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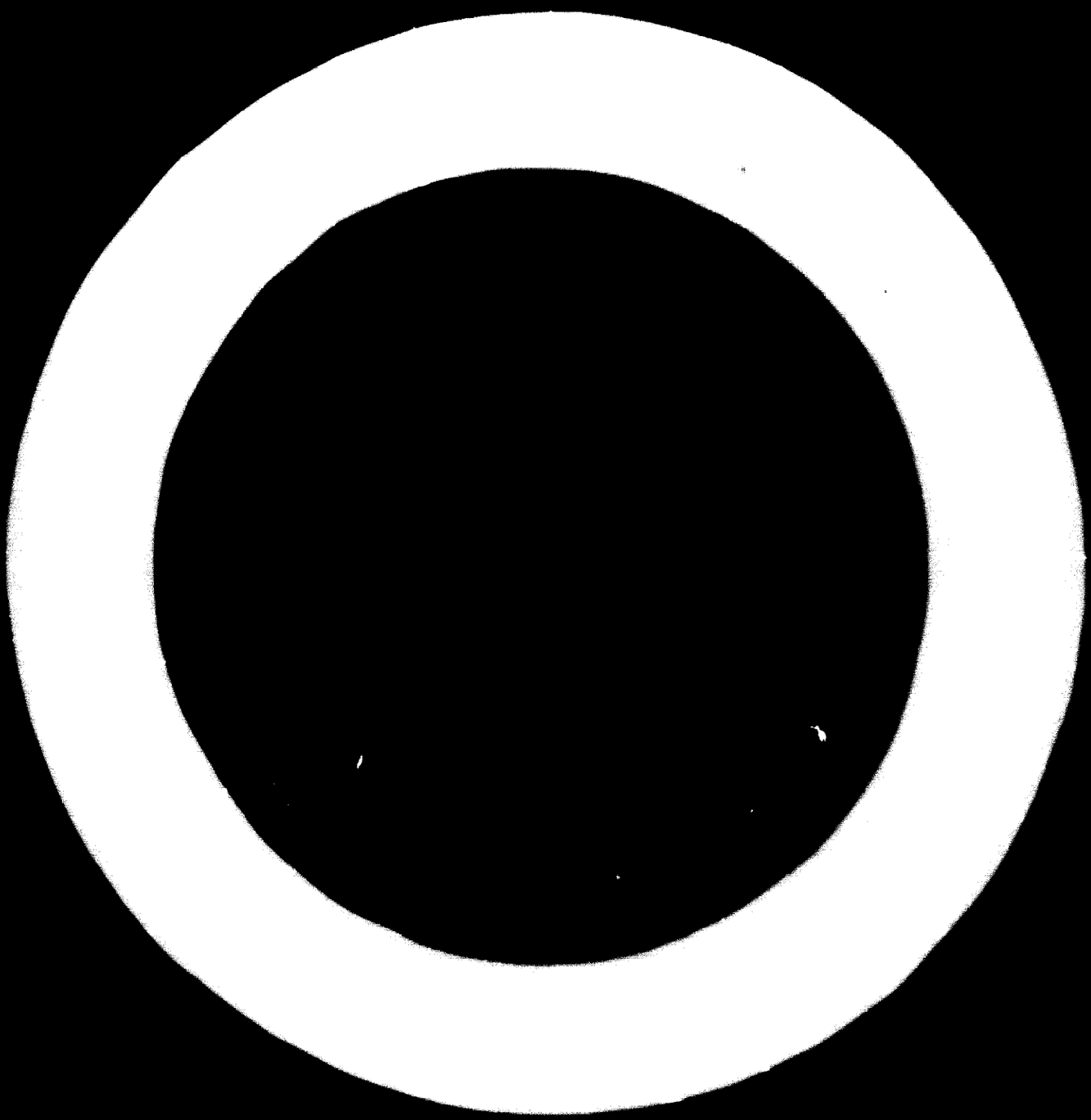
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

PREFABRICATION IN AFRICA AND THE MIDDLE EAST

Report of the Expert Group Meeting
held at Budapest, Hungary
and Bucharest, Romania
17–29 April 1972

Including summaries of lectures
presented to the Meeting



EXPLANATORY NOTES

"Tons" are metric tons.

"Dollars" ($) are United States dollars.

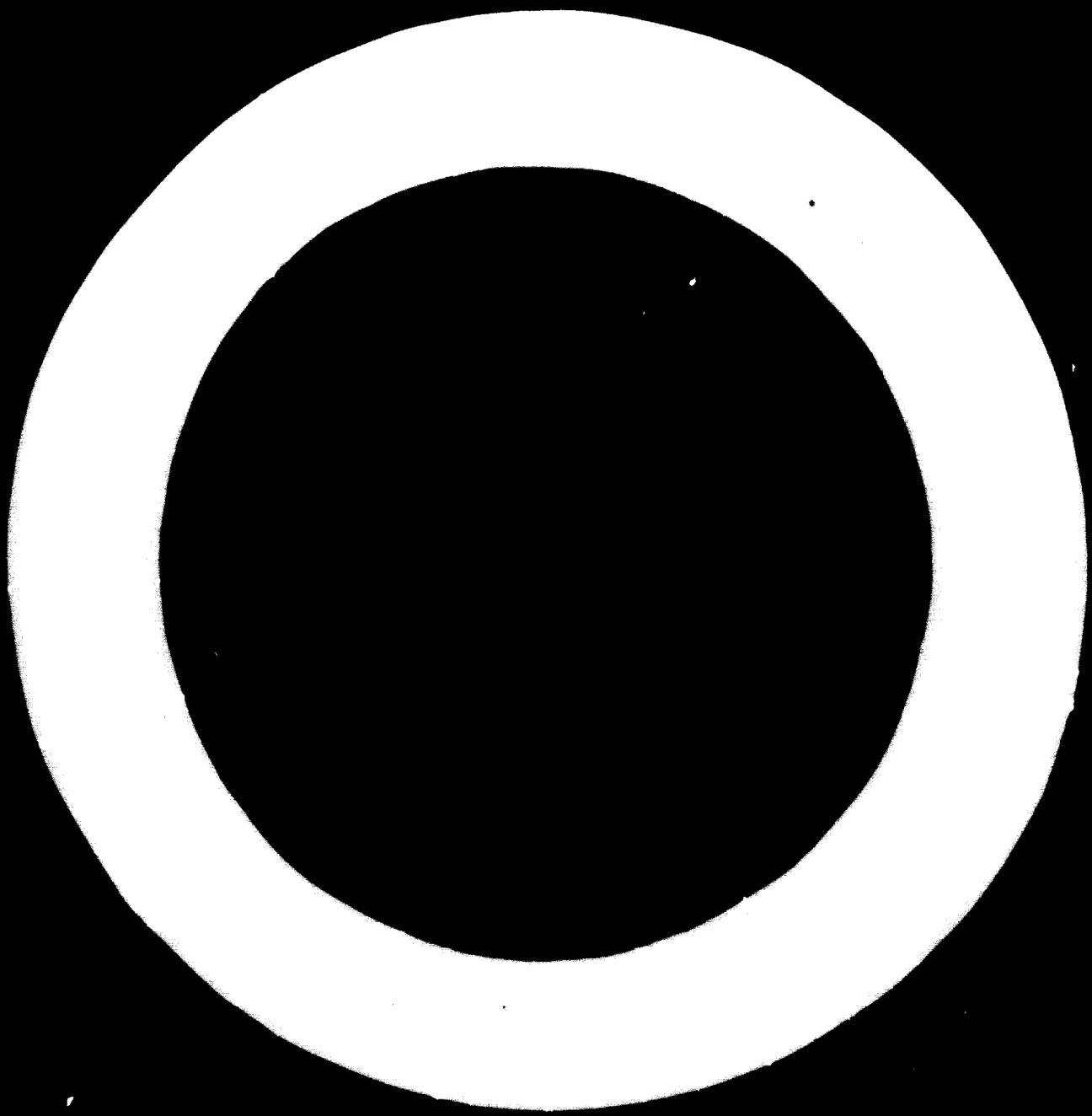
The term "billion" signifies a thousand million.

