to 27 percent. Thus, the industry acts as a critical stimulus or bottleneck to the construction sector in much the same manner as the construction sector influences the national economy.

The importance of building materials to construction in developed and developing countries and in various types of construction is illustrated in Tables 2.1 and 2.2. The allocation of costs among different types of construction in the U.S. indicates that material contribution was higher in building construction (50-54 percent) than in infrastruture projects (44-49 percent). (Table 2.1)

More detailed data on the mix of basic resources by type of construction in developing countries are available for Kenya (Table 2.2). The portion of value represented by materials is significantly higher for speciality contractors (44-51 percent) using higher-value plumbing and electrical supplies than it is for civil engineering infrastructure projects (24-33 percent), which use large volumes of lower cost materials.

Developing countries significantly increased their building materials production in the 1970s (Table 2.3). Especially impressive was the 35 percent share of world cement produced. Moreover, many developing countries achieved manufacturing capability in sectors

TABLE 2.1

BUILDING MATERIALS AS A PERCENTAGE OF CONSTRUCTION IN THE U.S.

TYPE OF CONSTRUCTION AND YEARS		MATERIALS AS PERCENTAGE OF CONSTRUCTION	LABOR	EQUIPMENT	PROFIT
Highways	1971	45.1	25.9		29. (includes Equipment)
Schools	1964-65	54.2	25.8	1.0	19.0
Hospitals	1965-66	50.4	29.6	1.3	18.7
Private Single-Family Housing	1968	43.4	20.4	0.9	35.3
Sewer Works					
lines	1962-63	44.5	24.3	11.2	20.0
plants	1962-63	49.2	26.6	8.2	16.0
Federal Office Buildings	1959	51.4	29.0	1.9	17.7
College Housing	1960-61	52.6	29.3	1.6	16.5

SOURCE: Moavenzadeh, F., and Koch Rossow, J.A., The Construction Industry in Developing Countries, Technology Adaptation Program, Massachusetts Institute of Technology, 1975.

TABLE 2.2

DISTRIBUTION OF RESOURCE INPUTS FOR CONSTRUCTION IN

KENYA 1968-1972

VALUE	SPECIALTY	BUILDING	CIVIL
1. Value Added	28-41%	26-43%	39-51%
Labor	23-35%	18-22%	23-32%
Depreciation	1-3%	3-6%	12-17%
Interest	0.6-7%	0.3-1%	0.6-2%
2. Intermediate Inputs	59-72%	57-74%	49-61%
Materials & Supplies	44-51%	26-42%	24-33%
Subcontract	1-6%	18-25%	1-10%

SOURCE: CMT, Role and Contribution of the Construction Industry to Socio-Economic Growth of Developing Countries, Cambridge, Massachusetts, 1982.

where previously there had been none. Thus while developing countries produce only 12 percent of the world's crude steel, 60 developing countries currently produce steel or are preparing to do so. (1)

While building materials are important to the growth of manufacturing in developing countries, it is difficult to establish the precise share of manufacturing to which building materials contribute. Some materials are used almost exclusively in construction, such as cement; others are used widely in other industries, such as steel. Manufacturing output is rarely disaggregated in a form suitable to ascertain the precise production levels of materials destined exclusively for building.

Also certain materials appear more than once in production statistics at various stages of processing. Cement is counted in the production stage and again in concrete products. Nevertheless, it is possible to establish production trends. During the 1970s, in certain product groups, notably non-metallic minerals and basic metals, building materials production in developing countries expanded faster than manufacturing as a whole.

Because the building and construction industries are intertwined, it is difficult to disaggregate the contribution of building materials to economic growth as measured by specific indicators such as gross fixed capital formation. However, it has been established that expenditures on building materials in developing countries usually represent 3-5 percet of GDP. (2)

Value added to total output by building materials industries tends to be a smaller proportion than value added by inputs into the various manufacturing processes. Data suggests that value added as a

TABLE 2.3

BUILDING MATERIALS PRODUCTION IN DEVELOPING COUNTRIES; PRELIMINARY ESTIMATES[1]

	Africa[2]		Latin America		Asia[3]		Total Percent	Total Percent
Material	1980	1971	1980	1971	1980	1971	1980	1971
Cement	2.6	2.3	8.4	6.1	24.0	12.2	35.0	20.6
Asbestos-Cement Articles	5.4	4.0	8.6	7.1	12.5	8.8	26.5	19.9
Concrete Blocks and Bricks[4]	1.7	0.4	0.1	0.2	0.6	0.8	2.4	1.4
Concrete Other Products[4]	2.3	1.3	0.4	0.3	2.1	2.9	4.8	4.5
Building Bricks, Clay[4]	0.2	1.2	0.6	0.5	16.7	7.4	17.5	9.1
Tiles, Roofing, Clays[4]	0.1	0.1	1.5	0.7	26.0	23.5	27.6	24.3
Tiles, Floor and Wall[4]	1.6	0.7	14.2	10.4	8.9	1.5	24.7	12.6
Sawnwood, Broadleaved	5.1	2.7	11.6	8.3	24.1	18.0	40.8	29.0
Plywood	1.0	0.8	3.7	2.4	14.1	8.6	18.8	11.8
Particle Board	0.4	0.5	3.9	2.5	1.9	1.2	6.2	4.2
Glass, Drawn or Blown in Rectangles, Unworked[4]	-	-	7.0	4.4	7.3	5.6	14.3	10.0
Crude Steel Ingots	0.3	0.1	3.4	2.4	8.5	5.6	12.2	8.1

[1] *There are several reasons why these can only be taken as estimates. Many production figures were based on United Nations estimates. Secondly, there is a wide variation in the definitions of the product groups; thus, percentages often do not accurately reflect what is intended. Footnote below cites other difficulties.*

[2] Excludes South Africa.

[3] Excludes Japan.

[4] For these materials, two separate sets of production data were provided in the UN Yearbook: (a) that which is reproduced above, production in metric tons, and (b) production in thousand cubic meters. Since no conversion tables for these specific materials were provided, the result was two sets of data. Metric ton production is shown in this table.

SOURCE: United Nations Yearbook of Industrial Statistics, 1980 Edition, Volume II, Commodity of Production Data.

percentage of output value is higher in production processes which employ more labor such as clay bricks and concrete products than in automated processes, such as the manufacture of metal products. However, more labor-intensive building materials processes rely on imported raw materials which diminish the value added to total output value. (3)

2.1 Demand for Building Materials

The demand for building materials is dependent exclusively upon construction sector activity. The levels and composition of construction will determine which building materials, and what quantities, will be incorporated into production. To avoid bottlenecks in the construction industry, the ability to anticipate and plan for fluctuations in demand for building materials is crucial.

The building materials industry is subject to direct and indirect influences on the demand for its products. Indirect influences include per capita income, distribution of income, investment patterns, credit policies, funding sources, and political risk and uncertainty. Five other factors directly affect demand for building materials.

(a) The Pattern of Construction Output

Because different constructed facilities use different building materials in different proportions it is important to recognize that the composition of construction output will determine the demand for building materials. Table 2.4 shows the patterns of material inputs into construction projects in Kenya, disaggregated by the type of construction. As is apparent, civil engineering is a large consumer of steel and aggregate. Non-residential buildings also

TABLE 2.4

MATERIALS INPUTS AS A PERCENTAGE OF TOTAL EXPENDITURE FOR

TYPES OF PROJECTS IN KENYA

Type of Input	Residential Buildings	Non-Residential Buildings	Civil Engineering
Sand	4.60	6.40	2.98
Aggregate	5.60	5.20	9.94
Cement	10.00	13.40	2.98
Hydrated Lime	-	-	2.39
Concrete Products	6.00	3.80	2.78
Hardcore Filling	1.50	0.90	-
Wood Products (Timber, doors, etc.)	8.90	3.00	0.40
Steel Products	3.00	17.90	22.88
Hardware & Windows	4.50	2.90	2.98
Paints	8.20	2.20	in Hardware
Glass	1.00	1.30	-
Floor Tiles	5.20	1.65	-
Roofing Materials	4.10	2.30	-
Plumbing and Sanitary Fixtures	7.80	5.00	-
Electric Installations	5.20	2.05	-
Explosives	-	-	2.98
Fuels, Bitumen, & Lubricants	-	-	2.40
TOTAL ALL MATERIALS:	75.60	68.00	52.71

SOURCE: CMT (1980), IV-44

consume large proportions of steel. The second most important material input in these buildings is cement. Building materials for residential buildings vary considerably from those used in civil engineering structures. Dwellings consume proportionally more wood, paints, tiles, and finished products.

(b) Technological Change

The pattern of usage of building materials by construction depicted above will prevail only as long as the technology employed is stable. Changes in both construction technology and production technologies of building materials will affect demand for building materials.

Three examples of advances in construction technologies which have been developed recently and may affect future demand for building materials in Egypt are relevant. The first, pre-fabricated housing, was expected to consume 100+ kg more cement per square meter than housing built by more conventional methods.(4) Two other technological innovations affecting the demand for building materials in Egypt include the use of pre-cast concrete components in housing construction and industrial buildings and ready-mix operations for delivering pre-mixed concrete to the work site. Both innovations reduce the consumption of cement per unit.

Furthermore, changes in building materials production technology would obviously affect future patterns of consumption and demand, exercised through pricing and product substitution. As changing technologies bring new building materials within the purchasing power of low-income consumers in developing countries, the demand for the products which they replace will likely fall.

(c) Availability and Prices of Materials

The availability and price of various building materials are subject to several determinants. The first is competing demand from sectors other than construction. Whereas building materials such as cement are consumed almost exclusively by the construction sector, others are not. UNIDO estimated that construction accounted for up to 50 percent of steel consumption (in the late 1960s), in the developing countries of Asia and the Far East. (5) Similarly, a Food and Agriculture Organization survey showed that the proportion of sawnwood used in construction varied from 40 to 86 percent. (6) If demand increased for non-construction products which used these materials as key inputs, such as automobiles or furniture, this would raise the price and reduce these commodities' availability.

A second determinant of price and supply of building materials relates to world production and consumption trends of these commodities, especially those with end uses other than construction. Commodity gluts and scarcities will affect the world prices for these raw materials and processed goods, which, in turn, will be reflected in the price structure within developing countries. Where alternative materials are available, upward or downward pressures on prices will vary demand for the interchangeable material inputs, even as the demand for the final constructed product remains constant.

The prices of inputs, too, will affect the price and demand for building materials. Cost increases in labor or energy are necessarily absorbed by the building materials industry. Escalating energy costs constitute a significant constraint on the ability of developing countries to provide building materials at a price within the reach of a mass market. Energy costs, in addition, are one factor contributing to changes in transport costs. Transport costs of both raw materials and finished products partly determine the prices of building materials. Just as energy costs may escalate the cost of transport, however, so too may infrastructural development decrease the cost. Finally, some governments regulate the price of certain building materials. In Egypt, for example, the government controls the price, supply, and distribution of cement. (7)

(d) Trends in Product Substitution

Elasticity of demand is obviously affected by the availability of products which can be substituted for a material whose price rises or whose supplies are suddenly cut off. The scope for substitution varies from one type of construction to another. For example, the range of materials suitable for use in civil engineering projects is usually limited. Cement, steel, bitumen and a variety of aggregates and filling materials are the principle materials consumed by the sub-sector.

(e) Public Policies

Public policies also affect the demand for building materials. Import and export policies are related to the regulation of price, supply, and distribution of cement, for example. Incentives to export certain building materials for their raw materials will reduce the domestic consumption of these items. Conversely, tariffs imposed on imports, as with import-substituting industrialization, will, depending on the efficiency of the indigenous operation, affect the domestic price of the protected product.

The government's role as a client should also be considered. The commissioning of major defense or engineering works may alter the nature of demand for building materials; these works may require heavy imports or severely retard other construction works, creating shortages of materials.

2.2 Supply of Building Materials

The output of building materials in developing countries is generally insufficient to satisfy demand. This is true for sophisticated industrial goods, such as glass, as well as for cement. A number of constraints reduce local production: underutilization of production capacity; input supply bottlenecks; low productivity; low absorption of technological processes and administrative/planning problems. (8)

Various stages in the industrialization of building materials may be recognized. Walling materials are among the first to be produced industrially, followed by roofing and flooring materials, and finally auxiliary materials, including fittings, finishes, and equipment. The high investment in civil engineering works in the early stages of development tends to encourage the establishment of a local cement industry. Though steel is also a primary input for civil engineering construction, the installation of steel industries are not easily undertaken in early stages of development.

