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WORKING GROUP No. 5

**APPROPRIATE TECHNOLOGY
FOR THE PRODUCTION OF CEMENT
AND BUILDING MATERIALS**

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**APPROPRIATE TECHNOLOGY IN THE CONSTRUCTION AND
BUILDING MATERIALS INDUSTRY**

Background Paper

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APPROPRIATE TECHNOLOGY IN THE CONSTRUCTION AND
BUILDING MATERIALS INDUSTRY

by

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SUMMARY

In recent years the construction and building materials industry in less developed countries has become more and more important. Hence it should be awarded second priority after the food and agro industries.

In construction there are several subsectors: international modern, domestic modern and traditional and small scale. Appropriate technologies are different for these subsectors. For the modern subsector technologies used in developed countries can be appropriate, however, in many cases production on a smaller scale and a lower degree of mechanisation is justified. In the building materials industry too production often is to be organized on a smaller scale (cement, lime, gypsum, etc.). It is important to develop the manufacture and use of local materials (stone etc.) and of industrial and agricultural wastes. Industrialization on various levels leads to an increased effectiveness of the construction and building materials industry, this being a prerequisite to increased outputs in new housing, new industrial complexes and the construction of better national and urban infrastructures (transport systems, etc.).

Governments should devote particular attention to the development of the construction and building materials industry, including the choice of appropriate technology, in order to promote economic development and the welfare of the population.

INTRODUCTION

United Nations bodies and specialized agencies such as UNIDO have been engaged long since in work on problems of industrialization and of appropriate technologies in developing countries. Without enumerating all relevant actions attention should be called to the International Symposium on Industrial Development, held in Athens, November-December 1967. Based on papers submitted to and deliberations at this Symposium, UNIDO has published in 1969 21 monographs on industrialization in developing countries. The subject of monograph No. 2 has been the Construction Industry, that of No. 3 the Building Materials Industry.

Taking into consideration that the Athens symposium and the publication of the monographs had been preceded by thorough preparations and that the monographs contain ample information on facts and trends up to 1967-1969, it seems appropriate to rely on them as basic documents and to cite certain data and statements from these two monographs.

These monographs were published just about a decade ago. Needless to emphasize that during the past ten years many changes have occurred. Many of the statements of the Athens monographs are still valid but many new development trends have emerged. Apart from certain common characteristics, the differences which have always existed between developing countries have become more and more pronounced.

Another basic material for this paper has been the Lima Declaration and Plan of Action adopted by the Second General Conference of UNIDO in March 1975, setting as one of its major targets to increase the share of developing countries in the total world industrial production to 25 per cent by the year 2000. This will not be possible without a substantial increase of the output of the construction industry and so the Lima Declaration also contributed to focussing attention in developing countries to the construction and the building materials industry.

An important means to raise the effectiveness of a productive sector of the economy is the use of appropriate technologies. The objective of this paper is to highlight the problem of appropriate technologies in the construction and the building materials industry.

The material is divided into three chapters:

The first chapter describes the main features of the construction and the building materials industry and summarizes the important role played by this sector in the national economy.

The second chapter deals with the trends of economic and technical development in the construction and building materials industry and discusses the appropriate technologies for different processes.

The third chapter is devoted to government policy and international actions promoting the use of appropriate technologies in the construction and building materials industry and the industrialization of construction.

Chapter I

THE CONSTRUCTION AND THE BUILDING MATERIALS INDUSTRY

I. 1. Traditional features

- I. 1.1 Construction and the production of building materials have always had certain specific features characteristic of this type of economic activity.
- I. 1.2 In the mining and manufacturing industries production is permanently located and the product has to be transported to the place of consumption. In construction, production takes place at the place of consumption: the finished product is immobile.
- I. 1.3 The product has a "one-off" character, it is not standardized, on the contrary, it has to be designed and carried out in each case according to particular requirements and circumstances.
- I. 1.4 Buildings have subsoil foundations and are affected by natural forces (wind, rain, sunshine, ground water, seismic forces, etc.). Construction techniques and architectural solutions depend also on the raw materials available and on historic development and habits. The fact that these factors are different at different locations also hampers the standardization of buildings as products of construction activity.
- I. 1.5 For centuries or even thousands of years procuring building materials meant extracting materials out of nature: stone, timber, clay, and perhaps one stage of transformation of these raw materials: the burning of bricks, lime, gypsum, sawing of timber etc. In many cases the cost/volume ratio was low, the building materials (stone, bricks etc.) were bulky and heavy. Such materials could not be transported to great distances owing to the high transport costs. Foreign trade in building materials was scarce and it was the designers of buildings, master builders and skilled craftsmen that were "imported" from one country to another to realize "prestige" buildings like churches and palaces - rather than the materials of these buildings.

In developing countries the production of building materials was insufficient. In developed countries, however, it gradually reached a very high level, so that in the recent past foreign trade started in building materials, too, exports being directed from developed to developing countries.

Statistics for 1960 show that Africa had to import 100 per cent of glass consumption; 60 per cent of paints and varnishes, 50 per cent of bricks, tiles and ceramics, 33 per cent of cement, 33 per cent of sawnwood and wood products, and a total of 58 per cent of the above building materials.