CONTENTS

INTRODUCTION

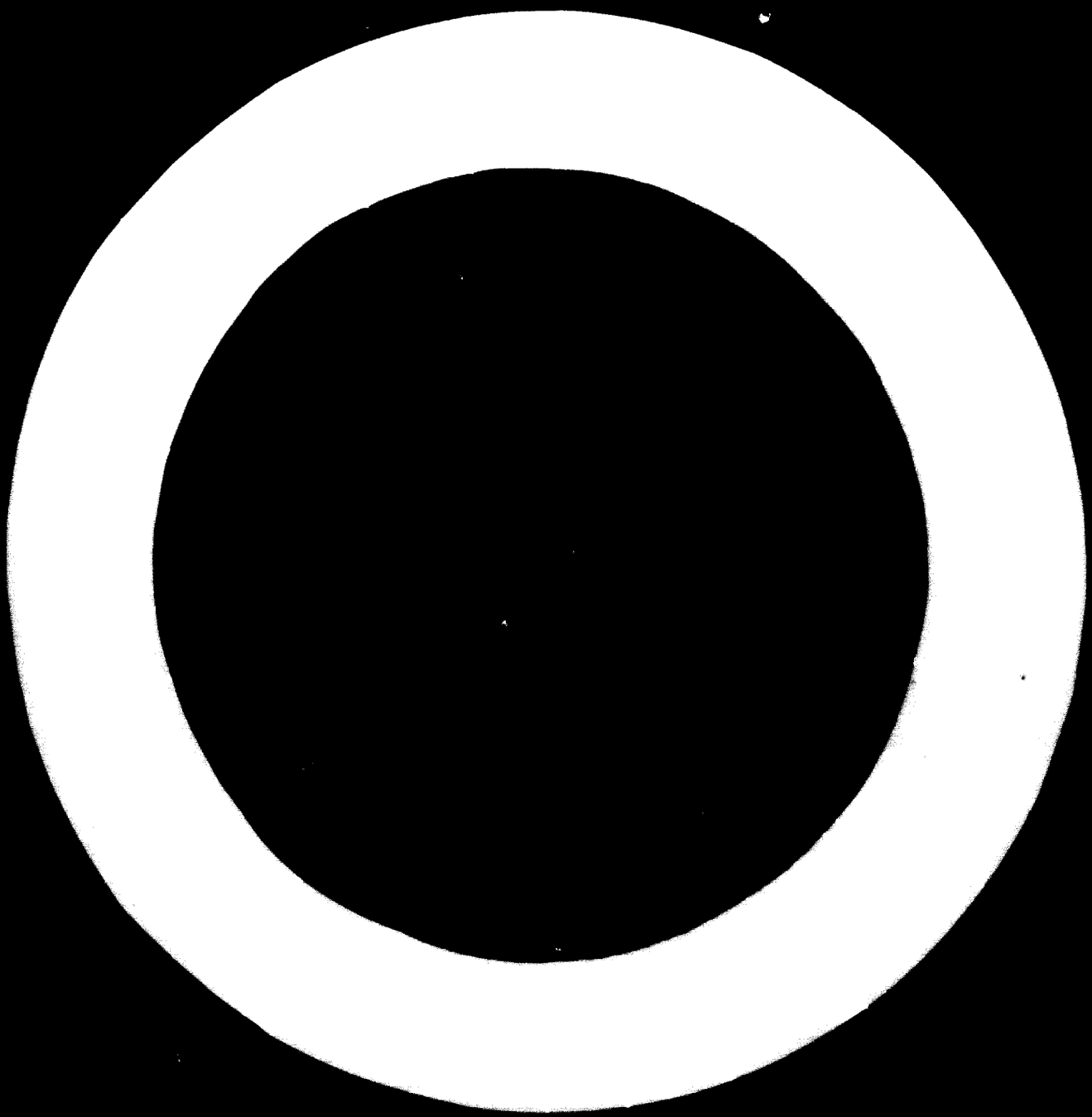
The Expert Group Meeting on Prefabrication in Africa and the Middle East was held at Budapest, Hungary, and Bucharest, Romania, from 17 to 29 April 1973. It was organized by the United Nations Industrial Development Organization (UNIDO) in co-operation with the Centre for Housing, Building and Planning of the Department of Economic and Social Affairs of the United Nations Secretariat, the Economic Commission for Africa (ECA) and the United Nations Economic and Social Office in Beirut (UNESOB).

The purpose of the Meeting was to study the technology and economics of prefabrication and industrialization in housing construction in Africa and the Middle East. Moreover, the possibilities of improving traditional housing production by simple building methods, more efficient construction techniques, and new and better building materials were to be examined.



Part one

REPORT OF THE MEETING



I. ORGANIZATION OF THE MEETING

The Meeting was attended by experts from 15 countries in Africa, Europe and the Middle East.

