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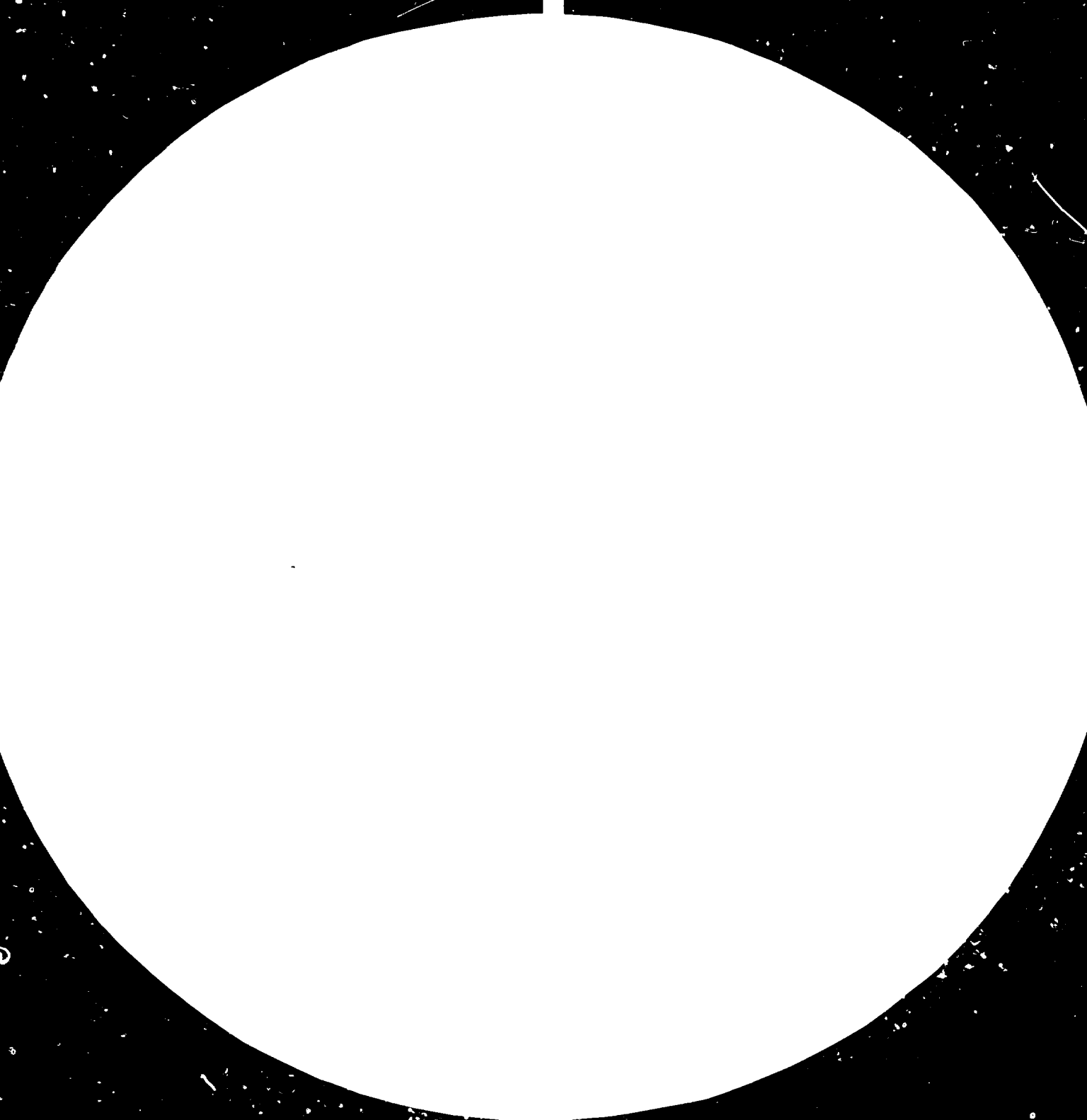
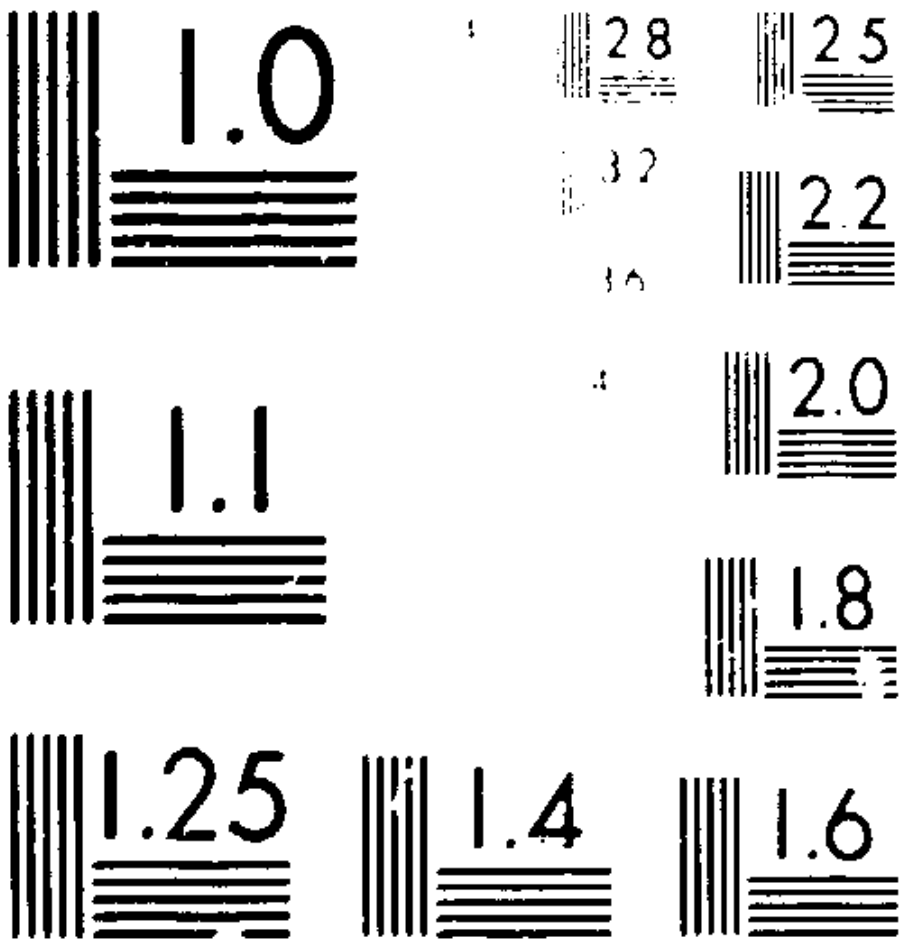
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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DEVELOPMENT OF CEMENT AND CONCRETE PRODUCTS INDUSTRY, LINKAGES AND ROLE IN THE OVERALL ECONOMY*