The most important determinant in the establishment of building materials industries by developing countries is the capital cost of initiating and maintaining operations. For steel, the price is considerable; in 1963 it was estimated that the capital cost in dollars per ton of steel was $250. (9) In 1976 Fortune assessed the annual cost per ton of capacity installed in steel at $600 to $1,000 in the case of entirely new units, and $350 to $500 for modernization and expansion operations in the United States. Other estimates offered in the late 1970's range as high as $1300 for new, large integrated installations and $490 for direct reduction/electric furnace. These figures, substantially higher than UNIDO estimates in 1976 ($312 for direct reduction/electric furnace to $690 for a 3,000,000 ton integrated unit using classical blast furnace and converter), reflect not only more realistic assessments of cost but rapidly rising prices. In developing countries, the costs of integrated plant installation and expansion are even higher (Table 2.5).

Although the percentage share of global production and absolute production levels and productive capacity have increased in the developing countries, (see Table 2.6) with an additional 55 million tons of capacity installed or due to be installed in the 1975-1985 period, import levels nonetheless continue to climb due to growing consumption.

The capital required to establish a cement industry is considerably less than for steel, but, high in absolute terms for developing countries when the production units involved are large. Table 2.5 shows that in 1978 in India the investment per ton of installed capacity was Rs. 741.25, or approximately $75 for a 1200 ton per day operation, and Rs. 597.29 or approximately $60 for a 50 ton per day capacity plant. Thus, for a unit using a rotary kiln, the minimum economic size of which is considered to be a 1,000,000 ton of annual output capacity (10), the minimum outlay required is $7.5M.

TABLE 2.5

MINIMUM CAPITAL COSTS OF PRODUCTION OF CEMENT, BRICK, AND STEEL IN DEVELOPING COUNTRIES

	Fixed Capital Investment	Working Capital	Total Investment
Bricks*($1000US)			
Tunnel kiln**	2086.0	95.0	2182.0
Hoffman kiln**	1860.0	90.0	1950.0
Cement***(per ton in US$			
1200 ton per day	71.0	3.1	74.1
50 ton per day	55.8	3.9	59.7
Steel			
Integrated Units			
5M ton, Venezuelan, $per ton			2000.0
0.5M ton, Algerian, $per ton			2000.0
Semi-integrated			
100,000 ton, Paraguay, $per ton			800.0

* 1975 dollars.

** Each plant has a daily output of 60 tons of perforated bricks, 2.5kg weight (UNIDO, 1978).

*** Cement Research Institute of India, 1978.

SOURCE: Moavenzadeh, Fred. "Global Prospects for Concrete Construction," Concrete International, February, 1984.

TABLE 2.6

BUILDING MATERIALS PRODUCTION IN DEVELOPING COUNTRIES[1]

(Preliminary Estimates)[2]

Material	Africa (excl. S. Africa) 1980	Africa (excl. S. Africa) 1971	Latin[3] America 1980	Latin[3] America 1971	Asia (excl. Japan) 1980	Asia (excl. Japan) 1971	1980 Total (%)	1971 Total (%)
Cement	2.6	2.3	8.4	6.1	24.0	12.2	35.0	20.6
Asbestos-Cement Articles[4]	5.4	4.0	8.6	7.1	12.5	8.8	26.5	19.9
Concrete Blocks and Bricks[4]	1.7	.4	.1	.2	.6	.8	2.4	1.4
Concrete Pipes[4,5]	1.1		.5		7.0		8.6	
Concrete, Other Products[4]	2.3	1.3	.4	.3	2.1	2.9	4.8	4.5
Building Bricks, Clay[4]	.2	1.2	.6	.5	16.7	7.4	17.5	9.1
Tiles, Roofing, Clay[4]	.1	.1	1.5	.7	26.0	23.5	27.6	24.3
Tiles, Floor and Wall[4]	1.6	.7	14.2	10.4	8.9	1.5	24.7	12.6
Clay[5]	9.8		8.1		3.3		21.2	
Floor Covering[5]	-		2.7		1.6		4.3	
Gravel and Crushed Stone[5]	.4		1.2		.4		2.0	
Sand, Silica and Quartz[5]	.6		4.2		2.2		7.0	
Limestone Flux and Calcareous Stone[5]	1.2		13.3		12.4		26.7	
Wooden Railway Sleepers	5.0	2.8	8.4	5.6	9.5	7.4	22.9	15.8
Sawnwood, Coniferous	.2	.1	3.9	2.2	6.0	4.1	10.1	6.4
Sawnwood, Broadleaved	5.1	2.7	11.6	8.3	24.1	18.0	40.8	29.0

TABLE 2.6 (continued)

BUILDING MATERIALS PRODUCTION IN DEVELOPING COUNTRIES[1]

(Preliminary Estimates)[2]

Material	Africa (excl. S. Africa)		Latin[3] America		Asia (excl. Japan)		1980 Total (%)	1971 Total (%)
	1980	1971	1980	1971	1980	1971		
Veneer Sheets	7.2	6.9	6.0	4.1	14.0	10.7	27.2	21.7
Blockboard[5]	-		90.3		-		90.3	
Plywood	1.0	.8	3.7	2.4	14.1	8.6	18.8	11.8
Particle Board	.4	.5	3.9	2.5	1.9	1.2	6.2	4.2
Paints, Cellulose[5]	4.5		1.5		13.7		19.7	
Paints, Water[5]	.6		17.8		4.0		22.4	
Paints, Other[5]	2.2		5.1		3.8		12.1	
Glass, Drawn or Blown in Rectangles, Unworked[4]	-	-	7.0	4.4	7.3	5.6	14.3	10.0
Glass, Cast, Rolle, Drawn or Blown[5]	-		1.3		1.2		2.5	
Glass, Safety, or Toughened or Laminated Glass[5]	.1		47.9		-		48.0	
Crude Steel, Ingots	.3	.1	3.4	2.4	8.5	5.6	12.2	8.1

TABLE 2.6 (continued)

BUILDING MATERIALS PRODUCTION IN DEVELOPING COUNTRIES[1]

(Preliminary Estimates)[2]

NOTES:

[1] The developing countries of Europe have not been included.

[2] There are several reasons why these can only be taken as estimates. First, many production figures on which these percentage calculations were based were themselves UN estimates. Secondly, there is a wide variation in the definitions of the product groupings actually reported by the countries to the UN, meaning that, strictly speaking, these percentages do not always accurately reflect what they are intended to. A third and fourth set of reasons stem from the problems discussed in notes 4 and 5 below.

[3] Latin America includes all countries of North America and South America, with the exceptions of Canada, the United States, and Puerto Rico.

[4] For these materials, two separate sets of production data were provided in the UN yearbook: (a) that which is reproduced above, production in metric tons; and (b) production in thousand cubic meters. Since no conversion tables for these specific commodities were provided, it was impossible to aggregate the two sets of data. As the more important, metric ton production was included in this table.

[5] In these cases, where the UN estimated neither global production nor output in many countries, we estimated each country's 1980 production at the level of its last recorded year. While the dangers of this procedure are obvious, it was reasoned that to have omitted all non-reporting countries for which no estimates were available would have resulted in an even less accurate and outright distorted picture. Moreover, since we are attempting to show only the rough outlines of a global schema, and in many estimated cases production levels account for an extremely small share of total world production, this procedure yields an overall view which is probably not substantially different from one based on quasi-official UN estimates. However, while production capacity, once established, can theoretically be called upon in the future, the same cannot be said of the past. Hence, 1971 production data was simply omitted for these materials for which no actual levels were reported.

SOURCE: UN Yearbook of Industrial Statistics, 1980 Edition, Volume II, Commodity of Production Data.

While the need to establish building materials industries in developing countries is apparent, many constraints challenge the capacity of developing countries to satisfy their construction sector's demand for building materials. The first is the constraint imposed on foreign trade by mounting debt service, shrinking markets in the developed countries, and reductions in aid from the developed countries. This foreign trade constraint is the prime motivating factor behind efforts to establish indigenous capability in building materials manufacture. This constraint also affects the availability of national resources and energy assets for production operations. While the availability of certain natural resources would not pose a decisive constraint, foreign trade limitations undermine plans for establishing an industry based on the importation of necessary raw materials. Similarly, the energy consumed for the manufacture, transport, and use of building materials is an important limiting factor. While research continues into alternative energy sources and energy saving production technologies, countries which import a significant share of their energy requirements wil be unable to satisfy local demand with indigenous building materials industries.

Another major constraint on establishing indigenous building materials industries is transportation. The low value/weight ratio of many building materials makes transportation costs a more serious constraint on building materials than on other industries. Where transportation is difficult, transportation costs can be higher than the production costs of certain goods.

Constraints are often imposed on the development of otherwise sound building materials industries by the absence or inadequacies of local support industries. The most obvious of these are capital goods industries which supply the equipment necessary to install various manufacturing plants. This is an increasingly relevant constraint as foreign exchange scarcities exacerbate the difficulty of developing countries in obtaining capital equipment at an affordable price.

In contrast to many constraints described above which are direct outgrowths of the current context of development, the underutilization of capacity presents a long-standing constraint on supply. The major cause for underutilization of capacity appears to be insufficient demand to support full capacity production, or alternatively, the uncertainty of demand. Others may include difficulty in obtaining materials, a paucity of operating capital, and labor problems. Given the expense of initiating manufacturing operations in developing countries in many major building materials industries, this constraint represents a serious waste of resources.

2.3 Trade and Foreign Exchange

Given developing countries' current foreign exchange difficulties, it is important to consider the role of building materials in international trade. The significance of expanding building materials production in developing countries is highlighted by the fact that building materials account for 5 to 8 percent of the total value of imports. This suggests that building materials use a disproportionate share of foreign exchange relative to inputs for other industries. The UN Commission for Africa has estimated more than $2.5 billion in foreign currency is spent annually by African countries to import building materials. (11)

Table 2.7 compares the levels of imports and exports in developed and developing countries in 1970 and 1979. The data show that, except for cement, building materials industries in developing countries had a substantially smaller share of world imports than that of developed countries. However, most industries in developing countries increased their share of world imports between 1970 and 1979. (12) On the export side, developed economies dominate the export market in most building materials. In general, building materials produced locally are those with low value to weight ratios, whose raw materials are abundantly available and capital requirements low, and those with relatively unsophisticated production methods.

Imports of almost all building materials in developing countries still exceed exports, with the greatest gap being cement. In 1979 developing countries imported four and one half times more cement than they exported.

The trade deficit associated with some materials approximates $3.5 billion. Cement accounts for most of this deficit with imports exceeding exports by over $1.5 billion. The problems of cement manufacture growth in developing regions are associated with the reduced scale of production and consumption in these areas.

Imports of building materials may be as low as 5 to 10 percent in the more industrialized developing countries such as Mexico and Greece. Imports are much higher, reaching 60 percent or more, for Kenya, the Ivory Coast and Yemen. (13) The low dependency of some countries on imported materials often reflects a development policy of import substitution and quantitative import controls to protect indigenous manufacturing industries.

TABLE 2.7

SHARES OF DEVELOPED AND DEVELOPING MARKET ECONOMIES;

TOTAL IMPORTS AND EXPORTS BY MAJOR BUILDING MATERIALS INDUSTRIAL GROUPS
(in percentages)

		Developed Market Economies				Developing Market Economies			
		Imports		Exports		Imports		Exports	
	SITC*	1970	1979	1970	1979	1970	1979	1970	1979
Wood Rough	242	90.1	87.3	45.4	39.7	9.9	12.7	54.6	60.3
Wood Shaped	243	89.6	90.1	85.0	80.8	10.4	9.9	15.0	19.2
Plywood Veneers Inlaid	63,121	93.2	79.2	64.4	50.2	6.8	20.8	35.6	49.8
Wood Simply Worked	6,318	94.9	97.5	83.8	84.0	5.1	2.5	16.2	16.0
Builders Woodwork	6,324	88.4	71.7	96.5	87.1	11.6	19.3	3.5	12.9
Stone, Sand, and Gravel	273	90.4	86.5	94.5	87.7	9.6	13.5	5.5	12.3
Cement	6,612	46.5	21.1	70.6	77.8	53.5	78.9	29.4	22.2
Clay, Refractory Building Products	662	79.7	76.7	97.9	95.8	20.3	23.3	2.1	4.2
Glass	664	85.6	78.3	97.8	95.5	14.4	21.7	2.2	4.5
Iron Steel Primary Forms	672	77.1	71.7	96.8	94.5	22.9	29.4	3.2	5.5
Iron and Steel Shapes	673	79.9	64.3	95.7	95.6	20.1	35.7	4.3	4.4
Iron Steel Universals, Plates and Sheets	674	78.0	73.3	98.4	95.9	22.0	26.7	1.6	1.4
Steel, Copper Nails, Nuts, Screws, Bolts	694	84.5	85.4	98.3	93.5	15.5	14.6	1.7	6.5
Pigments, paints	533	72.6	71.9	96.2	96.7	27.4	28.1	3.8	3.3

* Standard International Trade Classification (United Nations)

SOURCE: United Nations Yearbook of International Trade Statistics, 1979.