The agenda included technical papers on different building systems and consideration of summary papers on the current use of prefabrication in the Middle East and Africa, the promotion of a well-planned construction industry, and the role of Governments. Country papers presented by participants provided information on building activities, raw materials, production and imports in the building sector as well as the planning and future trends in housing industries in Africa and the Middle East.

G. Furdescu (Romania) and C. Rydeng (UNIDO) were Directors of the Meeting, and A. Tsheknavorian-Asenbauer (UNIDO) was Co-Director. The members of the Technical Committee of the Meeting were A. Gonzalez Gandolfi (Centre for Housing, Building and Planning of the Department of Economic and Social Affairs, United Nations Secretariat), A. B. Puplampu (ECA), M. Jaff (UNESCO) and T. Ringsholt (UNIDO consultant), who also served as the Rapporteur.

Prefabrication factories and building sites were visited in Hungary and Romania. These visits are described in the annex.

II. SUMMARY OF THE DISCUSSION

In the course of the discussions that followed the presentation of the technical papers, it was agreed that prefabrication could be an effective means of developing industrial and agricultural construction as well as housing. As the global need for housing would increase greatly during the next 50 years, the industrialization of building would be necessary.

It was emphasized that every decision concerning the industrialization of building should be based on the knowledge of specific local conditions, such as the users' requirements, the materials available, the technical level, traditions and economic conditions. A decision should be preceded by technical and economic evaluations to reach an optimum solution.

It was agreed that the essential conditions for the industrialization of building were continuity of demands, standardization, specialization of labour and management co-ordination. Mechanization was also required when a certain level of development had been reached.

Production of housing could be increased through the adoption of rationalized building of housing methods. The basic steps in the rationalization process were the local industrial production of building materials; the introduction of standards and modular co-ordination; and the partial production of some prefabricated components such as doors, windows, lintels, trusses and light-weight roofing elements. The prefabrication of housing, as practised in industrialized countries, could be introduced in urban areas. In rural areas, the industrialization of the building materials industries would probably be more beneficial.

In a discussion of basic urbanization in Africa, attention was drawn to the extreme difficulty of providing houses and the basic services for low-income citizens. Often the basic services consumed all the resources for housing and urbanization. Realistic solutions required a review of building regulations and standards, since most building regulations had been copied from abroad without regard to local conditions. Appropriate standards would be determined only through comprehensive planning.

To accommodate future changes in family patterns and in the general standard of living, industrially produced houses should be constructed with a degree of flexibility, such as the possibility of moving walls within apartments. Although the prefabricated buildings lacked variation, careful town planning would prevent the appearance of monotonous rows of building blocks.

The properties of lateritic soil suitable for the production of building blocks were discussed. The best quality was obtained with soil containing approximately 40 per cent clay. Immersion tests had shown little deterioration of surface and no loss of strength. In fact, immersion contributed to a slight increase in strength. Adhesion to mortar and other engineering properties had been tested with good results.

The heat insulation of buildings in tropical areas was also discussed. High insulating properties were advantageous when air conditioning was used. These properties were improved in buildings with thick outer walls or with sun-ray protected walls, possibly in combination with cross ventilation.

It was stated that bricks of the lowest quality should not be used in prefabrication with clay. The results of European research indicated that problems with efflorescence could be avoided. The possible use of prefabricated brick panels in constructions would depend on local conditions.

The novel use of gypsum as permanent form work was explained. The cost of a mobile factory to produce the elements was estimated to be approximately $25,000. The method should be carefully tested in countries that had abundant gypsum resources.

It was suggested that the following government measures would support the development of the industry:

Inclusion of the building sector in national development plans

The creation of building research centres

The promotion of education and the training of technicians and skilled workers.

The Meeting recognized that the production of increasingly complex building materials and components within each country followed a pattern. Although the steps might not follow the same sequence in all countries, the following steps were usual in the development of the prefabrication industry:

(a) Production of raw materials,

(b) Production of units and sections;

(c) Production of components and assemblies;

(d) Complete prefabrication.

The subject of labour in relation with industrialized techniques was debated. There was a consensus that, contrary to generalized opinion, industrialized methods in a country with a progressive building industry would create many employment opportunities.

Attention was focused on specific aspects of various techniques of prefabrication. They included the advantage of flexibility in the production of different products when markets were limited, the importance of the weight of components and its direct relation to the need for mechanical lifting and handling equipment, the influence of climate on the selection of wall systems, and the relative importance of savings in the costs of the structure when the costs of land, plumbing, electrical installations, joinery and finishes had been taken into account in the total costs of a building.

III. CONCLUSIONS

The following conclusions of the meeting were based on the lectures and the discussion of the industrial approach to housing.

Industrialized methods should be introduced gradually in a country. The requirements and needs should be the subject of preliminary research studies. Information about possible solutions should be collected, and the technical and economic data should be analysed. Equal attention should be paid to an analysis of the economic and financial conditions and to the establishment of thoroughly prepared performance specifications. These specifications should indicate the physical requirements that would be in harmony with the local cultural and sociological patterns.

Closer international co-operation in the use of industrialized methods in house construction in developing countries would help to prevent unnecessary overlapping. The resources of non-governmental organizations should be used as well as those of United Nations programmes.

The following activities would further the exchange of experience and information:

(a) Studies of the developing countries' needs and the possibilities of assistance by industrialized countries;

(b) Construction of pilot plants in developing countries as training facilities for local personnel to accelerate the development of the building industry;

(c) Orderly circulation of results, know-how and the experience of research and development work.