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INTRODUCTION

Cement and concrete products industry is a rapidly developing sub-sector of the construction and building materials industries. In order to see the situation and prospects of the cement and concrete products industry in developing countries, it is useful to have a broader look at the construction industry as a whole, its role in the national economy, the process of industrialization and to see what measures could be taken, both on the national and international level in order to assist its development.

A) FEATURES OF THE CONSTRUCTION AND BUILDING MATERIALS INDUSTRY

The traditional construction and building materials industry has the following features:

a) 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;

b) The product is not standardized. It has to be designed and produced in each case according to particular requirements and circumstances;

c) Buildings have subsoil foundations and are affected by natural forces (wind, rain, sunshine, ground water, seismic forces etc.). Construction techniques and architectural design also depend on the raw materials available and on historic development and habits. Since these factors differ at different locations, the standardization of buildings as products of construction activity is hampered;

d) For centuries or even thousands of years, procuring building materials has meant extracting materials from nature, e.g. stone, timber and clay, and perhaps one stage of transformation of these raw materials e.g. the burning of bricks, lime, gypsum, sawing of timber etc. In many cases the cost to volume ratio is low, and the building materials (stone, bricks etc.) are bulky and heavy. High transport costs prevent the transport of such materials over great distances;

e) Although the production of building materials has been insufficient in developing countries, it has gradually reached a very high level in developed countries. As a result, foreign trade in building materials started to grow in recent years, with developed countries exporting to developing countries.;

f) This situation has arisen from the high degree of concentration of production of building materials in developed countries. In 1966/67 Europe , the Soviet Union and the USA, accounted for 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;

g) Buildings are expensive products with long production and life (use) cycles;

h) Construction characteristics have resulted in a lack of central organization and concentration and traditional, medieval forms of organization have long survived. There are many small construction enterprises working for only a limited area and with a small annual turnover;

i) Construction processes are very labour-consuming, and many unskilled workers are required in addition to artisans;

j) 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;

k) 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.

Some of the features new to the construction and building materials industry in developing countries are as follows:

a) In developing countries, the traditional small-scale construction sector was unable to satisfy all needs. This led to the emergence 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 required to ensure a sufficient accumulation of capital to enable firms to make the necessary investments in up-to-date production techniques (purchase of powerful building machines etc.);

b) Value added by construction represents 2-10 per cent of the gross domestic product (GDP). For most developing countries it represents 3-5 per cent, and for most developed countries, 5-9 per cent;

c) The volume of construction activity during the past decade increased considerably in several developing countries;

d) The range of building materials has been considerably extended. Traditionally, the building materials industry covered only the extraction and production of stone, clay, sand, gravel, cement, lime, gypsum, glass, bricks and tiles. At a later stage, the production of building components (prefabricated concrete and reinforced concrete components, doors, windows, building equipment etc.) has been introduced.

e) During the past decade, several developing countries have successfully increased their production of cement and prefabricated concrete components. Many other materials still have to be imported.

B) THE ROLE OF THE CONSTRUCTION INDUSTRY IN THE NATIONAL ECONOMY

Formerly, the construction and building materials industry was not regarded as an economic sector to be developed on a high-priority basis. For a number of years this situation has been changing, and it is now generally accepted that its development is of crucial importance to developing countries. Some of the reasons for this new position are outlined below.

Construction accounts for approximately half of all fixed capital investments, and new construction is required for most development projects. In particular, new manufacturing facilities and new housing must be constructed to ensure the development of industrial production and to overcome the housing shortage.

The shortage of 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 is an important step towards increasing construction output itself.

A well-balanced increase in construction output helps to satisfy the needs of the population, because it improves the housing situation, creates new jobs in new factories, reduces unemployment and promotes further building activity.

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 areas, for whom the construction site is the first organized working place. Many of these workers leave construction after a certain period to become employed by other industries. Thus, construction has in a sense a training and educational role in the overall industrialization process of a country.

The construction sector involves many different types of workers (masons, carpenters, plumbers, painters etc.) and enterprises, and is a purchaser of the products of many other industries (steel, aluminium, plastics etc.). The growth of the construction industry therefore has widespread positive effects, whereas a slump in construction has far-reaching negative consequences.

The public sector's demand for construction is high and government intervention has become necessary in many fields. Public buildings, schools, hospitals, roads and airports are directly financed and contracted by central, regional or public authorities. With regard to new housing, public authorities also play an active role. Government policy in increasing or reducing construction works expenditure strongly influences the economic climate in the construction and building materials industry.

Construction is both a concentrated and a small-scale activity. Central government or large, private industrial projects are carried out through the concentrated efforts of the construction industry; local development projects are the result of small-scale construction activities. Hence the construction industry takes an equal share in major central development projects and in furthering local development aspirations, including self-help in the non-monetary sector.

C) THE PROCESS OF INDUSTRIALIZATION IN THE CONSTRUCTION INDUSTRY

The industrialization process in developed countries cannot simply be copied in developing countries, though for the modern (both domestic and international) subsector it could be a basis for the choice of appropriate technologies.