A similar picture could be observed in other developing regions.

This situation has been due to the high degree of concentration of production of building materials in the developed countries. In 1966/1967 Europe, North America and the Soviet Union manufactured 72 per cent of the world's cement production. As regards wood products their share was 83 per cent of sawn softwood, 79 per cent of plywood, 85 per cent of fibreboard and 92 per cent of particle board.

- I. 1.6 Buildings are expensive products with long production and life (use) cycles.
- I. 1.7 Characteristics inherent in construction led to the lack of central organisation and concentration and traditional medieval forms of organization have long survived. There were many small construction enterprises working only for a limited area and with a small annual turnover.
- I. 1.8 Construction processes are very labour consuming and besides skilled craftsmen many unskilled workers are required.
- I. 1.9 In construction the capital outlay for machines and equipment is lower than in manufacturing industries and management techniques have hardly been affected by the industrial revolution.
- I. 1.10 The design of the products (buildings) is not (as in the manufacturing industries) a prerogative of the producer, on the contrary, design is usually carried out by designers (architects, civil engineers and others) independent of construction firms.

I. 2. Some new features

- I. 2.1 In developing countries the traditional small scale construction sector was unable to satisfy all needs, which brought about the appearance of new national and international firms active on a larger scale in the market. National firms may adopt conventional or modern production techniques; international firms usually introduce modern techniques. A gradual, often very slow, concentration of firms is taking place even in developed countries. A certain degree of concentration is a prerequisite for a sufficient degree of capital concentration enabling firms to make investments necessary for up-to-date production techniques (purchase of powerful building machines etc.).
- I. 2.2 Value added by construction represents 2 to 10 per cent of the GDP; for most developing countries it represents between 3 and 5 per cent and for most developed countries between 5 and 9 per cent (Athens monograph No. 2).

In the past decade the volume of construction activity increased considerably in several developing countries. E.g. in Nigeria the sectoral breakdown of production of GDP, at prices of 1974/1975 changed in the following way (percentage figures):

	1970/1971	1974/1975	1977/1978	1979/1980
	%			
Manufacturing industries	5,0	4,7	5,7	6,9
Construction	3,5	5,7	7,3	9,0
Other (agriculture, mining etc.)	91,5	89,6	87,0	84,1
Total:	100,0	100,0	100,0	100,0

(Source: Third National Development Plan, 1975-1980, Nigeria)

The construction industry in Indonesia has grown during the period 1969-1973 at an annual rate of 21,1%, compared with a GDP average annual growth rate of 8,7% during the same period.

However, in a number of developing countries construction still produces a too little proportion of GDP.

- I. 2.3 The range of building materials has been widened very much. Traditionally, the building materials industry comprised only the extracting and production of stone, clay, sand, gravel, cement, lime, gypsum, glass, bricks, and tile. At a later stage, the production of building components (prefabricated concrete and reinforced concrete components, doors, windows, equipment of buildings etc.) has been introduced. The manufacturing of products from materials mainly applied by industries other than construction (steel, aluminium, plastics etc.) is usually not considered to be an activity of the building materials industry.

In the past ten years several developing countries have successfully increased their production of cement and prefabricated concrete components. Many other materials have still to be imported.

- I. 2.4 The absolute and relative economic situation of individual countries or of certain groups of countries has changed to the better or worse slightly or drastically during the past ten years. The increased income of oil producing countries has created a great demand for construction in these countries. At the same time most developed countries experienced a slump of domestic demand for construction. For many big firms in UK, France, FRG, USA, Japan, it has become a matter of survival to expand their activities to countries with a building boom (Gaylor R. F.: Building in Saudi Arabia; Building Technology and Management, 6. 1978. p. 2-8.). Some developing countries earlier not active in the export field (Korea South, India, Yugoslavia) have made successful efforts to win construction contracts abroad e. g. in Arab countries.

All this resulted in increased foreign trade in the field of the design and construction of buildings, civil engineering works, and building materials.

Several factors contributed to a strengthening of the domestic construction industry even in those countries which import construction capacities. Partnership agreements have also contributed to this development.

I. 2. 5 Earlier, the construction and the building materials industry were not considered an economic sector to be developed on a high priority basis. For some years past this situation has been reversed and it is now generally accepted that their development is of primordial importance for developing countries. In the next paragraphs some reasons for this new position are listed.

I. 3. The role and importance of the construction and the building materials industry

I. 3. 1 Let us take two imaginary countries A and B, the first a developed, the second a developing one and look at the following hypothetical (but very realistic) figures:

	Country		Ratio
	"A"	"B"	A/B
GDP, \$/capita	5000	250	20 : 1
Value added by construction, %	10	4	
Value added by construction, \$/capita	500	10	50 : 1

Obviously in country A there exists already an infrastructure, a built environment, a high level stock of buildings; in country B this is yet to be created. Therefore the need for new construction is higher in country B than in country A. However, the actual volume of construction is much lower and the ratio of volumes of construction is higher than that of GDPs. This means that the gap between the two countries is widening instead of being reduced. It is true that some types of buildings (new housing) are cheaper in developing than in developed countries, however, the costs of major civil engineering works and industrial buildings are on the same level. Therefore to close the gap between the volumes of the stocks of buildings developing countries must substantially increase the volume of construction activity.