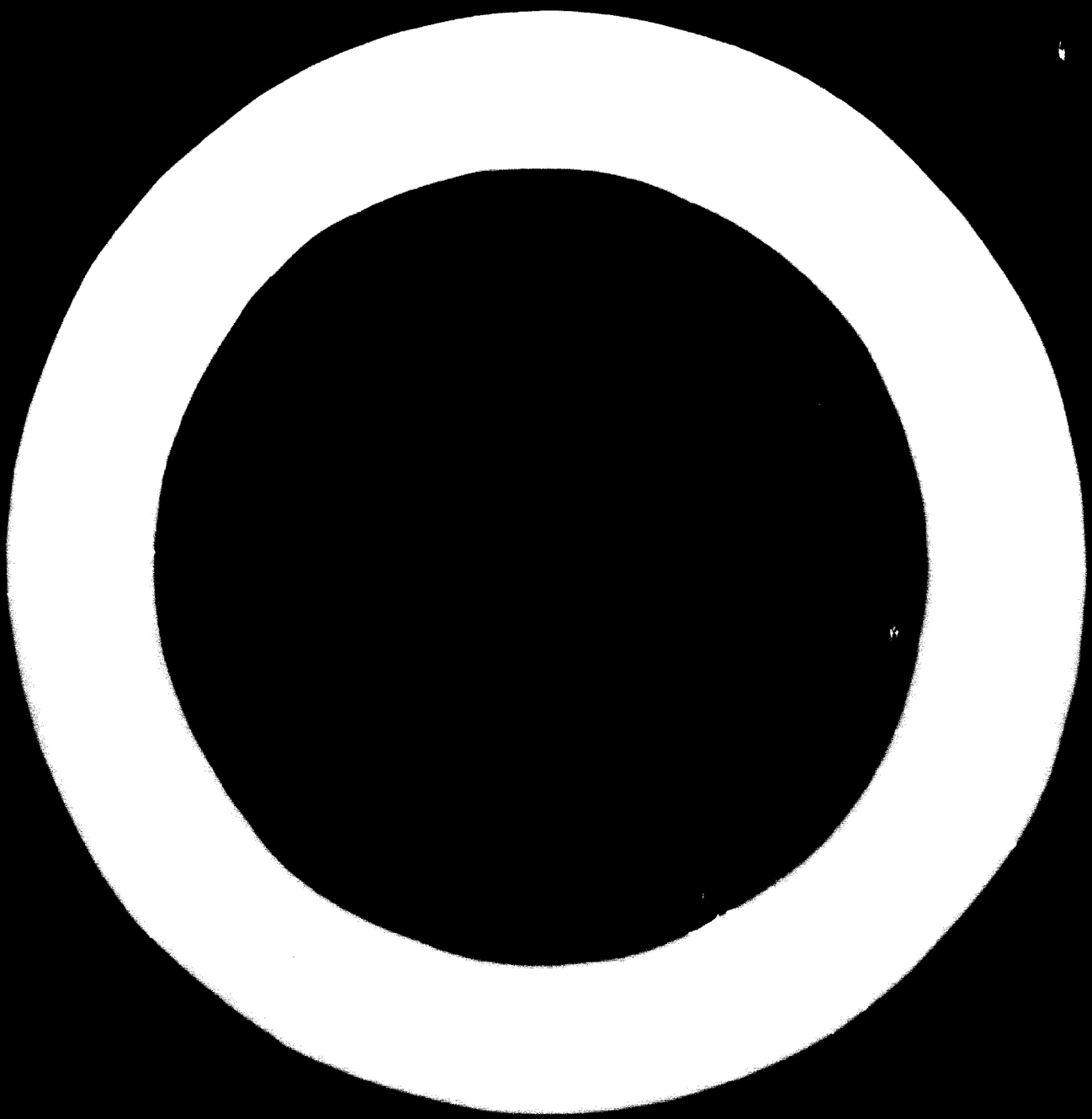
Priority should be given to the prefabrication of small-size and linear "one-dimensional" elements, which could be used effectively with other forms of industrialized or traditional building. The first step towards industrialization would be the improvement of traditional building methods.

An international building competition similar to those in architecture could provide a means of gathering and disseminating information about a number of housing methods. It was suggested that the United Nations sponsor the competition and publish the results for world-wide distribution.

The information presented by participants from 14 countries in Africa and the Middle East on the existing building industries, future trends and available resources has contributed to the rational planning of local housing policies. The next task should be the development of local performance specifications.

Part two

SUMMARIES OF LECTURES PRESENTED TO THE MEETING



THE STATUS AND PROBLEMS OF PREFABRICATION IN AFRICA

Economic Commission for Africa

Under the traditional building methods followed in Africa, the following conditions obtained:

(a) Each head of family was his own builder. He used the methods and techniques which he had learned in apprenticeship from his ancestors. The whole society knew the same techniques, and where needed they helped one another to construct the required building. Thus traditional building was executed by self-help and co-operative methods;

(b) Local materials were extensively used. Most materials were assembled near the building site with minimum processing;

(c) The construction of most buildings in a locality was based on the same or similar structural systems. These systems had proved to be suitable in use;

(d) Architectural forms, sizes and openings were standardized to a remarkable degree within the same geographical or tribal region. Nevertheless, neither drabness nor monotony was in evidence;

(e) The evolution of the built-up environment traditionally had not been directed by specialists. This evolution developed spontaneously from experience in the use of forms and structures;

(f) The built-up traditional environment fulfilled the basic functions of shelter, security and privacy without monotony and the so-called unpleasant effects of standardized construction on the environment.

Increasing urbanization and the growth of specialized professions have resulted in the growth of a large number of specialized builders who satisfy the general demand for housing and building. The traditional systems have broken down and have been replaced by systems developed by these specialist builders. It is common in many modern societies to notice as many building systems as there are specialist builders. This situation has created a very fragmented building industry in which there is such a large number of products, components and producers that it has been difficult to meet the growing demand for buildings without rationalization.

The first step in rationalization has been to support manual effort by mechanization. However, since mechanization could achieve only a limited increase in the efficiency of the building industry, the next step is industrialization. The following are prerequisites for the

industrialization of the building industry:

National building codes that establish uniformity

Building regulations that emphasize function as well as standardization

Promotion of the industrialized production of building components

Use of dimensional and modular co-ordination in the design of buildings

Long-term planning to create the appropriate markets which would justify the necessarily large capital investments in prefabrication plants

Some African countries have begun to manufacture prefabricated housing. However, they have not been successful for the following reasons:

(a) Absence of the appropriate planning to create a steady demand for the buildings;

(b) The prevalent belief that the standards of prefabricated buildings are lower than those of traditional constructions;

(c) Use of machinery and technology that are inconsistent with the locally available materials, know-how and manpower;

(d) Insufficient consideration of the feasibility of the adopted system.

The development of the appropriate technology for the African environment should take the following current conditions into account:

Abundance of manpower

Lack of skills

Availability of simple machines

Relative scarcity of capital because of the lack of appropriate financial institutions for long-term financing

Planning bodies that do not recognize the economic importance of the building industry

National building regulations which do not include prefabricated housing

Prejudiced attitudes towards prefabricated buildings

General lack of processing industries for improving local building materials

In introducing prefabrication in Africa, the following conditions should be borne in mind:

The basic prefabricated elements should be made by artisan methods or with simple machines

These elements should be light enough to be handled by a minimum of two but no more than four workers

Elements should be assembled with the help of simple machinery such as pulleys or non-mechanized cranes

The first designs for all prefabricated houses should acquaint householders with the new methods to create an atmosphere in which there is no shock rejection of prefabricated systems. Therefore, the first prefabrication process should be half traditional and half mechanized to permit a gradual adjustment to the new methods.