Of all building materials industries in developing economies, the cement industry is the most heavily dependent on imports. Between 1970 and 1979, cement imports in developing market economies grew from 53.5 percent to 78.9 percent (Table 2.7). In monetary terms, the negative trade balance for the cement industry grew from about $895 million in 1976 to over $1.7 billion in 1979. In contrast to the growing dependence on imported cement in the Third World, imports of cement in the industrialized market economies declined from 46.5 percent in 1970 to 21.1 percent in 1979 (Table 2.7).

Not all developing countries are net importers of cement; in 1975, Venezuela, the Republic of Korea, Thailand, Trinidad and Tobago, and India were net exporters. Although Egypt and Ghana, are net importers of cement, they also export some cement.

2.4 Growth of Indigenous Building Materials Industry

In order for developing countries to have meaningful targets for their industrial growth, several international agencies, including various units of the United Nations, have attempted to estimate the level of production. For exammple, the Lima Declaration and Plan of Action in 1975 set objectives to be achieved by the end of the century for the expansion of industrial capabilities in the developing world. In particular, the Lima Conference set as a goal the increase of the developing countries share in world industrial production nto 25 percent.

The Lima Development Objective (LIDO) Model, was developed by UNIDO to aid the analysis of the Lima target (14). Its purpose is to formulate, up to the year 2000, scenarios reflecting the achievement of the Lima target on the basis of different hypotheses regarding the future state of the economy. In order to meet the Lima objective, for example, the LIDO model estimates that developing countries would have to achieve growth rates of 7.4 percent in the 1980's and 8.4 percent in the 1990s. Their share of world investment must rise to over 30 percent by 1990 and close to 40 percent by 2000.

In order that industrialization of construction and building materials fulfill the Lima Target of International Development Strategy for the Third Development Decade, investment in construction and capital goods, which normally constitutes 98 percent of the capital formation in an economy, must rise collectively in developing countries. According to the LIDO Model this increase must range from a 23.4 percent share of GDP in 1975 to 32.7 percent in 2000. To accomplish this, investment must grow at an annual average rate of 6.8, 9.2, 10.8 and 8.5 percent respectively in Africa, Asia, Latin America and the Middle East. Furthermore, developing indigenous capabilities in these industries, especially building materials, would reduce import bills and diversify exports. This would improve the deteriorating balance of payments positions of many developing countries.

Although impressive gains have been achieved by several developing countries in improving their capacity to produce building materials, many others are still far behind in meeting their demands.

Given these gains in some countries of Latin America and Southeast Asia, it would be justified for other developing countries collectively or individually to redirect attention to achieving comparable gains. There are several reasons for these developing countries to emphasize the development of their industrial potential in building mateials:

(1) Significant percentages of the building materials utilized in developing countries are imported, resulting in foreign exchange losses.

(2) Import-export data suggest the persistence of a trade pattern whereby developing countries export raw materials and import the same materials at advanced stages of processing.

(3) It may be impossible for many developing countries to achieve industrial capability in all sectors. Energy and capital constraints pose insurmountable obstacles to the development of certain manufacturing activities. To compensate for underachievemnt in these areas, more progress must be made wherever natural, material, and human resources permit.

(4) The Lima goal aside, building materials should be prominent in the industrial policy goals of developing countries because of the basic human needs which they can uniquely satisfy.

The challenge facing developing countries to supply construction and building materials to satisfy this demand is urgent. For developing countries which must import these capabilities in the form of finished goods and technical services, import reductions forced by balance of payments deficits will inevitably frustrate growth. To avoid this undesirable scenario, the development of indigenous capability in these target sectors is critical.

3.0 ECONOMICS OF PRODUCTION

The establishment of a viable domestic building materials industry to supply the materials needed by the indigenous construction industry is a major concern of any economic development program. A review of the condition of underdevelopment reveals many interrelated economic and technological problems including capital scarcity, abundance of unskilled labor, market base restriction and economies of scale issues. This section will briefly review the conditions that prevail in developing countries which have significant influence on the economics of and choice of technology of production of building materials.

3.1 Labor-Capital Substitution

Developing countries face severe capital shortages. Few have capital resources adequate to maintain a rate of growth of five percent or more.

An array of arguments advocating the adoption of the labor-intensive, "appropriate" technology is reduceable to a two-pronged thesis: first, that the provision of employment opportunities will promote human welfare; and secondly, that human welfare is advanced by the provision of housing, rural access roads and other facilities meeting basic human needs which are, in turn, made possible by the mobilization of labor where other resources are scarce.

Developing countries generally have an abundance of cheap, unskilled labor and lack technically skilled native labor (Egypt and India excepted). The large numbers of unskilled and unemployed workers are one of the available resources of developing countries while simultaneously constituting a great social problem. Providing employment, therefore, is considered by the governments of many developing nations to be an urgent priority of economic development.

Capital scarcity and the surplus of cheap labor suggest the desirability of labor-intensive economic activity in developing countries. However, labor-intensive methods of production may be inefficient for many processes. Moreover, many products produced by labor-intensive methods may be of inferior or variable quality. If labor-based building materials production and construction technologies are to gain credibility, they must be as efficient and productive as capital-intensive technologies. Of interest in this discussion, however, is choosing from among competing technologies and specifying the conditions making it feasible to substitute labor for capital in the production, distribution and use of building materials.

Capital-intensive industries require specific conditions which developing countries may find difficult and costly to meet. Capital-intensive industries, for example, require highly skilled workers. In many developing countries, it is necessary to import skilled workers and other technical personnel from industrialized countries. Also, extensive capital-intensive operations require a considerable infrastructure (road, power supplies, housing for workers).

Clearly, neither simple labor nor capital-intensive modes of production represent a complete solution for developing countries, with most developing economies having areas in which one or the other of these methods is appropriate. In most instances, however, a mixture of varying degrees of capital and labor intensity is optimal.

Industries which are adaptable to varying mixtures of capital and labor intensity are said to be "technologically flexible". Woodworking and brickmaking, for example, are among the traditional technologically flexible industries. Many modern industries whose technology is exlcusively capital-intensive are, as a result, beyond the means of many developing countries. The United Nations and others, therefore, have suggested that a high priority be given to the development of efficient capital-savings techniques in the core operations of technologically inflexible industries (1).

Labor-intensive production techniques offer numerous advantages for developing countries. First, they generate a high rate of employment per unit investment. Studies of road construction in India, the Phillipines and elsewhere have found that employment created by using labor-based methods is potentially seven to eight times that of equipment-based alternatives (2). Labor-intensive construction methods also benefit the development of the local construction industry and support industries such as the manufacture of tools, simple equipment, and indigenous construction materials.

Another advantage of labor-based production in the 1980's lies in its foreign exchange saving potential. The true cost of importing capital equipment may be higher than its nominal value, if the price is in hard currency, requiring export promotion schemes which require the curtailment or postponment of domestic consumption.

Other issues, such as technical efficiency and total resource prductivity are also important to demonstrate the feasibility of labor-intensive technologies. Construction is generally considered to be a technologically flexible industry. Although electrical and mechanical work is highly labor-intensive, most aspects of building and civil engineering lend themselves to different possible resource combinations. The same end product can be produced in several ways, using various mixes of factor inputs. Concrete structures can be constructed with several technologies of different labor-capital ratios.

The most commonly used criterion for selecting the best technology is minimizing the cost of production by considering the marginal costs of the most important factor inputs, capital and labor.

In many developing countries, however, market prices of factor inputs (wages and equipment costs) do not correctly reflect the relative scarcities of the input factors in the economy. This disparity in market cost and time value of the input factors could be dependent on numerous factors such as monopoly, unemployment and excess capacity, tariffs, overvalued currency, uneven rates of inflation in different factor input sectors, and so forth. As a consequence of these imperfections, the commercially superior techniques may be inferior from the viewpoint of the economy as a whole. Thus, at the micro-economic, or firm level, the correct choice will depend on the prices the decision-maker has to pay for the inputs used in alternative techninques. If these prices are distorted, the correct choice at this level may then be incorrect with respect to the national economy. To compensate, policy makers at the national level should make use of "shadow prices". Shadow prices are fictitious account prices which more accurately reflect the relative scarcity of the input factors for the economy as a whole, and therefore may be used to determine the economically superior technique. They may also be devised to take into consideration a country's resource base and national development goals.

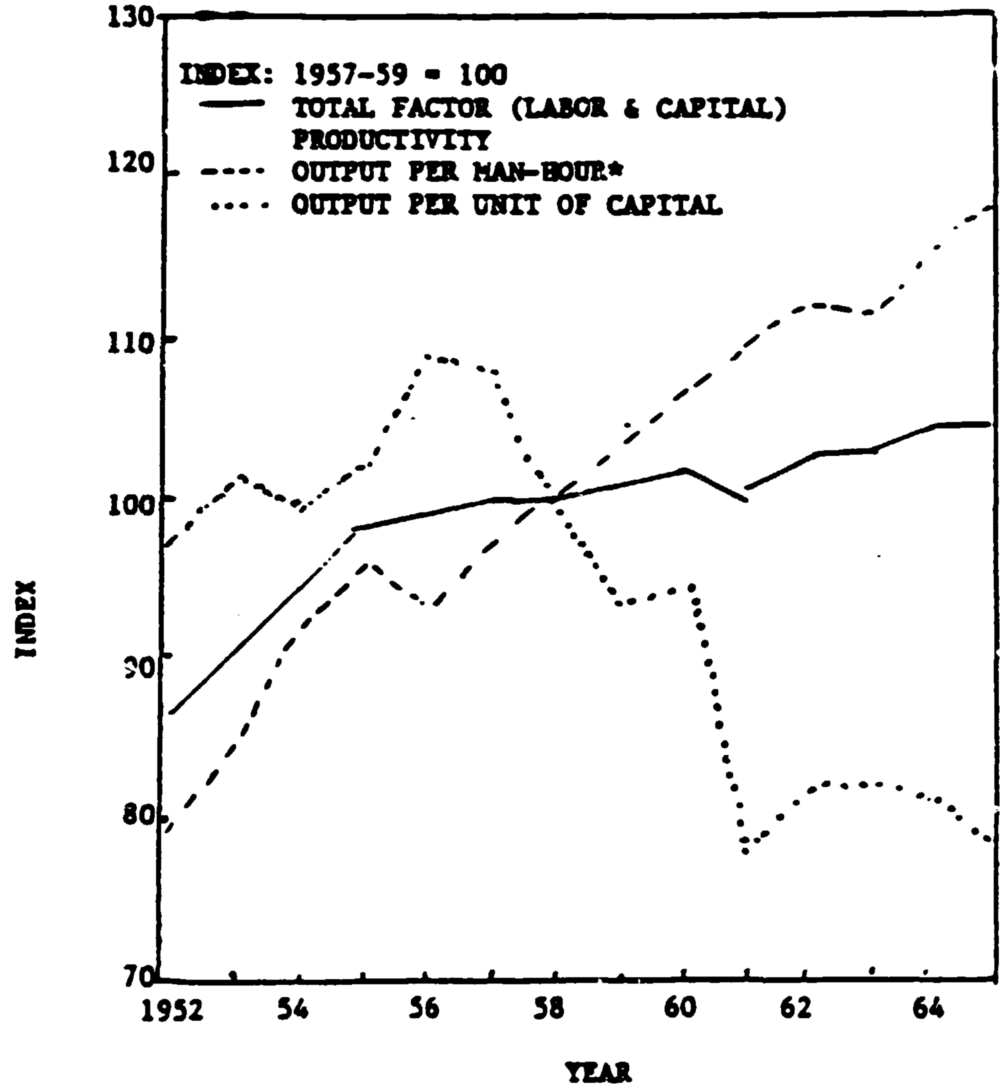
Productivity is often measured exclusively in the form of labor productivity. Yet labor is only one of the factor inputs of production, and maximum labor productivity does not necessarily imply that all factors of production are being utilized optimally. If measures developed for capital productivity were used more widely, much labor-saving bias (3) could be eliminated.

Any single factor index only partially measures productivity in the industry as a whole. What is needed is a total factor index that is a weighted combination of all inputs, which would cancel the effects of factor substitutions. Various economists have formulated joint labor-capital productivity indexes, and Kassimatis has derived one for the construction industry on the basis of his definition of capital input (4) (Figure 3.1). Kassimatis defined capital input as the financial capital tied up in construction during the production process (indirectly including materials) and in equipment and inventories; thus he has developed a capital productivity index. Figure 3.1 shows total productivity to have increased over time, but at a slower rate than labor productivity (1.5 percent per year from 1952-1967), because of the influence of capital productivity, which declined as labor productivity increased.

Understanding the technical efficiency and resource productivity is not always sufficient to compare methods. A major difficulty in assessing technical feasibility of alternative technologies has been that most estimates of the cost of labor-based technologies are calculated on the basis of a plant design which has been geared toward an equipment-based method.

FIGURE 3.1

INDEXES OF FACTOR PRODUCTIVITY IN CONTRACT CONSTRUCTION



*Based on Kassimatis' derived deflator.