In the traditional domestic subsector, appropriate technology has a different meaning. Here the decisive factors are small-scale, capital investment and the maximum use of domestic (local) resources. Technical solutions applied in developed countries often lead to inappropriate technologies for the small-scale domestic industry. 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. Major industrial development projects, for example, require modern industrial methods; big urban agglomerations (there are many of them in developing countries: Bombay, Buenos Aires, Cairo, Calcutta, Manila, Mexico City, Sao Paulo and Seoul to mention only a few) call partly for new industrialized housing, commercial and other buildings, and partly for low-cost housing; small settlements and industrial development projects require simple but improved construction technologies using 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 vatious materials, labour, machines and other input factors changes, and this changes the cost (price) relation of different technologies.

Based on the experience of developed countries the main fields of industrialization in the construction sector are the following: 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 and up-to-date management methods. The same holds true for developing countries, despite certain important differences.

The main objectives of the development of the industrialization process are as follows: 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, and agricultural and industrial wastes; to reduce the weight of the building structure and as a complementary objective to decrease the volume of materials to be transported in relation to the building volume; and to transfer as many processes as possible from the changing building sites to off-site factories.

In developed countries much effort is devoted to energy conservation, a problem neglected as yet in many developing countries.

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

Since the first buildings were erected, they have been either heavyweight 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 heavyweight and light-weight components is part of the industrialization process.

A wide variety of prefabricated (reinforced) concrete products exists: masonry blocks, beams, lintels, paving stones, curbs, flooring and roofing tiles, fences, railway and tramway sleepers, street lampposts, large wall and floor panels, stairs and staircase components, components for frames, retaining walls, pipes, culverts, bridge components etc. In many developing countries factories have been established for these products. A further development of prefabricated (reinforced) concrete components can be expected which will require higher cement production. Pre-stressed concrete products are also finding growing applications.

A controversial aspect of prefabrication concerns the production and use of large reinforced concrete panels. In Europe (both Eastern and Western) this has been a revolutionary new housing technique introduced after the Second World War. In the Union of Soviet Socialist Republics, and other socialist countries of Eastern Europe, large panel construction became the basic means of reducing or eliminating severe housing shortages. The main advantage of this technique has been the high productivity of labour: practically the same number of workers produce twice as many flats.

Large panel construction in developing countries has acquired some special characteristics. In a 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 also leads to positive changes in developing countries with regard to the productivity of labour and new housing output. Moreover, 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 be a useful method of providing new housing in developing countries mainly for a high density urban population with a severe housing shortage. On the other hand, it cannot be regarded as the only means of industrialization; many other means also produce 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 pre-cast concrete panels, may produce certain conflicts. Building designers consider that the use of large panels restricts the design process. Designers at least during a transition period would prefer techniques that facilitate an individual approach for each building. Component manufacturers, on the other hand, prefer to produce standardized components in large quantities. The preferences of the designer therefore conflict with those of the component manufacturers. However, through mutual understanding a satisfactory compromise can be reached. Governments should actively support the introduction of industrially made building components, thereby eliminating conflicts between participants in 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.

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

A changing pattern in the production and use of building materials and components may be a major factor in industrializing of construction. Some general trends in this changing pattern are as follows:

a) The overall cost of building materials and components expressed in percentages of construction costs tends to grow as a consequence of moving on-site processes to off-site factories (prefabrication);

b) The proportion of materials extracted directly from nature decreases, while the share of materials and components that reach their final form of application after several production cycles increases;

c) The share of traditional building materials (stone, bricks etc.) in the overall cost of materials tends to decrease;

d) Among traditional materials, the share of cement is growing, while that of bricks is diminishing.

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 equipment has to be improved. In this connection, I would like to mention also the rapid development in the use of ready-mix concrete. The development of more lightweight building materials and components to a certain extent alleviates the increasing strain on the transport system.

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, namely the use of up-to-date management and programming methods. Flow-line methods have been introduced as an adaptation of conveyor production in construction. The critical path method and similar network programming techniques are easily adaptable for use in the construction industry. The complexity of operations calls for an extensive use of computers, as is usually the case 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.