Certain countries which have adopted prefabrication do insist on a minimum planning cycle of five years for the factory. A transition cycle of at least the same order in Africa would be recommended, since it would take a long time for the new production methods to be fully established and sufficiently proved for inclusion in building codes.

In the development of this type of technology, it may be necessary to incorporate in local building regulations the structural systems and sizes of prefabricated components that would be suitable in any given place at any time; these regulations should be subject to regular assessment and review as conditions change. Thus far, there is no organized system in Africa.

The insistence on standardization and modular co-ordination in building would create manufacturing industries with large outputs of low-cost building components. The advantages of modular co-ordination in building are well known. If components were mass assembled and of standard dimensions that were consistent with function, it would be easy to increase the housing supply by self-help and co-operative methods.

The optimal use of local building materials would demand the use of standardization and modular co-ordination so that components could be easily assembled without specialized training, as in the automotive and aircraft industries. The quality of the end-product would be less dependent on the skills employed on the site and more on the process used in the factory. Given the broad basis of standardization and modular co-ordination, systems could be developed which correspond with geographical and climatic zones.

A broad survey is given of the prefabricated housing industry in selected African countries that illustrate the development of the industry. The prefabricated housing scheme is reported in detail. It could be developed and used on a larger scale, not only in Kenya but also in other countries. The scheme is recommended for its low cost, flexibility and appropriate technology.

THE STATUS AND PROBLEMS OF THE HOUSING AND CONSTRUCTION INDUSTRY IN AFRICA

Economic Commission for Africa

The housing and construction industry is the largest single consumer of the resources of capital formation at all levels of development. Although the construction of housing, buildings and infrastructure is important in the general development, the sector has not benefited from long-range planning and co-ordination that could optimize the use of resources.

There is no shortage of cement, lime, clay, metallic ores and wood resources in Africa. In view of the potential resources of electric power and petroleum, the current scarcity of economic fuel and power does not present an insurmountable problem. However, a serious obstacle is the relatively small national market for household fittings, sanitary ware and hardware. This limitation is further aggravated by the inadequate domestic and international transport facilities.

The bulky nature of certain building materials, for example, bricks, makes it necessary to locate these industries near population centres. This has the effect of limiting the widespread use of such materials. Bricks are, however, widely used in construction in North Africa where brick-producing factories are well distributed over the countries of the subregion. For materials such as cement, which could be transported over relatively greater distances, the prices are prohibitive in land-locked countries such as Chad, Mali, the Niger and the Upper Volta. Since raw materials are not lacking in these countries, international arrangements whereby a factory or factories are suitably located to supply cement to more than one country would save considerable investment resources.

There is an acute shortage of skills in the construction industry at the intermediate level. Technical institutes should be established to teach these skills, with emphasis on the use of local materials. This kind of training could even begin with the basic traditional techniques by which buildings were constructed before imported materials became widely used. The Department of Planning, Faculty of Architecture,

University of Science and Technology, Kumasi, Ghana, has made significant attempts to revive the use of traditional techniques in housing as a means of reducing costs. Model houses have been built completely from local materials. A locally constructed machine made improved stabilized earth blocks at a cost of $15 per square meter.

The use of artisan methods in house construction and the minimal use of standardization generally lead to high costs of housing for citizens with average incomes. More houses could be constructed with the present resources provided realistic standards were adopted. An example is a co-operative housing estate in Dar es Salaam, United Republic of Tanzania. It was established through the joint efforts of the Government, ECA and the International Co-operative Housing Development Association. Low-cost dwelling units for 330 families have been constructed on the estate with the aid of co-operative housing societies.

The lack of long-term planning and the inadequate management procedures resulted in increased building costs. In order to reduce these costs, government machinery should be created to co-ordinate the efforts of all State and private building organizations and thus establish certain standards and long-term strategies for the industry. To reduce costs further, the capacity of the building industry must be known in terms of the supply of building materials, labour and machinery. Care should also be taken to ensure that whenever new machinery is acquired for a large project, there shall be a demand for the use of the machinery after the execution of the project. The possibility of including the costs of building machinery as capital assets should be examined.

Most Governments in Africa have attempted to ensure that considerable sums shall be invested in housing and that domestic resources shall be used to the greatest possible extent in developing the sector. Present advice and assistance to Governments from ECA place emphasis on improving marketing, handling and transport facilities to reduce the cost of materials delivered to the building site.

In the field of housing and urbanization, the basic problem in Africa has been the neglect of traditional social attitudes, not only in the interiors of the houses themselves, but also, very often, in the town and

neighbourhood patterns. The assumption made by planners that the physical structures would change social attitudes has proved to be wrong. The result is overcrowding inside the houses and the lack of adequate public facilities in the towns. Another urban problem caused by the migration from rural areas is the growth of slums and squatter settlements in towns and suburban areas.

The present pattern of residential areas is groups of "hamlets" or villas with the low density of 5 to 10 dwellings per hectare. Infrastructure for this type of urban grouping is very costly. This high cost is not generally reflected in rents or financial amortization. A situation is created whereby substantial subsidies are directed into the housing of a certain social class. At the other end of the scale are the well known slums and shanty towns which officially have the status of a neglected child. The rational solution is to work out a system of land use and the provision of infrastructure which has the highest potential for improvement. This is the basic problem of the professions that deal with the physical evolution of the built-up environment.

Given land, the available materials and techniques, as well as the financial resources, horizontal housing would appear to be the solution which for the time being offers the following advantages: low cost of basic structure and related infrastructure with regard to technical specifications and materials; and ease of expansion within land allocation to suit changing family and living conditions.

The solution to the problems of the housing and construction industry in Africa requires the following integrated approach:

(a) An intrepid urbanization and housing policy for the increasing number of households as part of long-term development planning;

(b) Imaginative physical planning for the optimum use of the land;

(c) A realistic policy promoting savings and investment as well as the flow of finance into the construction industry;

(d) Basic decisions concerning quality levels (housing standard) founded on human needs and economic reality;

(e) The encouragement of intensive technical and economic research projects;

(f) Dynamic co-ordination of research results and practical applications;

(g) An effective public machinery for co-ordinating and managing the housing and construction industry in terms of building regulations, standards and administration, budgeting and tendering procedures, the supply and marketing of building materials, manpower, productivity and production capacity.