SOURCE: Reference 4

The planning and design phases of production facilities greatly determine the technological nature of the production phase. This has led the World Bank to propose a "neutralization" process, whereby bias against the use of labor-intensive techniques would be eliminated (5). This process would involve preparing designs and procurement documents so they do not dictate a specific technology, but rather afford the opportunity for competitive bidding by both labor and capital-based methods.

The microeconomics of building materials manufacture varies greatly from product to product. Cement products, steel sections, wood products, bricks, and other building materials all require different raw materials, capital inputs, power and fuel supplies, labor, levels of consumption, and other factors. The utility of various products also varies; bricks, for example, have virtually no uses other than construction, while steel may be used in hundeds of applications. The manufacturing processes and possible utility of each product must be considered individually.

3.2 Market Base Restrictions

Markets for various products in developing countries tend to be restricted by low per capita income and inadequate infrastructure. Per capita income of less than $500 per year is characteristic of developing countries. Per capita consumption of many building materials is directly related to per capita income. As a result, low income countries have low to moderate capacities for the immediate consumption of many goods, including building materials.

Developing countries also have low levels of infrastructure for the support of general economic growth. The infrastructure of an economy includes public works (roads, airports, dams, power stations, etc.) which are necessary for substantial economic growth, and public services (housing, schools, hospitals, etc.) which raise the living standards but do not contribute directly to economic growth.

The geographic extent of the market base for any given product is dependent on the ease of transportation of the product. It may prove economically and technologically possible to deliver large precast concrete panels within a 5-mile radius of an urban area, for example, while deliveries 50 miles away may not be feasible at any cost. The geography of the market base therefore depends on the size, weight, and required quantity of a given building material, and on the ability of the transport infrastructure to move these goods at low cost.

3.3 Economies of Scale

The development of building materials manufactured in developing countries is not only a function of technical variables but is dependent on economic considerations. Data on the reasons for underutilization of capacity in building materials industries show that market problems and financing are among the most prominent difficulties (6). Therefore, it is important that a preinvestment survey and market study be undertaken before establishing a building materials plant.

The basic raw materials for the manufacture of almost all building materials are usually locally available and inexpensive. Thus there is no need to expend scarce foreign exchange on raw material imports. For example, cement can be produced locally at a lower cost per ton than the cost of imported cement in most developing countries. However, although the basic constituents for cement manufacture -limestone and clay- are always locally available, developing countries typically have little information about their natural resources, especially non-metallic and non-petrochemical resources (7). For example, India has known reserves of over 59,600 million tons of cement grade limestone, but only a fraction - approximately 7,900 million tons - has been brought under the category of reserve, the rest remaining in the category of inferred or indicated (8). In addition to the cost advantages of using local materials, expenses can be kept down further because many building materials, except for aluminum, steel, and a few others, can be manufactured using mostly unskilled and semi-skilled workers and relatively unsophisticated equipment.

Developing countries often lack the market demand to justify the large-scale production or kind of infrastructure that steel manufacture requires. Steel is inherently a large operation. Even a 100,000 ton per year plant, the minimum economic size, requires 10,000-15,000 workers, excluding technicians, administrators, engineers and a sophisticated infrastructure.

Cement, unlike steel and aluminum, can be economically produced on a small scale. Cement plants can have production capacities of only 20-30,000 tons per annum and be efficient (Table 3.1). The optimum unit capacity in India has been determined to be 2000 tons per day for a single unit plant.

The scattered concentrations of raw material deposits for bricks, lime, gypsum, and cement manufacture also favor small scale production. Given the often primitive transport systems in developing

TABLE 3.1

ECONOMIC FACTOR IN LARGE-SCALE VERSUS SMALL-SCALE PRODUCTION OF CEMENT, INDIA

Economic Factors	Large-Scale Cement Production (Rupees/ Worker	Small-Scale Cement Production (Rupees/ Worer
Fixed Capital	4,550.00	1,854.00
Working Capital	1,860.00	1,750.00
Total Invested Capital (K)	6,400.00	3,600.00
Annual Wage (V)	936.00	537.00
Annual Value of Processed Raw Materials (R)	1,747.00	1,561.00
Annual Value of Gross Product (P)	3,660.00	3,150.00
Annual Net Product (Y)	1,860.00	1,860.00
Annual Surplus Product (M)	410.00	845.00
Gross Output/Capital Ratio (P/K)	0.60	0.90
Net Output/Capital Raio (Y/K)	0.21	0.39
Annual Profit Norm	0.06	0.23

SOURCE: Moavenzadeh, Fred. "Global Prospects for Concrete Construction," Concrete International, Vo. 6, No. 2, February 1984.

countries and the high transport costs of these materials- because of their low value weight ratios- transport costs (i.e., fuel and delivered costs of raw materials) can be minimized by having small-scale economical plants close to raw materials.

3.4 Small-Scale Industry

Constraints on supply imposed by energy costs, the size of the market, costs elevated by transport distances, and underutilization of plant capacity suggest the adoption of technologically flexible production methods making greater use of indigenous materials. Central to acquiring technological flexibility in production are: reducing plant size, locating plants closer to raw material sources and product markets, and employing more labor-intensive methods. Given the scarcity of resources for development, total factor productivity assumes paramount importance. The optimal use of all factors of production and the achievement of maximum efficiency, while insufficient, is a necessary step in revitalizing industrialization in the Third Development Decade. Attaining efficiency, in turn, is impossible without the technological flexibility which permits effective adjustments to be made during the production process for reasons such as changes in the quality and prices of available materials and other inputs.

Small-scale industry can ameliorate many obstacles to industrialization through its ability to utilize technologically flexible production methods. In an era of rapidly changing technology, small plants offer the best prospect of remaining competitive. Computer assisted manufacturing, increasingly utilized in developed countries, enables a far wider variety of final product design than would a comparable investment in fixed machinery. Thus, reprogrammable machines with a capacity to limit production runs and manufacture several different products may offer a solution to the long-standing problem of limited market bases in the less developed countries, where small populations and low per capita income levels limit consumer demand. In addition, computer-assisted manufacturing does not displace workers (as perhaps it might in advanced industrial countries), but rather reduces the need for highly skilled managers and labor which, because they are in short supply in key industries, pose a serious constraint on production. Indeed, from the viewpoint of the entire economy, automated production can be highly efficient in its use of labor: the savings resulting from lower operating costs can in principle be reinvested elsewhere, such as in construction, which is highly labor absorptive and which accordingly would create jobs for the reservoir of unskilled and semi-skilled workers.

Small-scale industry also enhances capital productivity and reduces the need for capital investment. The underutilization of capacity in large-scale, modern industrial operations has diminished their capital productivity and offsets the savings which (large) scale economies were once believed to meet. The operation of small plants near full capacity reduces the waste of precious capital resources and alleviates the constraint of investment capital shortages in at least two ways. First, because the gestation period is low for a smaller plant, the potential for quick returns on capital investment is greater. This might persuade entrepreneurs and banks to invest in this type of manufacturing operation, and may open up new sources of financing previously unsuitable because of the prohibitive length of repayment terms. Secondly, because financing costs are substantially reduced, investment opportunities will be accessible to small entrepreneurs. Thus the total capital and entrepreneurial pools available to indigenous industries may be augmented. Small industries also breed indigenous entrepreneurial talent.

Interestingly, small plants are increasingly compared favorably in capital productivity in various industries with larger ones previously believed to have achieved scale economies at much higher production levels. One reason for this reversal is that cost comparisons between large-scale modern industrial operations and more traditionallly-based methods have often erroneously assumed that large scale plants would always operate at full capacity. The problem of idle capacity, especially serious in developing countries, is aggravated by the uncertainty of demand.

Small scale plants also reduce the market base necessary to sustain a profitable manufacturing operation, which minimizes the important constraint of transport costs on the building materials industry. In practice, it is difficult to locate manufacturing operations at a reasonable distance from both sources of raw materials and the consumer market, since raw materials are principally found in rural areas while the largest markets are invariably in cities. Thus, the scaling down of plant size would permit the installation of building materials industries in rural, but accessable areas.

An element of technological flexibility which would ease the constraint imposed by transport costs is the potential use of mobile production facilities. The Hungarian Institute for Building Science which has sponsored research in this area has succeeded in developing a mobile lime calcinating plant, whose product may be substituted for cement.

The following areas should be explored to promote small-scale industry:

(1) Reorganizing Production

From direct reduction methods in steel-making to vertical kilns for firing cement, cost-effective production technologies have been developed which represent dramatic improvements over earlier, artisan-type operations. Plans should be formulated to step up the installation of these kinds of industries, while research on these methods' refinement continues.

Production of building materials, like the manufacturing industry, can benefit from down-scaling operation. The building materials industry already boasts many viable manufacturing processes for small-scale plants. Breaking down the production process into smaller component parts may facilitate the entry of more labor-intensive techniques, leaving the crucial operations to somewhat more capital-intensive units.

Subcontracting, a standard practice in developed countries, might be encouraged as a source of demand for the products of small industrial plants. Large public sector firms might be encouraged to subcontract operations to private small and medium industries. This would also discourage heavy capital investment.

Because small plants are normally more labor-intensive than their large-scale counterparts, labor-based production methods should be encouraged wherever competitive with capital-intensive manufacturing techniques. Labor-intensive methods save capital and obviate the importation of sophisticated equipment. They also promote the development of local construction industries and support industries such as the manufacture of tools, simple equipment, and indigenous construction materials. Most importantly, labor-based production enhances technological flexibility: labor can be redeployed more easily than capital equipment.

(2) Making Resources Available

Increasing the capital available to small firms can facilitate their growth and potential contribution to development. Yet, documented difficulties which small manufacturing firms have had with the commercial banking systems in several countries suggests that to make financing accessible to worthy borrowers, some decentralization of banking services may be desirable.

Much needs to be done in the area of human resources. New ideas for labor training programs should be tried, given the high failure rate of many attempted to date. Some form of apprenticeship in small firms could be a fruitful avenue for further study.

(3) Reforming Regulatory and Fiscal Policies

A review of existing legislation in many developing countries would likely unearth evidence that bureaucratic requirements and tax systems contain serious and systematic disincentives to small industry growth. As a start in translating these into positive inducements to growth, the scope of bureaucratic intervention in the life of small industry could be narrowed, and tax systems could be reformed to create incentives for expansion.

(4) Protecting Nascent Small-Scale Industry

Incentives are often insufficient to induce investment in a competitive world market. To create a secure climate in which private investors will emerge, states need to protect nascent small-scale industrial plants. Import tariffs, quotas, or other mechanisms may be employed as a protective shield behind which new and newly expanding small firms can grow. Ideally, these measures should be temporary and adopted for pre-fixed terms to avoid subsidizing inefficiency by eliminating competition altogether.

3.5 Indigenous Building Materials in Developing Countries

Developing countries are conscious of the contributions of building materials to their economic development and growth and are making efforts to develop cheap, serviceable, adaptable and easily assembled building materials made of locally available raw materials.

The knowledge, skill and the art of using indigenous building materials in construction have been passed down informally from one generation to another and use of these materials continue to be in vogue in developing countries. However, to meet the more exacting demands as regards performance and quality of buildings and other types of constructions, appropriate techniques for improved use of indigenous building materials are necessary. Research and development in this field have been initiated in some developing countries and some innovative techniques have been evolved.(9)

A wide variety of indigenous building materials are available naturally depending on geographical conditions. Broadly, two types of indigenous materials could be identified. In hot and humid climates, which support the growth of plants and forests, a variety of organic materials like grasses, leves, straws, reeds, bamboos, timber and allied materials are obtained. In areas having hot and dry climate, inorganic materials like clays, laterite, sand, stones, etc. are found in abundance.

Often indigenous building materials are used in their natural form with very little processing. These are also used as raw materials for producing a variety of building products skillfully or by employing simple technology. A variety of buiding products from materials like wood and bamboo have been made which have found extensive application in construction. Burnt clay bricks and tiles, building lime and clay pozzolana, etc., are amongst the foremost building materials produced from indigenous resources which have been the main stay of construction activities in many developing countries.

To indicate the extensive use of indigenous building materials, it may be stated that in India as per 1971 Census, there was a total housing stock of 93.0 million dwelling units in the rural areas. Out of this, 72.2 percent of the dwelling units, i.e., 67.1 million, employed mud as principal building material, particularly for walling in one form or the other.

With the development of means and facilities of transportation, indigenous building materials have also found greater use in areas where they are not locally produced or available.

The development of building materials technologies in developing countries is based on two approaches: (1) the improvement of existing building materials and methods; and (2) the develoment of new materials and components for building systems.

Some of the criteria for the choice of appropriate strategies in the development of building materials technologies can be low cost of buidi~g materials production plants; the size of the existing raw material base; the mechanical properties and overall performance of building materials like strength, ductility, formability, weldability, hardness, and temperature resistance; energy requirements; environmental issues and existing local building skills and customs of building practice.