This means that construction (including in this case the building materials industry) should be a sector of dynamic development which means that its growth rate should exceed that of the whole economy (e.g. the growth of GDP). Sectors having dynamic growth rates usually need government attention; this especially applies to construction for reasons to be explained in the following paragraphs.

I. 3.2 New construction is a requirement for most development projects. Construction itself constitutes approximately half of all fixed capital investments. Construction of new manufacturing facilities is needed to implement the development of industrial production, new housing is needed to solve the housing shortage, construction creates a better built environment.

The shortage in building materials and the lack of an adequate transport system (roads, railway lines, harbours, airports, etc.) have often been an obstacle to the expansion of construction. Therefore the construction of roads, bridges, railway lines, harbours and facilities for the building materials industry constitute an important step toward increasing the output of construction itself.

A well-balanced increase of the output of construction contributes to the satisfaction of the population, because

- it improves the housing situation;
- creates new jobs in the new factories and thereby other new buildings;
- reduces unemployment.

I. 3.3 It is a well-known fact that the population growth rate is higher in developing countries than in others. While the annual world population growth rate is about 1,7 per cent, in the majority of developing countries this rate amounts to 2,5-3,3 per cent. The population growth rate of urban settlements is even higher. So e.g. in some Arab towns in the Middle East the average annual population growth rates amounted to:

Kuwait-City	1961-1965	18,0%
Riyadh	1963-1968	10,0%
Bagdad	1957-1965	8,3%
Basra	1957-1965	8,3%
Amman	1966-1970	7,8%
Mecca	1962-1971	7,5%

More recent statistics show slightly reduced growth rates in some countries, however, in most developing countries those high population growth rates still exist and are - together with the desire for quick economic growth - among the factors that make a quick development (and industrialization) of the construction industry an absolute requirement.

I. 3.4 Construction is a labour-intensive activity. As such, assuming a given fixed capital outlay it employs comparatively more workers than other economic sectors. The construction industry also has a "mission" to fulfil, owing to the fact that many workers come from rural-agricultural areas, for whom construction is the first organized work-place. Many of these workers leave construction after a certain period to become employed by the manufacturing industry or by other users of buildings produced by the construction industry. Thus, construction has in a sense a training-educational role in the overall industrialization process of a country.

- I. 3.5 Construction is an aggregation of many crafts. Many different types of craftsmen and enterprises have shares in construction (mason, carpenter, plumber, painter, etc.). Construction is a purchaser of the products of many other industries (steel, aluminium, plastics, etc.). Therefore the growth of the construction industry makes itself extensively and positively felt whereas a slump in construction has far-reaching negative consequences.
- I. 3.6 The public sector's demand for construction is high and government interference has become necessary over a wide range. Public buildings, schools, hospitals, roads, airports are directly financed and contracted by central or regional/local public authorities. In matters of new housing public authorities usually also have much say. Government policy in increasing or reducing expenditures for construction works contributes greatly to the economic climate in the construction (and the building materials) industry.
- I. 3.7 Construction is at the same time a concentrated and a small scale activity. Central government or large, privately owned industrial projects are realized by the concentrated efforts of the construction industry; local development projects are realized by small scale construction activities. As a consequence, the construction industry equally takes share of major central development projects and of implementing local development aspirations, including self-help in the non-monetary sector.

Chapter II

ECONOMIC DEVELOPMENT, INDUSTRIALIZATION AND APPROPRIATE TECHNOLOGIES IN THE CONSTRUCTION AND THE BUILDING MATERIALS INDUSTRY

II. 1. Economic and structural changes

II. 1.1 According to the situation of the construction and the building materials industry developing countries belong to the following categories:

- Countries with high government income;
- Newly industrializing countries with construction export aspirations;
- Other developing countries with different levels of GDP.

Most OPEC countries belong to the first category. In these countries construction outlays have been increased very rapidly and a flattening of the growth curve (on a high level of construction activity) is taking actually place. The extremely quick growth has been achieved by inviting foreign firms to carry out major works and eventually by increasing the domestic labour supply by employing foreign workers. To protect and promote the domestic construction industry different measures have been taken and in some countries a partnership of foreign and domestic firms is required or preferred.

The domestic construction industries in some newly industrializing countries (South Korea etc.) have reached a high degree of development within a short period and now these countries try to obtain construction contracts abroad.

In the first two categories (and even more so in category three) domestic architectural and engineering design lacks sufficient capacity and experience to be able to solve all design tasks. Design and consulting offices of developed countries are invited to fill the gaps.

Category three includes countries with very different levels of GDP: on the one (lower) end perhaps with the Sahel countries and on the other (higher) end with some Latin American countries (e. g. Brazil). In countries with a low GDP/capita, construction and the building materials industry still face the problems that were common for most developing countries a decade ago. In countries where GDP/capita has grown quickly over the past ten years, construction and the building materials industry too have quite remarkably developed.

II. 1.2 In the past decade in most developing countries government departments (ministries) and agencies have been established to supervise:

- industry (including the building materials industry and perhaps the construction industry too) and industrial development;
- housing and urban development;
- the protection of the environment.

Governments have made considerable efforts to educate and train the actual and future staff of these public bodies and to introduce modern methods of planning, programming and supervision in these fields.