GOVERNMENT POLICIES AND MEASURES FOR THE INDUSTRIALIZATION OF BUILDING

Centre for Housing, Building and Planning of the Department of Economic and Social Affairs, United Nations Secretariat

The inability of the building industry to meet the ever increasing demand for the construction of housing is a serious problem. The key position of the building sector in the national economy underlines the magnitude and relevance of the problem.

Low productivity, high costs, lengthy building cycles and the poor quality of completed structures are the main challenges of the building industry. The lack of building production capacities in countries with insufficient labour resources is a result of the insufficient productivity of artisan and semi-industrialized building methods.

The application of modern industrial methods of organization and production can meet these challenges. The industrialization of the building industry is a gradual process that reflects the local patterns and pace of industrialization in a specific country.

The complexity of building and its importance for the national economic and social development requires direct governmental action to define the policies and to enforce the measures for industrialization. Policies and measures for industrialization are divided into three categories corresponding to the early, intermediate and advance stages of industrialization.

The itensity and extent of industrialization and the time needed to achieve the particular stages vary. Therefore, the elaboration of a strategy and programme for industrialization must be based on a careful analysis of all relevant factors.

The progress of industrialization depends on the fulfilment of a number of prerequisites. The following measures are some of the most significant:

(a) Efficient governmental regulation of building activities;

(b) Integration of the building industry into the national development plans to create a stabilized building market in terms of the volume and continuity of demand and adequate ancillary services;

(c) Well-established national housing and land-use policies, schemes for financing housing and long-term urban planning;

(d) Introduction of the modular system and improvement of standardization and building regulations;

(e) Establishment or further development of building research in accordance with the requirements of industrialization;

(f) Development of new and improved building materials;

(g) Changes in building design to permit the use of prefabrication and other techniques of industrialization;

(h) Education and training of skilled labour and technicians.

The Government should offer various incentives to promote the process of industrialization. Important opportunities are found in the financing of pilot housing projects in which industrialized methods are used, and in the subsidizing of prefabrication plants.

Rationalization measures should represent the first step towards more complex industrialization. They include improved organization, planning, control, use of new and improved materials including partial prefabrication, the increased use of hand tools and light machines, improved design and better co-ordination of all building activities. This phase of development will gradually lead to the full industrialization of the building industry.

CURRENT STATUS AND PROBLEMS OF THE HOUSING AND CONSTRUCTION INDUSTRY IN THE MIDDLE EAST

United Nations Economic and Social Office in Beirut

The paper examined the housing crisis in the region covered by the United Nations Economic and Social Office in Beirut and gave estimates of the housing requirements of several countries in the Middle East. The available statistical data indicated that the cost of a dwelling represented the earnings of two or three years for a skilled worker and four to seven years for an unskilled worker.

According to the paper, the countries of the UNESOB region have intensified their efforts to alleviate housing problems as well as to develop their natural resources and economic infrastructure. These activities are reflected in many public construction projects, which depend on an adequate development of the construction and building materials industries. However, this crucial role of the building materials industry has only now been recognized. It is essential that the building materials industry be developed and improved, not only to reduce the costs of house-building, but also for the execution of programmes requiring large-scale capital investment in agriculture, industry, transport and infrastructure.

The countries of the region have been handicapped in the implementation of their national plans. The rates of investments have been very low in most sectors. For example, although the total planned investments in Iraq from 1965 to 1969 were $1,870,000, only $1,022,000 were actually invested. In Saudi Arabia and Jordan the rates were far less than 50 per cent. These poor performances were attributed mainly to inadequate planning and lack of construction policies. The introduction of prefabricated industrial buildings could hasten the implementation of a country's economic development plans.

Cement is the locally available basis for building and construction since steel and wood are imported. Iron and steel products account for 30 to 40 per cent of the total imports of major building materials in the region. In 1970, the total combined production of cement plants in six countries was more than 5 million tons.

The only prefabrication and industrialized building industries in the UNESOB region are two railway sleeper plants in Iraq and Syria, and a prefabricated house factory in Kuwait. While technical progress in prefabrication is still at a comparatively early stage and the technical merits of different systems used in the industrialized countries vary greatly, the problem now requiring solution is essentially an economic one, namely, how far can any technically sound system prove economical in practice and lead to the reduction of the building costs? Furthermore, employment, continuity of demand and social habits must be taken into account to determine the feasibility of prefabricated production.

There are significant opportunities for the development and implementation of more efficient and rational construction materials and techniques, particularly the more widespread use of modular co-ordination, standardization and partial prefabricated elements. There is an opportunity for further research and development of new materials which can be produced from the local petrochemical resources.

UNIDO ACTIVITIES RELATING TO THE CONSTRUCTION AND BUILDING MATERIALS INDUSTRIES

Secretariat of the United Nations Industrial Development Organization

The beginning of operational activities in developing countries depends mainly on clearly defined technical requirements. These technical requirements are usually best described in a proposal for action that serves the following purposes: it is the initial estimate of all requirements and can be used as basic material in negotiations with governments. This preparatory activity leads to the formulation of a draft project document, which becomes the basis for the official request. The same approach is used for operational projects. Field experts submit periodic reports of their activities. They are always requested to include realistic needs in project modifications and project documents.

The final industrial development projects consist of project components from both governmental and United Nations resources. The Governments usually supply project facilities in the form of buildings, land, and counterpart engineers and staff. Training, transfer of know-how and limited financial assistance may be supplied through the United Nations Development Programme (UNDP).

The following items indicate the diversity of UNIDO activities:

Counterpart training
Fellowship training
Technical administration
Diagnostic missions
Feasibility studies
Establishment of short- and long-term assistance programmes
Evaluation and testing of raw materials
Establishment of technological institutes and advisory centres
Production of documentation and manuals
Evaluation of industrial projects
Evaluation and procurement of equipment
Proposals and implementation of factory modifications
Administrative proposals for establishment of new factories

Technical and economic analysis and prognosis for existing and new factories

Trouble shooting

Organization of meetings

Investment promotion activities

Until now, most UNIDO effort in the field of construction and building materials industries has been concentrated on the establishment of basic building materials industries. However, successful progress in these industries in developing countries now requires more emphasis on the use of building materials in construction industries. This approach was encouraged at the Fifth Session of the Industrial Development Board, where several delegations spoke of the need for greater emphasis in the work programme of UNIDO on construction activities.