In the area of traditional materials a large part of the current research is devoted to extending the use of cement, improving the properties and performance of concrete and developing the use of plastics in buiding. Current research in the cement-concrete category includes building blocks made of soil cements, lightweight concretes with organic agricultural wastes as aggregate, concrete suitable for tropical climates, reinforcement of concrete with steel suitable to tropical climates, bamboo or other harvestable plants available locally and concrete reinforcement with basic fibers. Also, the use of agricultural wastes as an aggregate, in addition to being cheaply available, eliminates the environmental problems that are associated with their disposal.

Plastics in the form of waterproofing of wood and fiber panels, plastic pipes and emulsion paints based on polyvinyl acetate are traditional materials included in current research. The indigenous use of plastic materials is growing rapidly because of their performance, the development of cost efficient processes and also their low energy content compared to conventional materials.

Preplanned building systems are often appropriate where construction activity or needs are of sufficiently large scale. They offer cost and time advantages. Table 3.2 shows the types of dwelling proposed by various countries in the early 1970s for their low-cost mass housing developments. The most common type of construction planned is one-and two-story dwellings. The worldwide need for one-and two-story construction has resulted in the increasing use of lightweight structural panels. Wood and ferrocement panels are considered the most promising structural panel systems.

Wood panels are particularly suitable for developing countries with significant wood resources. The use of locally manufactured plywood in the production of prefabricated structural panels is an area of great potential development. Recent studies indicate the continuing trend for the development of the related industries and deal with the technical and economic conditions for their viability in the environment of a developing country.

Ferro-cement panels are also considered advantageous for use in construction in developing countries. They combine improved mechanical properties with relatively low cost and ease of manufacture. Finally, increasing attention is lately being given to the development of composite materials for roofing systems. Composites normally consist of a reinforcement, a filler and a coating which are held together by a binder. Current research is focused on the production of suitable binding materials which are scarce in developing countries.

A recent case study on the development and promotion of appropriate technologies in the construction and building materials

TABLE 3.2

TYPES OF CONSTRUCTION RECOMMENDED BY VARIOUS GOVERNMENTS

FOR LOW-COST HOUSING PROGRAMS

COUNTRY	TYPE OF HOUSING PROPOSED	SUGGESTED BUILDING MATERIALS	TOTAL FLOOR AREA (ft^2)	LIVING SPACE PER PERSON (ft^2)
PAKISTAN	1 story with central courtyard	permenent	275	125
INDIA	1 story semi-detached	brick	250-480	135-190
INDIA	Village House	mud, thatch	500	250
HONG KONG	11 story flats	cocrete	413	58
SINGAPORE	Semi-urban small dwelling	timber, thatch	530	400
KENYA	2 story	permanent	960	132
TANGANYIKA	1 story	semi-permanent	1000	200-400
UGANDA	1 story detached	semi-permanent	1000	280-560
ZANZIBAR	1 story house	semi-permanent	660	190-380
SOUTH AFRICA	detached house	permanent	650	530
WEST INDES	1 story detached houses	timber	500	150-300
LATIN AMERICA	1 story rural detached houses	-	684	388-465

SOURCE: Moavenzadeh, F. and Sanchez, R., Building Materials in Developing Countries, Massachusetts Institute of Technology, 1972.

industries in India indicates the importance of traditional and new building materials as well as of building systems.(10)

The brick, lime and wood industries are the focus of traditional materials industries. At the same time, the utilization of industrial and agricultural wastes are increasingly promoted. The manufacture of rice husk lime binder, light weight concrete with use of fly-ash, roofing systems and other clay-based new materials is also encouraged. Finally, particular emphasis is given to the development and improvement of building materials in low income rural areas with the utilization of indigenous raw materials like soils, grasses, palm leaves, bamboos, stones, timber and other.

3.6 Rural Versus Urban Demand

Data pertaining to the relative proportion of construction demand in urban versus rural areas were only available for the category of residential buildings for eight countries, presented in Table 3.3. With the exception of Portugal, the bulk of dwelling construction takes place in urban areas. Little else can be inferred with confidence from the data, which reveal erratic patterns not simply explainable by the percentage of the population residing in urban centers nor by the level of development, as measured by per capita GDP. Honduras, whose urban population at 36 percent is only slightly higher than that of Portugal (though it is much less developed), concentrated 90 percent of residential building construction in urban areas. While the proportions of construction in urban areas remained fairly constant in some countries during the 1970s, as in Yugoslavia, or increased, as in Mexico, Egypt and Greece, the urban share of dwellings actually declined in Syria and Israel.

TABLE 3.5

PERCENTAGE DISTRIBUTION OF CONSTRUCTION BETWEEN RURAL AND URBAN AREAS

(Residential Building Only)

	Rural	Urban	Percent Population Urban (1980)
HONDURAS			36
1974	1	99	
1978	10	90	
EGYPT			45
1972	26	74	
1973	10	90	
1974	8	92	
SYRIA			50
1968	15	85	
1971	21	79	
1972	17	83	
1973	24	76	
1974	21	79	
1975	33	67	
1976	30	70	
1977	27	73	
1978	34	66	
(avg. 1972-78)	28	72	
MEXICO			67
1960	52	48	
1970	41	59	
PORTUGAL			31
1972	72	28	
1973	72	28	
1974	73	27	
1975	82	18	
1976	81	19	
1977	81	19	
1978	80	20	
1979	80	20	

TABLE 3.3 (continued)

	Rural	Urban	Percent Population Urban (1980)
YUGOSLAVIA			42
1972	47	53	
1973	48	52	
1974	44	56	
1975	44	56	
1976	45	55	
1977	47	53	
1978	48	52	
1979	46	54	
GREECE[1]			62
1968	31	69	
1970	21	79	
1972	18	82	
1973	16	84	
1974	25	75	
1975	21	79	
1976	20	80	
1977	19	81	
1978	18	82	
1979	20	80	
ISRAEL			89
1972	10	90	
1973	11	89	
1974	15	85	
1975	14	86	
1976	14	86	
1977	13	87	
1978	21	79	
1979	24	76	

[1] Authorized

SOURCES: Mexico - Germidis, The Construction Industry in Mexico.
All Other Countries, UN, Yearbook of Construction Statistics.
Percent Population Urban, World Bank, World Development Report 1982.

This suggests that strictly economically-induced demand cannot account for the spatial configuration of construction activity; rather, other intervening factors have influenced the siting of residential construction output. One such factor may be public policy. Government programs designed to foster the creation of new settlements and towns outside existing urban centers or in other ways to meet the housing needs of the rural population would likely favor rural construction. The availability of domestic or international financing for housing construction, too, will shape the demand structure of the residential and other sectors.

The potential for rural demand for construction, of course, extends beyond the residential construction sector. Efforts to improve agricultural output and productivity, an important policy issue in developing countries, would heighten the need for rural access roads, water supplies, irrigation works, markets and storage facilities.

Growing urban centers, too, require infrastructure as well as housing, especially water, sewerage works, and so forth. Both urban and rural areas have intense needs for schools, hospitals, and productive facilities. Population, alone, however, is not always an adequate guide to the magnitude that demand for various construction final products will assume. Other factors, such as distribution of income, will affect levels and nature of demand.

3.7 Informal Sector

Once planned, designed, and approved and contracted, the construction project is the responsibility of the construction firm. In most market-economy developed countries, work is mainly carried out by small and medium-sized enterprises employing between five and two hundred persons. In the planned economy countries, large enterprises frequently have payrolls of six hundred to four thousand. In the less developed countries, the construction industry is crudely divided into a modern, formal sector, dominated by firms (local or foreign) which use advanced technologies responsible for the construction of major infrastructure works, and an informal sector, which is comprised of a mass of small non-industrial enterprises operating in rural areas or on the periphery of towns.

The failure of construction firms of the formal sector in developing countries to provide an adequate supply of decent, affordable housing is best evidenced by the rise and rapid proliferation of the informal sector. The sheer size of the informal sector is stagering. Riedel and Schultz suggest that the average number of dwellings built in the sector is four times the number report.(11) The Government of Honduras estimated that 90 percent of the dwellings in that country were erected in the informal sector or by the occupants of the houses themselves. In the Ivory Coast, it was estimated that in 1971 the informal sector accounted for 30 percent of the value added by the total construction sector, 39 percent of intermediate consumption of materials and services, and 35 percent of the total value of output of the construction sector. The informal sector furthermore employed over 62,000 workers, compared with 42,000 in the formal sector. In Kenya, the informal sector contribution to total construction GDP averaged approximately 30 pecent in the years 1969 to 1978.

Not subject to building codes, utilizing almost exclusively indigenous materials and employing local labor has increased the reputation of the informal construction sector with the international lending institutions. The informal sector is seen as a flexible, resourceful and realistic means by which to satisfy the real need for construction in developing countries. Yet, quality control problems have created some concern.

Nonetheless, programs to exploit the capabilities of the informal sector are underway. Sites and services projects, which have received substantial funding from the World Bank, provide land, public utilities, and technical and financial assistnce to low-income families to enable them to build and improve their own housing. The sites and services concept stresses involvement of the occupants, utilization of labor-intensive techniques that are technically feasible and economically justifiable, and the use of indigenous construction materials and products.

Not only do sites and services projects partially fill a country's housing needs, but they also contribute to the urban economy and indigenous construction sector capability. For example, buiding shanty towns offer a number of informal employment opportunities. Projects which draw on specialized labor skills tend to reduce urban unemployment. Also, because the building materials depend on local raw materials and manufacturing capabilities, expanded markets are created for the projects of the informal sector.

The development of the Local Development Associations (LDA) cooperative movement in Yemen in 1967 is an example of an approach that holds the potetial for marshalling local resources from the informal sector and directing them toward worthwhile development projects. Between 1973 and 1978, the LDA's constructed 13,780 kilometers of roads, 2286 education projects, 1545 water supply systems, 79 health care projects and 248 other projects. The number of LDA's grew from 28 to 187.(12)

3.8 Innovative Uses of Materials

This discussion is limited largely to materials readily or potentially available in the developing areas of the world. Some represent fairly simple technologies, while others require higher technologies, but these are being introduced. Because of this, the more traditional materials, including wood, concrete, conventional brick and block, soil, glass, and many others, are not included here in spite of the fact that active exploration of innovative uses of these materials is going forward.

3.8.1 Sulfur:

Elemental or raw sulfur is found in all volcanic areas of the world and in extensive deposits elsewhere. More recently, large supplies, now estimated at approximately 30 percent of total production, are coming from the de-sulfurization of natural gas, smelter gases, and petroleum. As high-sulfur coal undergoes similar processing, or as stack gases are cleaned, additional supplies will become available. With the growing availability of sulfur at relatively low cost, interest in its use as a binder in building units such as concrete block and tile, in coatings, and as impregnants, is growing.

Sulfur has long had a number of limited uses in building and allied fields. For example, sulfur acting as cement mixed with various mineral fillers has provided mortar for acid-resisting masonry.

When impregnated with sulfur, pulp and paper products become dense, strong, and weather resistant. Similarly, when wood is impregnated with sulfur, it is markedly hardened and strengthened, and its resistance to moisture and to attack by fungi, bacteria, and insects is greatly increased. Likewise, porous stone, such as sandstone, can be markedly hardened to weathering, rain and attack by pollutants.

Among the properties of sulfur favorable to construction is its relatively easy utilization, requiring generally simple handicraft techniques.(13) It is waterproof, adheres strongly to many construction materials, and is a poor conductor of heat and electricity.

As is true of other materials, sulfur has its drawbacks. Possibly foremost is flammability, although ways of reducing flammability are being developed by the use of relatively inexpensive fillers.(14) It is brittle, although the addition of hydrocarbons can reduce brittleness and increase plasticity. A number of other uses of sulfur are examined below.

Sulfur may be used in place of portland cement or other hydraulic cements in making concrete, or it may be used as an impregnant to improve the properties of masonry units such as concrete block and brick.(15) Sulfur concrete can use the same equipment and construction technology as portland cement concrete, thus no new skills are required for its applications.

Sulfur reinforced with fiber and treated with a plasticizer that also acts as a thixotropic agent is being used to construct masonry walls by a surfce-bonding technique instead of the usual mortar joint.(16) Tests indicate that the wall is stronger than standard masonry.

Similar wall construction is obtained by brushing or spraying a mixture of glass fiber and portland cement paste on dry-stacked blocks. Glass fiber must be alkali-resistant and fire resistance remains a considertion, depending upon the application.

Sulfur combined with asphalt can provide superior roadbeds,(17) especially where aggregates are scarce or poorly graded, resulting in large voids among the particles. The sulfur fills those voids. It is reported that increased strength and hardness allow reductions in thickness of pavements of up to 20 percent. Depending upon relative availability of asphalt and sulfur, costs may also be reduced as much as 20 percent.