II. 1.3 It has often been stated that inadequate banking and financing facilities hamper the flow of funds (savings) into construction and slow down the growth of fixed capital formation, hence the growth of the construction industry. Again it can be stated that during the past ten years in certain countries a spectacular progress has been achieved in this field too; in others the situation has remained still unsatisfactory.

II. 1.4 Foreign trade also has new features besides traditional ones. In many developing countries the production of cement and other building materials has substantially increased, however, the foreign trade of building materials is still a major source of supply. Companies in developed countries have often created subsidiaries or mixed companies for construction projects in developing countries.

The introduction of "building systems" in developed countries led to a new form of foreign trade. In system building the whole structure is lightweight and therefore components of complex integrated buildings can be shipped from one country to another.

II. 2. The process of industrialization and the use of appropriate technology

II. 2.1 In the preceding chapters it has been shown that to achieve the objectives formulated in the Lima Declaration it is absolutely necessary to substantially increase the output of the construction industry both in its traditional and in its modern subsector. To achieve this the construction and the building materials industry have to be industrialized and appropriate technologies have to be introduced and used.

The process of industrialization in progress in developed countries cannot simply be copied in developing countries though for the modern (both domestic and international) subsector it contains much to serve as a basis for decision making in choosing appropriate technologies.

In the traditional domestic subsector appropriate technology has a different meaning. Here the decisive factors are small scale, small capital investment, the maximum use of domestic (local) resources. Technical solutions applied in developed countries often lead to inappropriate technologies for the small scale domestic industry and therefore other solutions have to be invented or existing ones adapted to local circumstances.

The tasks of the construction industry are different enough to call for very different technologies: So e. g.

- major industrial development projects call for modern industrialized methods;
- big urban agglomerations (there are many of them in developing regions: Ciudad de Mexico, Buenos Aires, Sao Paulo, Cairo, Seoul, Bombay, Calcutta, to mention only a few) call partly for industrialized new housing, commercial and other buildings, partly for low cost housing;
- small settlements and small industrial development projects call for simple but still improved construction technologies making use of local raw materials and skills.

Hence there is not just one appropriate technology for one product, on the contrary, several technologies can be considered to be the most appropriate at the same time, depending on the scale of operations and other factors.

The selection of appropriate technologies depends on factors changing with time. The relation between the prices of various materials, of labour, machines and other input factors changes and this changes the cost (price) relations of different technologies.

In the following chapters an overall description of the industrialization of the construction and the building materials industry is given; however, it should always be remembered that appropriate technology is seldom identical with the most sophisticated one, on the contrary, in developing countries this may rather be an exception than a common practice.

II. 2.2 According to the experience of developed countries the main fields of industrialization in construction are as follows:

- Prefabrication;
- Mechanization;
- Introduction of research into the building process;
- Changing pattern in the production and use of building materials and components;
- New design methods and standardization;
- Changes in the manpower employed;
- Up-to-date management methods.

This also applies to developing countries, apart from certain important differences.

The main objectives of the industrialization process are:

- to increase the productivity of labour;
- to increase the output of the construction industry;

- to make good use of local resources, including local raw materials, agricultural and industrial wastes;
- to reduce the weight of the building structures and as a complementary objective to decrease the volume of materials to be transported as compared to a certain volume of building;
- to transfer as many processes as possible from the changing building sites to off-site factories;
- to close the gap between construction and manufacturing industry as far as the degree of industrialization is concerned.

In developed countries much effort is concentrated on energy conservation, a problem of less importance as yet in many developing countries.

II. 2.3 It has often been stated that prefabrication has always been part of construction. The Japanese tatamis, the stones pre-cut to standardized dimensions are just two forms of prefabrication. However, prefabrication in our age has a new, earlier unknown feature: it is based on modern mechanized processes.

Since the first buildings were erected, buildings have been either heavy-weight or lightweight. To the first category belong stone, clay, bricks, concrete, to the second timber and fabrics. Mechanized manufacturing methods have been introduced in both categories and the prefabrication of both heavy or lightweight components constitutes part of the industrialization process.

In Europe prefabrication has been mainly realized with heavy (concrete or reinforced concrete) components. In North America, Japan and North Europe the main development trend has been to prefabricate timber houses. Though both forms of prefabrication yield similar positive economic results, the term prefabrication usually refers to the manufacturing of concrete (reinforced concrete) components. One of the reasons for this ambiguity is that the prefabrication of timber components meant just a gradual modernization of the existing woodworking industry, whereas for the prefabrication of concrete components a completely new type of manufacturing industry had to be created.

There exists a wide variety of prefabricated (reinforced) concrete products:

- masonry blocks;
- beams, lintels;
- paving stones, curbs;
- flooring tiles;
- fences;
- railway sleepers, street lampposts;
- large wall and floor panels;
- stairs and staircase components;
- components for frames;
- retaining walls;
- pipes;
- bridge components etc.

In many developing countries factories have been established for these products. A further expansion of prefabrication of (reinforced) concrete components can be expected. This too requires higher cement production. Prestressed concrete products also find growing application.