A growing number of UNIDO fellowships in construction industries have been requested and awarded. The fellows will, on their return to their home countries, often be the counterpart experts with whom further co-operation can be established.

A SYSTEM-BUILDING DESIGN PHILOSOPHY

J. F. Munch-Petersen

The development of industrialized building (with its increasing use of prefabricated components) is a natural consequence of labour scarcity and rising wages in Denmark. The administrative organization of the building industry is undergoing a simultaneous development leading to the situation in which all details of the construction of a building from the preliminary design to the final occupancy will be covered by a single organization that is set up by an investor, a non-profit housing association or a contractor.

As an example, statics is a small part of structural design, which in turn is a small part of the planning of an industrial product. Structural components represent a small but most important part of all the manufactured products that are in the completed building. The design philosophy of structural components must be geared to the production as well as to the over-all design of the complete home.

Standardization, dimensional co-ordination, modules, uniform building codes, elimination of unnecessary local or individual deviations from logical, optimal solutions are means of achieving better and less costly production. There must be a reasonable compromise between economy and the variation a country can afford.

Furthermore, the gearing of design to production implies a thorough knowledge of "system philosophy". Different types of systems are defined by the relationship between the planning organization, the designers, the suppliers and the contractors.

Among the necessary conditions for industrialization are the continuity of production, which is basically a problem related to the national economic and housing policies as well as a design problem related to the use of existing manufacturing techniques, control of the number of variants of a component and the use of special components. Although concrete has been the logical material in system building in Denmark, most of the reasoning would be applicable to system building that is based upon structural timber components instead of precast elements. Some basic factors of the approach to innovation in building construction in a developing country are given.

THE GENERAL ADAPTABLE LIGHT-WEIGHT BUILDING SYSTEM

H. H. Olrik

The use of plastics in buildings has been developed particularly for prefabricated external staircases and balconies. A simple construction system of entire buildings in plastics has been designed. Its first application was in a Danish kindergarten building.

The general adaptable light-weight building system has been adapted for low-cost housing programmes. The design accomplishes the following objectives:

(a) The number of standard building elements are reduced to a minimum;

(b) The building can be manufactured and erected by unskilled labour without expensive equipment;

(c) The system is highly adaptable for any style of house under different climatic conditions.

BUILDING WITH LATERITE BLOCKS

T. Ringsholt and T. C. Hansen

A new, low-cost building material, latorex, is discussed. The production method is described by which all laterites and lateritic soils can be mixed with an inexpensive additive, pressed into block shape and cured in plastic tents heated by sun or hot water.

Flow sheets for labour-intensive as well as fully automated production plants are shown. Equipment is discussed in detail and approximate costs are given.

The properties of latorex are compared with properties of other building materials. Examples are given of various block units and of a system for low-cost, low-rise buildings using latorex blocks.

BUILDING WITH PREFABRICATED WOODEN ELEMENTS

K. M. Turkia

Industrialized housing systems that use wooden elements are analysed with regard to their unique characteristics and the nature of the building elements. Emphasis is placed on material requirements (quantity and quality of materials), the nature of the factory, the extent of automation and labour input, the degree of fabrication, and the transport and erection methods. The paper discussed skilled labour requirements; provided a set of manufacturing drawings and erection instructions; and set forth the principles of factory design.

Financial analysis with appropriate economic feasibility calculations is discussed.

STRUCTURAL PROBLEMS IN SYSTEMS BUILDING

K. Guntofte

The analysis of functional requirements is the logical approach to building design. The building codes based upon traditional techniques are quite often not in accordance with such efficient design methods. For the development of industrialized building techniques, it is absolutely necessary that the final product be defined by the functional requirements that are given in building codes in order to enable the customer, the designer and the contractor to agree on a logical, technical basis. The functional requirements and the corresponding struotural joints, as well as façade joints, are described. The structural joints must transmit concentrated forces and ensure the interaction between several components. Although façade joints must be structural, they must primarily be resistant to wind and water. Two-stage joints are therefore preferable. Some principles of the design of precast components are also set forth in the paper.

MOBILE HOMES - AN EXAMPLE OF ASSEMBLY-LINE-PRODUCED LOW-COST HOUSING

T. C. Hansen

The mobile-home industry is the only large-scale producer of factory-assembled housing in the United States of America and probably in the world. The low cost of production is the fundamental reason for its success.

In 1969, the American mobile-home industry reported sales of 413,000 homes with a retail value of $2.5 billion. It accounted for 48 per cent of the total number of single-family houses built in the United States in 1969. An estimated 7 million people live permanently in mobile homes. The production is analysed with respect to design, production methods, production capacity, investment costs and production costs.

The mobile-home industry has demonstrated that assembly-line production can reduce costs more than 50 per cent lower in comparison with conventional construction. Moreover, the price of mobile homes has increased only slightly during a period in which conventional construction costs have increased sharply.

The rapid growth of the mobile-home industry represents a revolution in American housing and may well lead to a breakthrough in industrialized housing all over the world. Application of this technology with suitable modifications should be seriously considered in efforts to increase the available housing in developing countries.

BUILDING WITH BLOCKS AND PREFABRICATED ELEMENTS OF AERATED CONCRETE

P. Nerenst

Aerated concrete is a precast light-weight concrete that possesses the favourable characteristics of low unit weight, good workability and high thermal insulation. The bulk of the raw materials for its production can vary within wide limits. It is usually possible to adjust the manufacturing process to permit the use of locally available resources.

Aerated concrete blocks may be introduced in a local market without major training programmes in the proper application techniques. The low unit weight, ease of handling and the outstanding dimensional stability are valued by masonry workers. Furthermore, these qualities promote speedy construction and improve the quality and finish of the completed job.

A prerequisite of the inclusion of reinforced products in an aerated concrete manufacturing programme is a feasibility study of the market to ensure optimal return on investments. The feasibility study is vital because considerable capital is required for the manufacturing of equipment and for the maintenance of a reasonable stock of a large variety of finished products.

A flexible building system for low-rise construction can be based on the use of aerated concrete slabs and panels. It is readily adaptable to local needs and customs.

A SIMPLE BUILDING SYSTEM IN PREFABRICATED CONCRETE USING THREE STANDARD ELEMENTS

H. H. Olrik

In Denmark most of the large housing projects are prefabricated constructions. The experience gained in the design and production of prefabricated elements for building construction has been the background for the development of a very simple prefabricated concrete system, which can readily incorporate traditional materials in developing countries.