D) THE ROLE OF RESEARCH AND DEVELOPMENT

Building activities were for long based on trial and error, with practical successes and failures contributing to knowledge in this field. During the last century, and especially in recent decades, construction has relied increasingly on scientific research and mechanical and civil engineering know-how. Building research institutes founded first in developed and later in developing countries are becoming more and more active 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 research and development (R and D) in other countries and to adapt the results to conditions in their own countries. Building research institutes are sponsored by Governments, whereas research in the manufacturing industry may be left in the hands of industrial enterprises, because construction is a decentralized activity spread over large areas. Construction enterprises lack the necessary resources for maintaining their own research units. An exception is Japan, where construction enterprises have established 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, lightweight aggregates (pumice, perlite, vermiculite, etc.), glass blocks etc. The climate and other factors (e.g. termites) prevailing in developing countries must be studied to make an appropriate selection of materials and structural components. There are many construction problems in developing countries (roofing, ventilation, etc.) for which no ready-made solutions are available. Though many of these problems have already been carefully studied, mistakes are still frequently made.

Industrialization and appropriate technologies can be achieved in many ways. It is therefore very important 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 neeeded to make correct decisions and take part in the implementation of these decisions. Industrialization and the use of appropriate construction technologies require designs that take into account the results of science and research in this field. To achieve this, up-to-date technical regulations and standards based on performance criteria have to be worked out. Functional and practical buildings requirements have to be defined. Since the conditions prevailing in developed countries are different from those in developing countries (climate etc.), the requirements may also fundamentally differ. The requirements must therefore be assessed for each particular country or region.

E) WHAT GOVERNMENTS AND INTERNATIONAL ORGANIZATIONS CAN DO

The development of construction and the building materials industry calls not only for a policy on the selection of appropriate technologies, but also for a comprehensive development policy. Government and international action related to appropriate technologies should also be planned in a wider framework.

Government regulation of demand is essential to the sound development of the construction industry. The appropriate central and regional (local) authorities handle planning and programming problems on different levels. The central authorities' organization has to be of a complex character because it has to comprise government supervision of industry, the construction industry and technical progress; regional and urban planning; housing; and protection of the environment.

Governments should ensure a sufficiently stable demand for construction. Stable demand is ensured, among other things, by long-term housing, industrial development and land policies. Government-sponsored road, railway and harbour construction also makes construction demand more stable.

Governments should also find the 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. Governments should formulate (with the participation of the construction industry) a technical policy on the industrialization of construction, especially that relating to the domestic industry. They should support R and D and capital investments to promote this industrialization process and the use of appropriate technologies in the various subsectors.

Building is one of the economic sectors where the establishment of a state-owned national building research institute may be necessary in most developing countries. Quality control and standardization should also be government responsibilities to a certain extent. Co-operation with R and D institutes in developed countries should be encouraged.

Governments should take measures to protect the domestic construction industry and domestic value added, and also the use of local resources for the production of building materials. This should not, however, take the form of overzealous protectionism that drives up prices and consequently damages the country's interests. It should rather consist of reasonable support given to the development of the domestic construction and building materials industry and the use of appropriate technologies.

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. First, in the building materials industry it is often necessary to organize production on a smaller scale than in developed countries; equipment for smaller plants must therefore be developed. Secondly, it is important to promote the exploration and use of local materials and the use of industrial and agricultural wastes. Thirdly, mechanization and prefabrication should be supported and adapted in scale and sophistication to the special circumstances of developing countries.

Education and training at all levels (workers, technicians, architects, civil engineers, site managers etc.) should be supported, always keeping in mind the aspects of the industrialization process and the use of appropriate technologies.

The programme of work which could be taken up by international organizations, above all UNIDO, may comprise, inter alia:

a) Assistance in the exchange of technical information between developed and developing countries and among developing countries themselves through the establishment of regional R and D centres with technical linkages with the national institutions;

b) Assistance in the transfer of technologies for the production of building materials and prefabricated components between developing countries;

c) Organization of training facilities for technical personnel in developing countries in the planning and execution of production programmes, as well as of new production and construction techniques developed in other developing countries;

d) Participation, financially as well as technically, in specific R and D projects that might be of relevance and interest to a number of developing countries;

e) Organization of seminars, expert group meetings etc. to discuss common problems and to exchange experience in the field of development, production and application of alternative building materials components and techniques.