The strong adhesion of sulfur to fibers and filaments of all kinds raises the possibility of a family of fibrous composites based upon sulfur as the matrix.(18) Strong indigenous fibers are found in many developing areas and could be employed as reinforcement. Some experimental work has been done with woven fabrics stretched across a frame coated and impregnated with sulfur. The weight causes the fabric to sag, which provides a good domed shell when turned over. The principle employed is a well-known one in mechanics and has been used with other fabric-matrix combinations.

Laminar composites, employing sheet material such as paper, pulp, or fabric can be utilized with sulfur as the binder and impregnant. The strengthening and hardening of paper by impregnation with sulfur has been mentioned above.

3.8.2 Roofing from Waste

Cellulosic materials such as refuse paper and cardboard are available practically everywhere. In Mexico this material is being converted into corrugated roofing material by a process using simple equipment.(19) Finished sheets hardened in hot air are placed on the roof by standard side lapping and overlapping arrangement on the wood framework of the roof.

3.8.3 Woven Bamboo Matting

Bamboo split into strips is commonly woven into matting for use as walls and partitions in many areas where bamboo is readily available. Customarily, splitting and weaving are done by hand, a slow and time-consuming process.

Simple machines have been developed to split bamboo quickly into uniform strips and to weave it into matting. The equipment is not bulky or complicated to use and can be set up locally.

3.3.4 Cement-Asbestos

Asbestos fibers and portland cement are available in various parts of the world. Where this is the case, cement-asbestos can be manufactured into many different shapes including pipe, board, and special shapes for housing. The resulting structure is highy resistant to fire, mold, decay, and wind. These deeply-corrugated long-span units have been employed in Mexico and other parts of Latin America as well as elsewhere.

3.8.5 Wood and Agricultural Wastes

Wood and agricultural wastes are potential sources for building boards and other building components when chipped, flaked, or otherwise made into particles that can be bound together by a suitale adhesive. Although synthetic resins such as phenol and urea formaldehyde are commonly employed, suitable binders can be derived from wood and agricultural wastes.(20)

Lignin and furfural are found in bamboo, wood and several common agricultural materials, including rice, peanuts and corn. Lignin is the binder that holds together the cells of cellulosic materials (woody tissues of all kinds). It can be used as a binder for other similar materials as in plastics and laminated boards and the well-known hardboards derived from wood waste. Furfural is a useful ingredient in industrial resins. Furfural and lignin react readily to provide molding compounds as well as binders for materials derived from wood and agricultural wastes. Such binders are particularly attractive where the synthetic resins are costly and not readily available.

3.8.6 Lightweight Carbonized Plant Materials

Lightweight insulating materials made by carbonizing indigenous plant materials offer the possibility of low-cost replacements for foamed plastics or conventional mineral materials, such as perlite, vermiculite, and expanded clay or shale that may not be locally available.(21)

Development work at the University of Toronto has demonstrated that cereal grains can be expanded and carbonized cheaply and efficiently by relatively simple slow burning under heat and pressure. The resulting lightweight porous carbon is biologically inert, fire resistant (stable to 2000° C) and highly resistant to water and chemicals.

In areas where edible grain cannot be diverted to this use, research is focused on locally available inedible kernals, grains, or other suitable plant materials not usuable as food.

3.8.7 Adhesives, Binders

Although mechanical fastenings including nails, screws, bolts and thongs are widely used to fasten together the components of dwellings, adhesives and binders are also extensively employed in place of, or in addition to, the mechanical fastenings.

Several binders such as sulfur and lignin-furfural from wood and vegetable wastes have already been mentioned. Inorganic binders include lime gypsum; hydraulic-setting possolans, fly ash, blast-furnace slag; portland cement; magnesium oxychloride sulfate; sulfur; silicates (water glass); and clay. Organic binders include various annimal products; plant derivatives from soybeans, seed and nut oils, and rubber; and petroleum derivatives like asphalt.(22)

3.8.8 Plastics and Composites

Although plastics and other synthetic polymers are largely high-technology materials, relatively costly and not generally available in many areas for housing for low-income people, in other regions with plentiful petroleum and a growing petrochemicals industry plastics offer attractive possibilities both by themselves and in combination with other materials.

There are some 20 to 30 commercially important classes of plastics with thousands of different formulations. Some are hard and brittle, others are soft and flexible. Some are transparent or translucent, others are opaque. Some stand up well to the weather and sunlight, others deteriorate quickly. Some burn readily, others do not support their own combustion, but all can be destroyed by hot enough fires. They are suitable in a variety of applications as building materials. Once the feedstock is available, the technology required to produce various building components is simple and highly suitable for small-scale enterprises.

Plastics find some of their best uses as constituents of composites, combinations of materials whose combined behavior differs from and often exceeds the behavior possible from the constituents acting alone. Three classes of composites are commonly recognized: particulate, fibrous, and laminar, with sandwiches a special case of laminar.

3.8.9 Implications for Local Housing Industry

Most of the foregoing innovative developments are applicable to the local housing industry and, in a large measure, to self-help. The equipment needed is in most cases isrelatively simple and usable with minimal instruction. The basic plastics industry, of course, is highly capital-intensive and complex but many of the products can be fabricated into final form and applied locally.

This is of greatest importance if new materials and means of using them are to penetrate into the small villages, towns, and rural areas where the great majority of people live in many areas of the world. It is not enough to develop new approaches to the production of housing; it must be possible to introduce them into the actual construction process as it exists.

4.0 MEASURES AND ACTIONS TO ENHANCE PRODUCTION OF BUILDING MATERIAL

In this chapter the constraints present in the development of a viable building materials industry in developing countries is reviewed, along with methodologies available to assess the desirability of establishing an indigenous building materials industry. Certain institutional issues which could facilitate the development of the indigenous industry are then summarized.

4.1 Ownership and Competitiveness

One of the most striking differences in the establishment of the building materials industry between developed and developing countries is the nature of its ownership and subsequently the impact that this ownership has on the competitiveness of this sector.

The nature of competition in the building materials industry in developing countries is significantly different from the nature of competition in this industry in developed countries. The building materials industdry in a developed country (e.g., the United States) is characterized by a very high degree of competition in some parts of the industry, as well as some oligopolistic elements in others.

In contrast, the building materials industry in developing countries is generally characterized by a very thin market. That is, this industry tends to be dominated by either a state-run firm, a few private firms, or foreign firms who force the developing country to be heavily dependent on imports in order to have a viable building materials industry. In no case does the degree of competition approach the intensity that exists in a developed country.

The implication of each kind of industrial organization in the building materials industry in developing countries is that significant welfare losses (i.e., a loss of resource to society, due to insufficient production behavior) may result. An example of inefficient production by state-run firms is their high degree of excess capacity and redundant utilization of labor and on many occasions that of capital. This in turn is often due to overly optimistic expectations about the future utilization of production plants. For example, in 1971 Mexico had developed aluminum production plants with the expectation to produce 70.0 million tons by 1975. Contrary to the expectations, it produced only 29.9 million tons in 1975. Even by 1981 aluminum production was slightly over 50.0 million tons and not increasing. This problem was underscored by the experience in Honduras where market problems (e.g., uncertain demand) were cited as the primary reason for excess capcity in their building materials industry. In essence, poor demand forecasts given the planned capacity led to serious excess capacity in both countries. While demand or supply uncertainties can lead to poor forecasts of industrial output under any industrial structure, the problem appears worse under state-run monopolies because they represent an entire industry's productive capacity, not just one firm's capacity. It should be pointed out, however, that a few countries, characterized by state-run production, have been successful in utilizing their production capacity. For example, South Korea has an almost 100 percent rate of capacity utilization of its steel industry (12.7 million tons production versus 13.1 million tons capacity in 1982 (Economic Intelligence Unit, 1983).

The existence of a private monopoly (or shared monopoly) will also reduce welfare, but for different reasons than a state-run firm. That is, it is well known that private monopolies often set prices above and outputs below competitive levels. Further, monopolies are often characterized by X-inefficiency in production (i.e., they do not produce output at a minimum to society) and dynamic inefficiencies in areas such as the intensity of research and development and technical progress.

Finally, complete dependence on imports may lead to welfare losses if foreign firms behave in a non-competitive manner by either setting monopolistic prices and/or by restricting sales.

The upshot of these potential welfare losses associated with each kind of industrial organization of the building materials industry (state-run firm, private monopoly, dependence on foreign firms) is that it will be useful to identify policies that could effectuate a more socially desirable form of industrial organization for this industry in developing economies. Before proceeding with the question of appropriate industrial organization, however, it is important to place more institutional perspective on the economic characteristics of building materials production in developing countries.

Further, it is important to emphasize that building materials serve as a key input into construction. This importance of building materials is not likely to be reduced by changes in construction technology (e.g., from capital intensive to labor intensive). The expenditure shares of building materials in construction remains fairly constant regardless of technology. In contrast, equipment and unskilled labor are highly substitutable as the technology changes. In particular, the expenditure shares of these inputs rise or fall (absolutely) by roughly 30 percent.

It is interesting to observe that there do not appear to be entry barriers in the building materials industry in the form of high capital requirements or significant scale economies for many building materials except a few. Indeed, it is possible to produce such materials as bricks, cement, and wood at a fairly small scale of output without incurring an economic disadvantage. In addition, small-scale production may even be more profitable than large-scale production (see Table 2.5). In short, it appears that building materials can be produced by a number of small competitors thus suggesting that competition in the production of many types of building materials may be possible. It is also useful to note that based on the trade flow statistics that are available, almost all developing countries are net importers for most building materials. This trade imbalance illustrates that one of the benefits from the development of a viable domestic building materials industry will be an improvement in foreign exchange and thus an improvement in GDP.

4.2 The Desirability of Developing the Building Materials Industry

As indicated throughout this report, the building materials industry -- either developed domestically or through trade -- can play an important role in a developing count y's economy. It is thus important to determine whether it is desirable for a developing country to use resources to enhance this industry or to rely on trade for building materials. Once it is determined that it is worthwhile for a country to have a viable building materials industry, then specific policy options can be considered.

In this section we identify various considerations that should enter into the developing country's cost-benefit decision as to whether to develop and maintain a building materials industry. We then illustrate these ideas by carrying out a limited cost-benefit calculation. We recognize that some observers might feel that such a discussion is unnecessary as it is never desirable for a country to rely solely on trade to secure particular commodities. However, our approach is still useful even if this position is accepted in that it identifies the costs incurred in following a policy of self-sufficiency.

The first issue that must be addressed is the true shadow costs of building materials production in the developing country. That is, it is essential to know what are the true opportunity costs of building materials production to the developing country in order to determine if it has a comparative advantage vis-a-vis foreign sources in this activity. While the determination of the shadow costs of building materials production will vary by commodity (e.g., cement vs. pipes) and by country, there are a number of important considerations that are common in this determination.

First, since we are concerned with the shadow costs, one must avoid incorporating economic distortions that may exist in the domestic economy into the calculations. For example, if the production process of a building materials requires inputs from a protected industry in the home market, one should use the world price for this input rather than the distorted domestic price. In addition, since one is concerned with shadow costs one should consider the true opportunity cost of labor in setting the price of this input. In countries where there is high unemployment this opportunity cost and hence associated shadow wage is likely to be quite low.

Additional complications in the shadow cost determination arise from the fact that building materials are tradable goods. Indeed, the export of building materials accounts for a significant percentage of these building materials. As such, it is important to include transportation costs (which can be considerable for "island" countries like Singapore, Cyprus, and Sri Lanka) with the domestic production costs to obtain the full shadow costs of building materials that are exported. As a final point, one must account for the benefits provided ... economy by the building materials industry through linkages. That ... emphasized before, the building materials industry can provide a ... to the construction industry (forward linkages) as well as to, for example, the chemical industry (backward linkage).

With the determination of the shadow costs of building materials for domestic use and export completed, one can then carry out the cost-benefit decision of whether a developing country should maintain a building materials industry. This is achieved by comparing the shadow cost of domestic production of building materials with the world price. If the shadow cost of building materials for domestic use and export is less than the world price, then the building materials should be produced by the developing country. Conversely, if the shadow costs exceed the world price then the building materials should be imported.