- II. 2.4 One of the controversial fields of prefabrication is the production and use of large reinforced concrete panels. In Europe (both East and West) this has been a revolutionary new technique introduced in housing after World War II. The highest outputs have been reached in the USSR and other East-European countries where large panel construction became the basic means to reduce or eliminate severe housing shortages. The main advantage of this technique has been the high productivity of labour: practically the same number of workers producing twice as many flats.

In the USSR approximately one million flats per year are built of large panels; Czechoslovakia, Hungary, GDR etc. each has an annual production of several ten thousands flats with this technique.

In several Western European countries such factories have also been built but the share of large panel buildings in new housing has never reached the level attained in East Europe. In West European countries this share has not exceeded 5 to 10 per cent so far; in East European countries it amounts to 50 to 70 per cent.

Large panel factories generally produce components for 500 to 4000 flats per year; most factories producing components annually for 1000 to 2000 flats.

Based on the European experience, mainly French (Camus, Pascal etc.), Danish (Jespersen, Larsen-Nielsen) and Soviet firms have established factories in developing countries (e. g. in Algeria, Saudi Arabia, Iraq, Iran etc.).

Large panel construction in developing countries has acquired some special characteristics. Due to hot climate external walls usually do not contain thermal insulation but consist merely of a single layer of reinforced concrete. Factory buildings do not require heating (as they do in Europe) and can therefore be of very simple structure.

Large panel construction leads to positive changes in developing countries, too, regarding the productivity of labour and new housing output. Also in developing countries special care has to be taken to avoid the monotonous, unimaginative appearance of buildings and residential areas; the successful realization of many projects proves this to be attainable.

Large panel construction techniques seem to provide a useful method of new housing in developing countries too, mainly for a high density of urban population with a severe housing shortage. On the other hand, it cannot be considered as the only way of industrialization, many other ways also giving positive economic results.

Prefabrication and the serial industrial production of building components - other than those of reinforced concrete - form part of the overall industrialization process. Some of the components that can and should be industrially produced are: doors, windows, partitions, etc.

The introduction of prefabrication, mainly that of large precast concrete panels may raise certain conflicts. The designers of buildings consider large panels as a strait-jacket imposing restrictions on the design process. Designers - at least during a transition period - would prefer techniques facilitating an individual approach for each building. The manufacturers of components want large series of standardized components and, as a consequence, the wishes of the designer and those of the manufacturers of components are contradictory. Through mutual understanding a satisfactory compromise can be reached (see: UN ECE Paris Seminar 1967: Industrially Made Building Components; ST/ECE/HOU/36).

Governments should provide active support for the introduction of industrially made building components, thereby eliminating conflicts between the participants of the construction process and speeding up the development of prefabrication.

Appropriate technologies for small scale production, using local materials have been introduced in many countries. Some examples are given as follows (examples from UNIDO circulars and reports):

- small scale cement and lime manufacture (realized in several countries);
- medium-sized sheet glass manufacture (Nigeria);
- modernized natural building stone manufacture (Haiti).

Asbestos cement products, mainly pipes and corrugated roofing components, also are of paramount importance for many developing countries. Several developing countries have already started to manufacture asbestos cement products though often with low outputs using not sufficiently up-to-date machinery. Due to the good technical properties of asbestos cement (impact resistance/resistance against atmospheric and bio-corrosion) the development of this industry should be supported.

II. 2.5 Mechanization is, in general, a tool of and for industrialization, for many construction processes it has a central significance. These are processes which must be carried out on the building site, e. g. the construction of roads, railway lines, finishing processes within buildings: painting, varnishing, flooring etc. Even in such cases partial prefabrication is aimed at: e. g. the painting of doors and windows in the workshop etc. Building machines are used for:

- earth-moving, construction of roads, railways, bridges, dams, foundations;
- mixing, compacting and curing of concrete;
- horizontal and vertical transport of materials and components;
- hand operated processes (painting, etc.);
- manufacturing of building components.

A UN study quotes the following data for the replacement of human labour by machines (Trends in the Industrialization of Building, UN, New York, 1970, ST/SOA/102, p. 58.):

Type of machine	Number of labourers replaced
Excavator	20-160
Motor-scraper	50-120
Dozer	70-90
Motor-grader	30-50
Earth compacting machine	20-50
Building crane	30-40
Dump car	20-30
Mixer	5-20
Conveyor	3-5

The manufacture of building machines requires certain overall experience in machine building, existing production facilities for crucial parts (electric and diesel engines, ball bearings, pneumatic parts, wire cables, steel castings etc.) and a market of sufficient size for such machines. In developing countries one or more of these requirements may not be satisfied and therefore most developing countries lack factories for the manufacture of building machines. In the near future such factories are not likely to be established but in exceptional cases, for only a smaller range of building machines. Some simple building machines (hoists, conveyor belts etc.) on the other hand can be and are produced in many of the developing countries.

In India e. g. facilities have been created for the production of big construction machines, like (UNIDO information):

- road roller
- hot mix plant
- paver finisher
- stone crusher
- prestressed concrete equipment
- concrete vibrator
- air compressor

For the small scale domestic industry small machines are economical and appropriate technologies can be implemented with simple low-cost equipment. In this category simple scaffolds, hoists, mixers, presses, etc. can be mentioned.