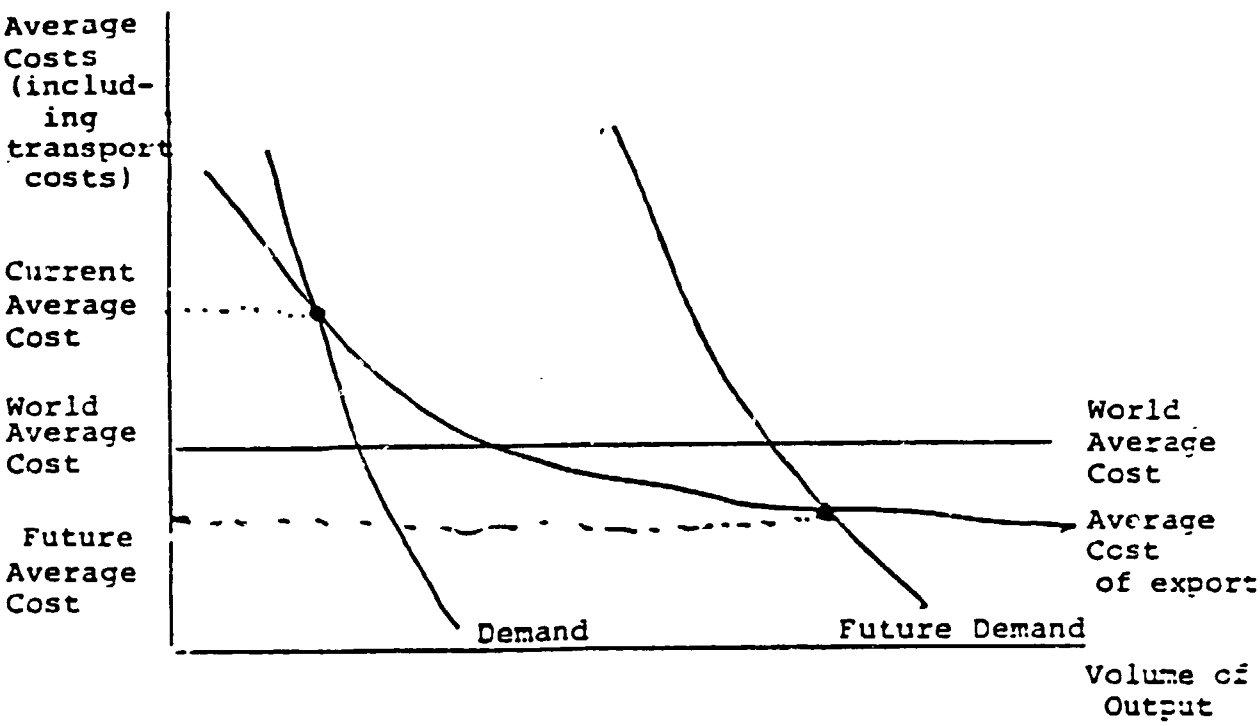
Essentially, the perspective employed here is based on the well-known notion of the comparative advantage. That is, a country should satisfy its economic needs by allocating productive resources to activities where they have an inherent production and technology advantage and by supplementing the activities, where they do not have such advantage, through trade. To be sure, there are a number of considerations which suggest that caution should be taken in applying this perspective to the building materials case. First, one must recognize the self-sufficiency perspective (adhered to, for example, by China and India) which argues against complete reliance on trade for building materials. Second, while it appears that there are not significant scale economies in the production of building materials, there may be scale economies in the transportation of building materials for export. It may be the case that a particular country's volume of exports is not at a level where these economies are exhausted, thus leading to high shadow costs in domestic production for export. However, if the demand for building materials for export increases over time, then these economies may be exhausted. That is, as shown in Figure 4-1, a significant shift in the demand for building materials for export might lower the shadow cost of production to the point where it is lower than the world average cost. As such, it is important in the cost-benefit calculation to identify any changes in demand that may significantly influence any conclusions.

It is useful to illustrate the preceding ideas by carrying out a cost-benefit analysis of whether a developing country should develop a building materials industry or import the particular building material. Data limitations precluded a very precise calculation, however, the analysis should be suggestive.

The minimum capital costs of producing cement and steel in developing countries are presented in Table 2.5. These costs are $2000 per ton for steel and $59.7 per ton for cement given a small plant (i.e., production of 50 tons per day). Ideally, these capital costs should be added to other production costs (and transport costs if exports are considered), accounting for any savings due to linkages, to determine the true shadow costs of producing these building materials in

FIGURE 4.1

DEMAND SHIFTS AND SCALE ECONOMIES



developing countries. Although the remaining figures are not available, one can still carry out a suggestive cost-benefit analysis by comparing the capital costs with world prices.

In the case of steel bars or steel structural shapes, we find that the world prices are roughly $400 - $500. These prices are considerably below the capital costs of steel production in developing countries. This suggests that especially when the remaining factor costs are accounted for, a developing country would be better off purchasing steel at the world price than producing it domestically.

In contrast, we find that the world prices of cement - as determined in the United States and Asia - exceed a developing country's capital costs incurred in producing cement domestically. Hence, it may be the case (after the remaining factor costs are considered) that the developing country should produce cement as opposed to importing it.

To summarize, we have argued theoretically and illustrated by way of an example that a developing country should employ the perspective of comparative advantage when deciding whether to engage in the production of building materials. While this perspective may be in conflict with alternative perspectives (e.g., self-sufficiency), it has hopefully been illustrated in this section that serious production inefficiencies (and concomitant welfare losses) can result from a failure to employ such a perspective.

4.3 Public Vs. Private Production

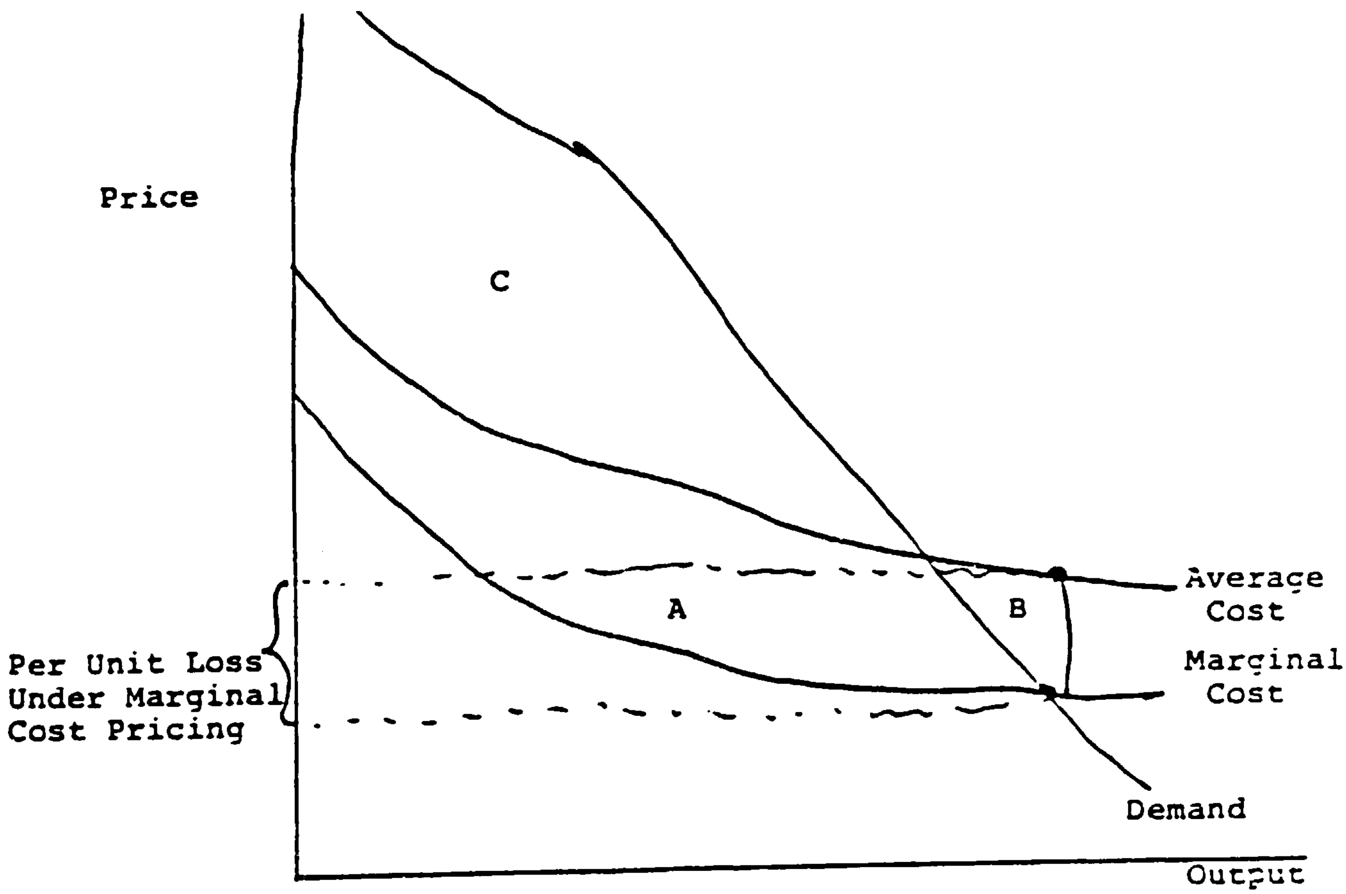
The previous section was concerned with whether a developing country should engage in the production of building materials. If the answer to this question, based on a comparison of the relavant shadow costs, is affirmative, then we must consider whether production should be carried out in the public or private sector. Again, this determination is based on a cost-benefit analysis, however different considerations arise in this analysis than before because our alternatives are solely domestic ones rather than domestic vs. foreign alternatives.

As indicated previously, there are several problems generally associated with public production of building materials. These problems include inefficient production methods (e.g., a high degree of excess capacity), a need for public subsidization due to financial losses, and a lack of responsiveness to the profit incentive. In addition, state-run firms tend to be preoccupied with political concerns as opposed to economic ones.

Given these concerns, it will generally be desirable for building materials to be produced in the private sector if workable competition is possible. More generally, it is a basic tenet of welfare economics that social welfare is maximized under competition. Public production of building materials is thus only desirable if there is some form of market failure; that is, the building materials industry is characterized by natural monopoly or there is an excessive degree of market or political risk. The first case (natural monopoly) has been argued to be an unlikely occurence in the building materials industry in developing countries. Nonetheless, this case is illustrated in Figure 4-2. As shown in the figure, the industry is characterized by natural monopoly because of the decreasing marginal and average cost curves throughout the relevant range of output (this is a sufficient but not necessary condition for natural monopoly). In this situation, production is not profitable under marginal cost pricing, as indicated

FIGURE 4.2

THE DESIRABILITY OF PUBLIC PRODUCTION



by the loss per unit under this pricing policy. The total loss is given by the rectangle composed of areas A and B. The social benefits from the output produced at marginal cost pricing are given by the relevant area under the demand curve, namely area A and C. Thus, the net benefits from production, even under economic losses, are the difference between area C and B. Since this difference will be positive, it is desirable to have production carried out by public means (e.g., a state-owned firm) and subsidized by the public, thus allowing the building materials to be produced and priced at marginal cost. To emphasize, however, it is unlikely that this justification for public production will be applicable to many developing countries' building materials industries.

A more likely justification for public production is the presence of risk. That is, if it is perceived that there is a substantial amount of risk (and an associated high cost) involved in materials production (attributable to, for example, volatile market or political conditions), then it may be necessary to conduct building materials production in the public sector as there may be no private firms who are willing to absorb the risk.

4.4 Government Policies Toward the Building Materials Industry

It is now appropriate to consider government policies that might aid the development of a building materials industry in a developing country. To begin, we will assume that the justification for this industry is based on the cost-benefit test discussed in Section 4.2 (i.e., it is socially desirable for the developing country to produce building materials). We are then concerned with whether the production will be organized publicly or privately. As stated before, public production is only economically justified in the cases where building materials production is socially desirable but privately unprofitable. As such, the government should treat building materials as a public enterprise and develop a state-run firm to carry out production. Public production is also justified if no private firms are willing to undertake the risk associated with production in a particular political or market environment.

4.4.1 Public Policies

To ensure the success of a publicly run building materials industry, the government should enact the following policies. First, it must be concerned with undesirable domestic competition represented by firms who might attempt to "cream skim" the most profitable domestic markets. Thus, since there is no guarantee that the government will be able to set sustainable prices (i.e., prices that make entry by other firms unprofitable), legal barriers to entry will have to be erected. In addition, the government may find that tarrifs have to be set to protect public production of building materials in its early stages of development. To be sure, excessive tariffs may actually indicate that the developing country does not have a comparative advantage with respect to the production of building materials, and, as such, should abandon support for this enterprise.

4.4.2 Public Policy and Private Production

If workable competition can be achieved in the building materials industry, then public policy will have several avenues in which to contribute to the performance of this industry and the growth of the developing country. Generally, the objective of public policy in the context of a building materials industry that is workably competitive is to provide protection from foreign competition as appropriate, set and enforce product quality standards, and encourage efficient and innovative behavior. The policy instruments with which these objectives can be achieved are tariffs and taxes, industrial standards, and patents.

4.4.3 Tariffs and Taxes

It is important to note that taxation policy and tariff protection in developing countries is significantly different from such policy in developed countries. As shown in Table 4-1 developing countries provide much higher protection than other countries for various building materials. The high level of tariffs is consistent with developing countries' emphasis on indirect taxation (i.e., value added and excise taxes) as opposed to direct taxation (i.e., profit and capital taxes) to generate revenues. For example, in 1978, Argentina and India derived 30 percent of their revenues from direct taxes and 70 percent from indirect taxation.

The implication of this form of tax and tariff policy is that it provides a favorable environment for the development of a workably competitive building materials industry. That is, the high tariff levels will provide the necessary protection for domestic firms so that the domestic industry can develop effectively and serve long-run domestic needs. To be sure, there are static welfare losses associated with tariffs, however they can be justified in the short-run if the domestic industry will develop effectively over time. The aforementioned tax policy also contributes to a workably competitive building materials industry because low profit taxes will encourage investment in the industry and reward firms for successful performance.

TABLE 4.1

THE NOMINAL LEVEL OF TARIFF PROTECTION
BY LARGE PRODUCT GROUPS COVERING BUILDING MATERIALS

	Developed Market Economy Countries	Developing Countries	Socialist Countries of Eastern Europe
Wood	4.5	31.9	14.4
Crude Materials and Products Thereof	5.0	25.0	9.7
Glass	7.4	36.9	15.6
Chemicals	6.9	19.5	10.5
Metal Manufactures	6.3	25.4	10.8
Machinery	7.8	23.9	14.9

SOURCE: UNCTAD Data Base on Trade Measures

This support should also be helpful in contributing to the industry's role in export markets.

To summarize then the role of tariffs in the developing country is to provide necessary protection for the building materials industry in its early stages of growth, while the role of taxes is to provide appropriate incentives for potential investors and management.

4.4.4 Industrial Standards

One of the major benefits from the development of a workably competitive building materials industry is in product quality and variety (i.e., the development of a high level of and choice among product qualities). Given that building materials come in various grades, it will be important for the government to set quality standards to prevent an unacceptable level of building material quality to appear in the market. The establishment and enforcement of product quality standards in building material production will enable the benefits of product quality variety to be achieved while guaranteeing a high minimum level of product quality.

Currently, there are very few industrial standards that have been set for building materials produced by developing countries. Such standards, however, will evolve in a competitive environment because domestic firms will undoubtedly become involved in joint ventures with firms in developed countries who face quality standards. This interaction will facilitate the introduction of quality standards by providing information to the domestic firms and government as to how these standards should be set and how they can be implemented. That is, it is most likely that firms in developed countries have accumulated considerable experience regarding the costs of using and producing sub-standard building materials. These costs include, for example, increased medical costs associated with injuries resulting from defective materials and increased production costs resulting from the additional work that has to be performed to produce an acceptable final product. By working with engineers employed by developed countries' firms, firms from developing countries should be able to acquire the information needed to set and enforce product standards. Moreover, they should see the benefits reflected in reducing costs through setting standards. If the likelihood of any joint ventures is remote, then the government can acquire information needed to set standards by subsidizing technical education that can be applied to the problem of product standards. This policy will be discussed in more detail below.

4.4.5 Patent Policy and Education

Perhaps of utmost importance to the economic growth of a developing country is the technical progress and the innovations made by its industries. In the case of the building materials industry, the government can play an important role in this area through patent policy and the support of engineering/science education. Patents are useful in encouraging technical innovations that may result from a firm's rersearch and development. By enabling a firm to extract the full financial returns from its research and development, patents provide a strong incentive for firms to undertake such activity. The optimal industrial structure for R and D is likely to be provided by a marketing competitive building materials industry. To be sure, patents may confer substantial private returns in the short-run, however they will confer widespread benefits to society in the long-run by increasing the economy's level of technological development.

In some instances, the government may find it desirable to subsidize technical education and research related to building materials production. For example, as indicated above, such research may be useful in developing information from which one could set product quality standards. Further, subsidies and research grants to universities would help educate the potential pool of workers who could use this education to aid the technological advancement of the building materials industry. In short, encouraging technical innovations through long-term patents and subsidizing technical education and research in building materials production will enable a developing country to obtain the important benefits from technological change as well as maintain a workably competitive building materials industry.

4.5 Summary and Conclusion

This section has been concerned with the appropriate economic policy toward the building materials industry in developing countries. We first described a procedure to determine whether a developing country should have a building materials industry and whether this industry should be developed publicly or privately. To the extent that it is in the developing country's interest to have a building materials industry, we argued that the greatest benefits would be derived from this industry if it were organized in a workably competitive manner. These benefits include benefits from price competition and benefits from non-price competition such as increased innovative activity and higher product quality and variety.

Given this background, we recommended several industrial policies which the government should pursue to enhance to domestic development of the building materials industry. These policies include tariffs and taxes, industrial standards, patents and education subsidies. Taken collectively, we feel these policies will be very effective in maximizing a workably competitive building materials industry's contribution to a developing country's economic growth.

5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This paper has analyzed the significance of the building materials industry to a developing country's economic growth and social development. This sector has been identified as playing a major role, both directly and indirectly, through forward and backward linkages, in increasing employment, capital formation, and aggregate investment in a developing economy. Further, since building materials (e.g., cement, steel, pipes) are tradable goods, they contribute significantly to a developing country's foreign exchange, either by import substitution or exports. Thus, improvements in the performance of this industry have the potential to contribute significantly to the developing country's economic welfare.

The socio-economic impact of this sector is so significant that its regulation and stimulation is, and should be, an important element of national policy. This is especially true in view of the current economic crisis facing many developing countries. Large amounts of domestic capital are being used to finance foreign debts, leaving fewer resources for domestic investment. The trade balance for imports of building materials is generally unfavorable with an approximate deficit of $3.5 billion for some materials. Reducing imports of building materials by stimulating the local production of building materials offers a partial solution as well as a number of other advantages.

5.1 Constraints on the Supply of Building Materials

While the need for a viable building materials sector in developing countries is apparent, many constraints retard the emergence and growth of this sector.

First, the high capital costs of initiating and maintaining

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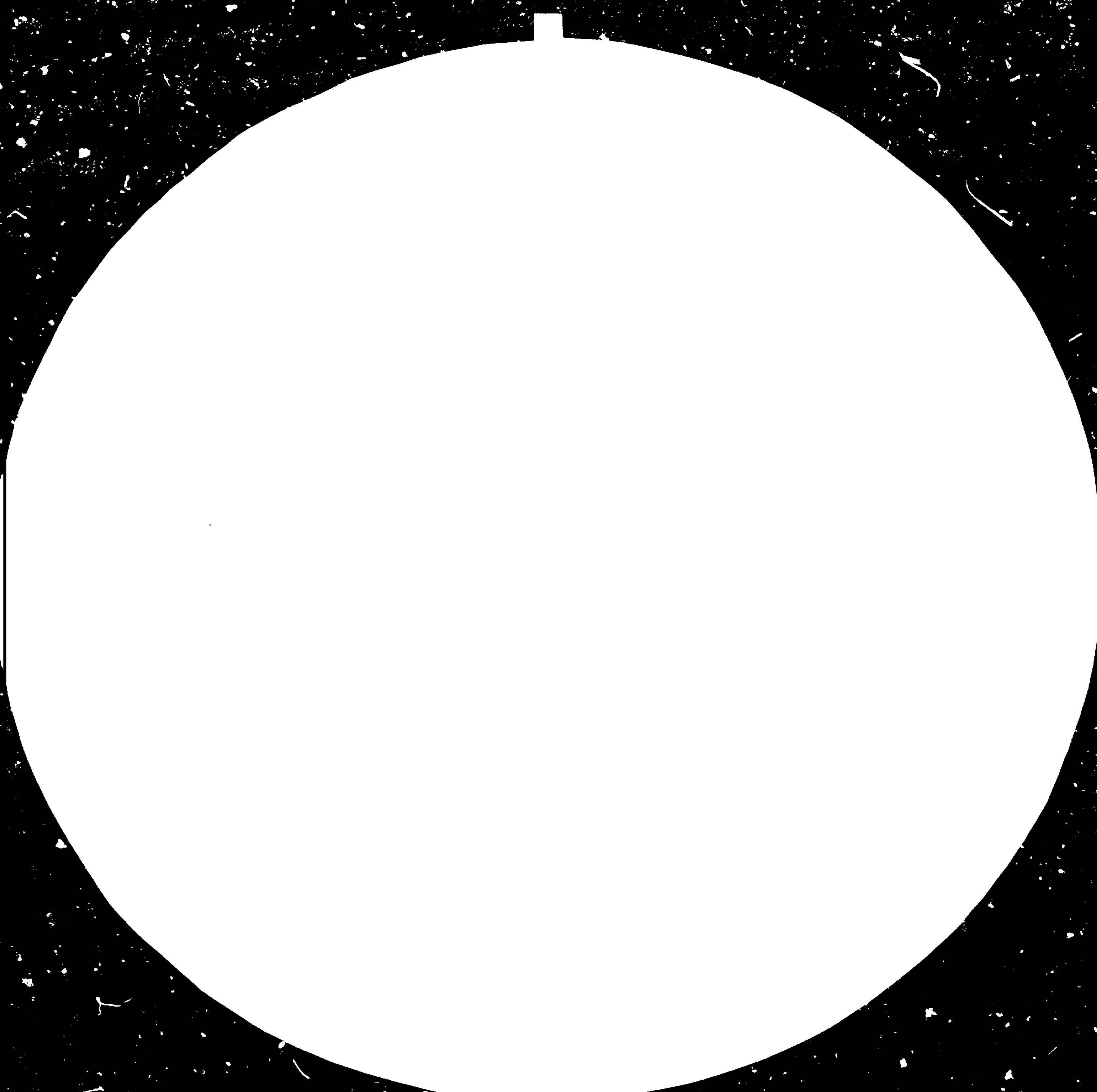

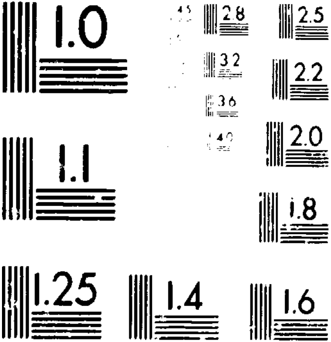

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(ANSI and ISO TEST CHART No. 2)

industrial operations is a factor. For steel the price is exorbitant and rapidly escalating. Although the cement industry rquires less capital than steel, it is still high in absolute terms when the production units involved are large. The recent difficulty of developing countries is raising international financing and attracting foreign capital has further exacerbated this capital crisis.

Second, inflexible standards and codes have constrained the growth of building materials industries in developing countries. Often governments establish national regulations which take little account of varying local conditions and resources. Such regulations inhibit technological adaptation.

Third, the relative absence of adequate tariff barriers to protect nascent, small-scale industry has created problems. Incentives alone are often insufficient to induce investment in a competitive world market. Import tariffs, quotas or other protective measures must be judiciously employed to provide a shield behind which new and expanding small firms can grow.

Fourth, the low value/weight ratio of many building material industries renders transport costs a more serious constraint on building materials than on virtually any other industry. Where transportation is difficult, transport costs can be higher than the production costs of certain goods. The constraint of transport costs varies inversely with the size of the consumer market for building materials. Were there a large enough market to sustain an economy of production scale within a reasonable distance from the manufacturing site, the constraint imposed by transport costs would be eliminated. A market sufficiently limited by the absolute size of the population, its density, or its purchasing power constitutes a serious constraint on the viability of many building materials industries.

Fifth, the energy consumed for the manufacture, transport, and use of building materials is a limiting factor of primary importance. Building materials usually consume considerable energy and often the type of energy which requires conversion. Those developing countries which import a significant percentage of their energy requirements will continue to suffer a serious constraint on the ability of the building materials industry to satisfy demand locally.

5.2 Recommendations for Action

Given its role in a developing country's economic and social development and in view of the constraints which inhibit its growth, the following actions could be taken by governments to enhance the development of a viable building materials industry:

(1) Planning. The building materials industry could profit from a comprehensive system of national industrial and financial planning. This course would include government creation or promotion of a national planning body and capital funding institutions. The potential for new financial instruments and other mechanisms to make capital available to public and private sector industry should particularly be explored. The principal benificiary of government planning should be small-scale plants and industries which are often more efficient and technologically flexible than large-scale industry.

(2) Manpower Training. New ideas for labor training should be initiated. In virtually all developing countries, there exist shortages of native planning, design and managerial talent. Professional labor and manpower development will require long-term educational efforts. Developing countries would be prudent to offer incentives to professional expatriates, and initiate lengthy training for future cadres of indigenous professionals.

(3) Developing Complementary Building Materials Industries. Given the difficulties of all developing countries, but especially the smallest and poorest, to establish building materials industries in all lines necessary to service even one major industry, a sensible strategy is one which encourages the development of complementary building materials plants on a sub-regional level. That is, neighboring countries undertake distinct building materials industries on a non-competitive basis which assures a complementary growth of industries consistent with the natural resources and endowments of each nation.

(4) Regional Research and Development Centers. To facilitate the growth of indigenous building materials industries, regional research and development centers are recommended. The introduction of husk and bamboo in several Asian countries as building materials, for example, depends fundamentally on research, experimental programs, and promotional efforts, all of which could be conducted in these centers. Similar testing could be pursued for labor-intensive construction, which is unlikely to be developed in the industrialized countries where capital-intensive methods are more efficently employed.

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