Even if building machines are imported it is essential to ensure their continuous operation. This is often overlooked and makes machines idle because of the lack of spare parts or adequate maintenance. Whenever building machines are procured from abroad, the storage of spare parts and facilities for maintenance and repair should be provided. In industrialized construction the number and variety of building machines becomes so high that even maintenance and repair shops are powerful strong organizations with a tool machinery like in a machine factory. When such maintenance and repair shops are built, promoters of industrialization are often tempted to convert these to real machine building factories which can then affect adversely the maintenance and repair of the building machinery: Without

attempting to dissuade any country from producing building machines the top priority of the good maintenance and repair of existing stock has to be emphasized.

In view of the major importance of mechanization and of the high cost of the machines, which if owned by one contractor may be idle for long periods due to lack of continuity of operations, the establishment of equipment and plant hire services should be promoted.

II. 2.6 A changing pattern in the production and use of building materials and components may constitute a major factor in the industrialization of construction. Some general trends of this changing pattern are:

- the overall cost of building materials and components expressed in percentages of the construction costs tends to grow as a consequence of moving on-site processes to off-site factories (prefabrication);
- the relative share of materials extracted directly from nature decreases, the share of materials and components that reach their final form of application after several production cycles increases;
- the share of traditional building materials (stone, bricks, etc.) related to the overall cost of materials tends to decrease, plastics being the characteristic winner in this change;
- of traditional materials the share of cement is growing, that of bricks is rather diminishing.

Monograph No. 3 of the Athens UNIDO symposium stated that until GDP in a country did not reach \$ 390 per capita (1965 data) or cement consumption 148 kgs per capita, cement consumption grew quicker than the GDP. Beyond these values the growth rate of cement consumption decreases. As most developing countries are below these limit values it is desirable that cement production should grow at a higher rate than does economy itself.

The production and use of bricks do not follow uniform trends. In most developed countries the production of bricks does not increase any more and often decreases; in developing countries an increase may still be desirable.

Construction uses but part of the steel output. The correlation between GDP and the steel consumption of construction is vague. Data seem to prove that the share of construction in steel consumption tends to be gradually lower because in developed countries an increasing part of the steel output is used for the manufacturing of durable consumer products.

No definite clues can be obtained from studying the use of timber in construction. However, it is clear that of timber-based products the share of various boards (particle board, wood-wool board, fibre board etc.) is growing.

In oil producing countries bituminous felts and asphalt are used for many purposes (flat roofs, roads etc.).

The manufacture and use of plastics has not gained ground yet in the construction industries of developing countries: obviously, there are great possibilities for expansion. Specific circumstances of developing countries (climate etc.) have to be considered seriously.

Economic development is manifested in buildings of more and more complex structures which on the other hand involves the widening of the range of building materials, components and equipment. In developed countries the number of different products used in building amounts to several ten thousands, nearly one hundred thousand. In this paper the principal types of products could but briefly be mentioned. It must be stated, however, that a growing complexity in the production and offer of building materials, components and equipment is in line with development.

However, it has to be emphasized again that the appropriate technologies are very often realized by means other than in developed countries. Developing countries should make use of their local materials, agricultural and industrial wastes. Some of the solutions mentioned in recent UNIDO publications are:

- production of cement stabilized and sun dried laterite building blocks (Ghana);
- prefabricated roofs in ferro-cement (Thailand);
- prefabricated building elements from kilned natural clays and silicates (Syria);
- flooring tiles from asbestos cement factory wastes (India);
- door and window frames from magnesium oxychloride cement and saw dust (India);
- particle boards from agrowastes, like paddy husk, husk ash, low grade wood, saw dust, groundnut husk, bagasse, cocoanut pith, seeds, grass (India);
- particle boards from paddy husks (Singapore);
- particle board from cassava stalks (U. K.);
- use of fly ash in bricks (India);
- lime sludge based masonry cement (India) etc.

These are but a few examples: many others could be quoted.

The technologies of developed countries cannot be considered appropriate in some cases because of the scale of production and it may be necessary to produce equipment of smaller production capacity and hence requiring smaller capital investment especially for developing countries. Such is the case e.g. for small scale cement and lime manufacture and for other building materials too.

The development trends in the production and use of building materials and components require new factories to produce these materials and components.

- II. 2.7 The development of prefabrication, mechanization, production and transport of building materials and components all widen the range of background activities of the construction industry.

To be able to transport the growing quantity of building materials and components to the building sites, transport too has to be improved. The development of building materials and components of a smaller weight alleviates to a certain degree the increasing tasks of the transport system.

The technical level and the degree of industrialization of construction depend greatly on this industrial background.

- II. 2.8 Prefabrication, mechanization and the use of up-to-date building materials and components are technical characteristics of industrialized construction. However, industrialization has a further characteristic feature, the use of up-to-date management and programming methods.

Flow-line methods have been introduced as an adaptation in construction of conveyor production. CPM (Critical Path Method) and similar network programming techniques are extremely well adaptable for use in the construction industry. The complexity of operations calls for an extensive use of computers, a commonplace in the management of large construction firms.

Therefore the introduction and extensive use of modern management and programming methods should be aimed at and encouraged.

- II. 2.9 For a very long period building has been an activity based on trial and error, practical success and failure contributing to man's knowledge about building.

In the last century, and especially in the past decades, construction relied more and more on scientific research, on mechanical and civil engineering know-how. Building research institutes have been founded first in developed and later in developing countries. These institutes become more and more active participants in the industrialization process. They do not have to concentrate exclusively on basic research, on the contrary, their main task in most countries is to follow the track of research and development in other countries and to adapt results to conditions of their own country. The reason for building research institutes being sponsored by governments, whereas research in the manufacturing industry may be left in the hands of industrial enterprises is that construction is a decentralized process scattered over large areas. Construction enterprises lack the sufficient means to maintain their own research bases. An exception is Japan, where construction enterprises actually maintain their own research institutes.

Developing countries often have natural resources (raw materials) that up to now have not been used for manufacturing building materials and components but which could be used for that purpose. Research (exploration of resources and quality control) is needed to make good use of such raw materials e. g. for the production of cement, lime, gypsum, aggregates, lightweight aggregates (pumice, perlite, vermiculite etc.), glass bricks, etc.

Climatic and other effects (e. g. thermites) prevailing in developing countries have to be studied to make an appropriate selection of materials and structural

components. There are many construction problems in developing countries (roofs, ventilation etc.) for which no ready-made solutions are available. Though many of these problems have already been studied to a satisfactorily high degree we are still witnessing mistakes repeatedly committed in such fields.

Industrialization and appropriate technologies can be realized in many ways and it is of extreme importance to screen the different solutions in order to be able to choose techniques appropriate for a particular country. Research institutes and information centres produce the knowledge needed to make correct decisions and take part in the implementation of these decisions.

Industrialization and the use of appropriate technologies of construction also means design that makes use of science and research. To achieve this, up-to-date technical regulations and standards based on performance criteria have to be worked out. Functional and users' requirements of buildings have to be defined. Conditions prevailing in developed countries being different from those in developing countries (climate, etc.) the requirements may also fundamentally deviate. Thus, the requirements have to be assessed for each particular country (or region).

- II. 2.10 Industrialization leads to changes in skills of construction industry employees. Unskilled labour is gradually replaced by machines. Various building machines require a growing number of operators.

Modern programming and management of construction activities can also be practiced only by people with new skills.

All these changes can be promoted by organization, education and training, in order to help those employed in the construction industry to acquire the knowledge and skill needed in the industrialization process.

Chapter III

GOVERNMENT POLICY AND INTERNATIONAL ACTIONS

III. 1. For some years past it has become obvious that the construction and the building materials industry play an extremely important role in achieving the desired objectives of developing countries. Hence in Kaduna in November 1977 the Conference of African Ministers of Industry awarded it second priority after the Food and Agro industries. It is proposed that such priority should be given to it by governments and international organizations alike.

III. 2. The fast growing tasks of the construction and the building materials industry call not only for a policy of how to select appropriate technologies but for a comprehensive policy for the overall development of these industries. Governmental and international actions related to appropriate technologies should be planned in a wider framework for this overall development of the construction and the building materials industry.

III. 3. The planning and programming of demand is an important government activity fundamental for a sane development of construction. Appropriate central and regional (local) authorities handle planning and programming problems on different levels. The central authorities' organization has to be of complex character because it has to comprise:

- governmental supervision of industry, the construction industry and of technical progress;
- regional and urban planning;
- housing;
- protection of the environment;

because all these affect to a certain degree the industrialization of construction. Governments should ensure a sufficiently stable demand for construction. If possible this stability is desirable not only for the construction industry as a whole but also for some of its branches. Stable demand is ensured (besides a stable overall economic climate) by long-term housing, industrial development and land policy. Government - sponsored road, railway, harbour, etc. construction also improves the stability of construction demand.

Governments should also find means to create good financing and legal conditions for the construction industry. This includes up-to-date and sufficiently simple building legislation (e.g. for building permits), contracting procedures, access to funds and foreign exchange.

III. 4. Governments should formulate (with the participation of the construction industry) a technical policy of the industrialization of construction especially related to the domestic industry. They should support research, development

and capital investments to promote this industrialization process including the use of appropriate technologies in the various subsectors.

- III. 5. Building is one of the economic sectors where the establishment of a state-owned national building research institute is justified. Depending on the circumstances prevailing in the country, governments should define the optimum size, staff, equipment and scope of work for such an institute. Quality control and standardization too should be to a certain extent government responsibilities.

Bilateral cooperation with research and development institutes in developed countries should be encouraged.

- III. 6. Governments should take measures to protect the domestic construction industry and domestic value added including the use of the country's resources for the production of building materials. This should not lead to overzealous protectionism shutting out foreign firms, driving up prices and as a consequence doing harm to the country's interests, but reasonable support should be given to the development of the domestic construction and building materials industry including the use of appropriate technologies.

- III. 7. The appropriate technologies to be applied in the construction and building materials industry of developing countries can be selected from advanced technologies in developed countries, however, certain differences have to be taken into consideration.

In the building materials industry it is often necessary to organize production on a smaller scale than in developed countries and equipment for such smaller plants have to be developed.

It is important to promote the exploration and use of local materials, as well the use of industrial and agro wastes.

Mechanization and prefabrication too should be supported, also adapted in scale and sophistication to the special circumstances of developing countries.

Governments should create a favourable climate for technology transfer from developed to developing countries. Technology transfer includes licensing, the purchase of know-hows and of modern production equipment, study tours and post-graduate courses abroad, invitation of selected experts, etc. Building Information Centres (Bauzentren) may offer useful contributions in this field.

- III. 8. Education and training are responsibilities partly undertaken by governments and partly by the industry. Education and training at all levels (workers, technicians, architects, civil engineers, site managers etc.) should be supported, paying always attention to the aspects of the industrialization process and the use of appropriate technologies (e. g. in university curricula, etc.).

- III. 9. International actions and cooperation should be supported by governments in all the above mentioned fields. International actions on bilateral and multilateral (governmental and non-governmental) basis should be brought forward

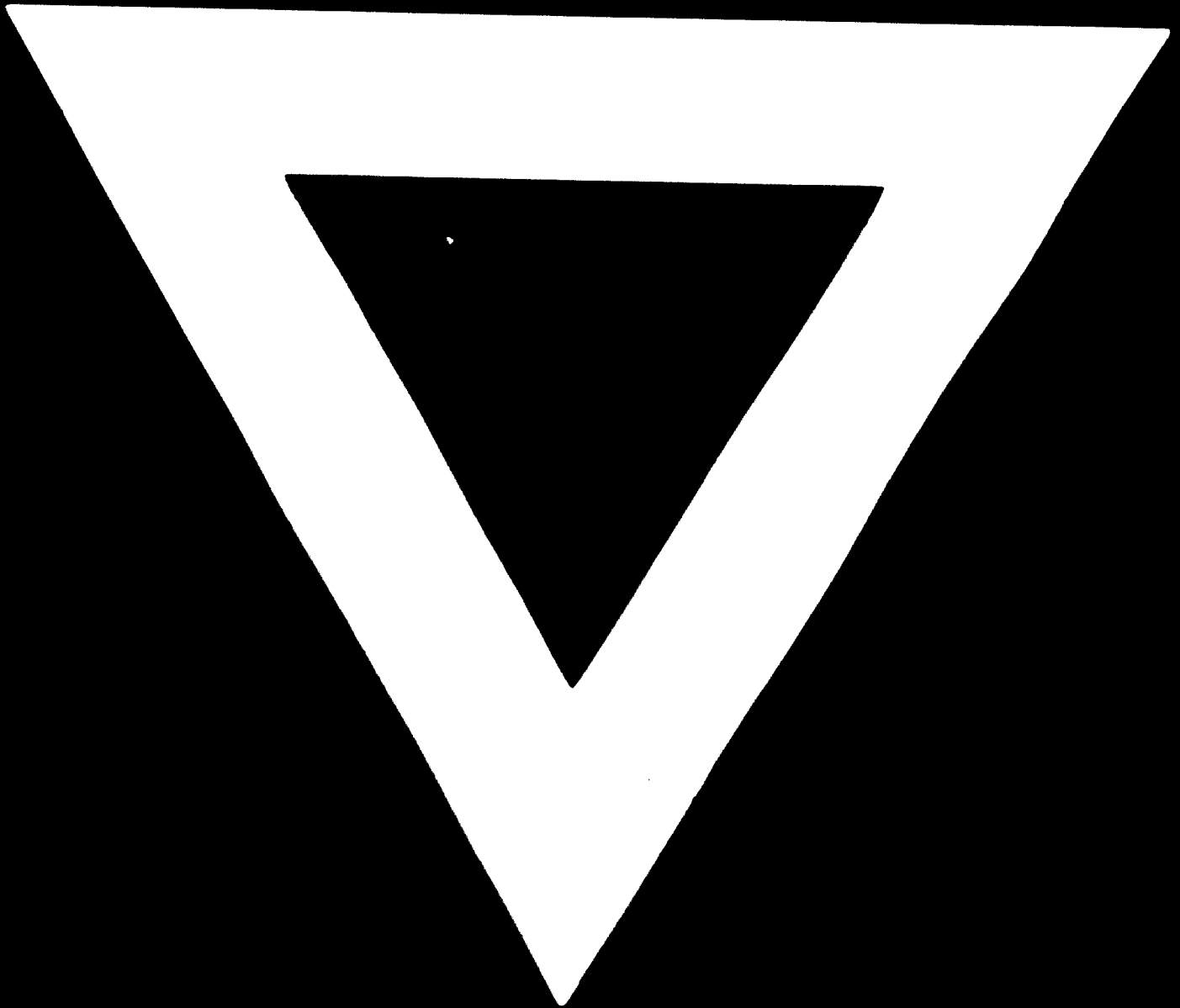
in all branches of the industry. Regarding the construction industry, such actions have failed to exert as yet a sufficiently direct impact. In most cases they have been project-oriented, aimed at new housing, new urban infrastructure (water supply etc.), new industrial complexes including in some cases new factories in the building materials industry (cement plants).

Therefore emphasis should in future be laid on the development, industrialization of the construction industry itself and the use of appropriate technologies. Measures described in the previous paragraphs (e. g. research, quality control, education, training, etc.) could be promoted by international actions too and such actions should be initiated and supported by governments.

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