This system offers a number of advantages such as the possibility of planning a wide variety of building types using a minimum number of standard elements; the exclusive use of unskilled labour in the manufacture and erection process, without costly mechanical equipment; and adaptability to local building traditions and social customs under different climatic conditions.

BASIC URBANIZATION IN AFRICA - A DISCUSSION OF COSTS AND STANDARDS

U. Winblad

In terms of costs and standards, the following three building cultures co-exist in Africa: traditional, the new traditional or intermediate, and modern. In urban areas, the principal problem is not the house itself but the prerequisites of water supply, waste disposal, surface drainage and access lanes.

For these basic utilities the choice today is between traditional and modern systems. The traditional systems are not satisfactory in urban areas; the modern system is very costly. Few efforts have been directed to the development of alternative utility systems.

An example of a possible "intermediate" utility system is given. There is, however, no single, simple solution to the problems of costs and standards. No new design, method of production or combination of materials can alone solve the housing problems in Africa's urban areas.

THEORIES AND TECHNIQUES OF A DANISH MANAGEMENT SYSTEM

J. Lützhøft

The paper gives a description of a Danish management system and illustrates the adaptation of industrialized production methods in housing production. Market research, sales policy, production planning and long-range planning are considered.

The development of a new industrialized housing enterprise should be based on feasibility studies, market research, investments, break-even point and profitability calculations. Furthermore, the project must be adapted to local building codes and requirements. An investment example with an annual budget and a time schedule is included.

CONSTRUCTION PLANNING AND ADMINISTRATION IN THE HOUSING INDUSTRY

J. M. Mønsted

After market surveys and development research have indicated the feasibility of industrialized production, buildings are mass-produced on the basis of preplanned designs. The housing industry is based upon technology, market demand, administration, labour force, finance and planning. Mass-produced housing can satisfy an increasing percentage of the urban need for low-cost units. Better-quality houses can be produced more rapidly with less labour than by traditional methods.

The manufacture of housing components is a particular specialization in the housing industry. The design of an appropriate model with some degree of built-in flexibility by an architect or by a system developer is considered. The break-even point for the housing industry is described. The introduction of housing systems requires planning of the production, sales, delivery, economy and control.

PREFABRICATION WITH GYPSUM

M. Parkanyi

The paper presents a new technological and economic approach to the problem of housing in developing countries, based on prefabrication in mobile factories. The simple manufacturing equipment of linear elements is easily transportable. The surface of the structure is assembled from gypsum elements. The application of concrete unites these surface elements. Since the surfaces are not load-bearing parts of the structure, the system is called non-tectonic.

The application of non-tectonic systems could open new vistas for building in the developing countries for the following reasons:

(a) Since natural or artificial silicate materials are found everywhere, light-weight constructions could be manufactured from them;

(b) The reduction of weight eliminates the use of mechanized equipment and lessens the effect of inadequate infrastructure;

(c) The combination of mass production of surface elements with in-situ concrete pouring permits the use of traditional materials and provides for handicraft forms of production;

(d) The low-cost technology combines the technical advantages of capital-intensive technology with the social and economic advantages of labour-intensive technology;

(e) Low capital investments are necessary for the simple manufacturing equipment.

PREFABRICATION WITH CLAY

J. Brytup

The use of clay building materials is an old tradition in almost all countries. The burnt clay brick has excellent engineering and aesthetic properties. Structural clay components are used in walls and floors. The advantages of prefabricated production of these components are outlined.

The design of brick panels is described in detail through various examples in use. The methods are evaluated for possible introduction in African and Middle Eastern countries. Several examples are given of the manufacture of floor slabs with various degrees of prefabrication. The choice of the degree of prefabrication facilitates the introduction of mechanization at any time depending on the economy, general technical level and infrastructure in a country.

PRODUCTION AND ERECTION OF AUTOCLAVED LIGHT-WEIGHT PANELS

C. Dobrescu

Autoclaved cell concrete is a new building material of artificial stone. It has the favourable characteristics of low weight, large compression strength in relation to the apparent density, absorption of sound, good heat insulation and minimal contraction.

A comparison is given of autoclaved cell concrete and traditional materials. Prefabricated elements of autoclaved cell concrete and their applications in several areas of the construction industry are explained.

PROBLEMS AND TRENDS IN PREFABRICATION OF HOUSES IN SEISMIC ZONES

E. Titaru

Laboratory and field research in connexion with theoretical analysis of building behaviour during earthquakes are summarized as follows:

(a) A structure can be safe against earthquakes if it possesses a high energy-absorption capacity, which will enable energy absorption during the seismic vibration. This energy-absorption capacity must not be damaged as a consequence of alternative repetition of the displacements in the postelastic range;

(b) For the safety estimation against collapse, the admissible elasto-plastic displacement criterium is to be used;

(c) The possibility exists for building prefabricated dwellings even in the strongest seismic zones without limiting the number of storeys;

(d) Resistant and ductile structural elements must be chosen, i.e. reinforced concrete, prestressed concrete and steel. Non-ductile and weak resistance materials, such as masonry walls, must be avoided;

(e) Simple shaped structural elements with sufficient strength and a high ductility must be chosen. Load-bearing shear walls and frames as well may be used. The structural system must be limited only to the minimum number of structural elements because the layout of the structural elements must be simple, clear and uniform;

(f) Light materials can be used in all non-structural parts such as interior partitions, doors, windows, floors and ceilings.

CONSTRUCTIVE FINISHING AND PROTECTION SYSTEMS APPLIED TO THE PRODUCTION OF WOODEN PREFABRICATED HOUSES IN ROMANIA

S. Iacob and N. Chelmeziu

The manufacture of prefabricated wooden houses in Romania uses wood-based particle boards and fibre boards as well as plastics and asbestos-cement insulating boards. On the basis of the experience gained at the Institute for Research and Technological Projects for the Woodworking Industry in co-operation with the manufacturers producing prefabricated house elements, the basic materials, construction methods and protective treatments are discussed. Laboratory tests of finishing materials revealed that the best results were obtained by plastering with plastics (polyvinyl acetate) and mineral additives.

The production technology is summarized. Its salient feature is the replacement of sawn timber by wood-based materials.

ASPECTS OF THE DESIGN, EXECUTION AND ASSEMBLY OF PREFABRICATED HOUSES

N. Topa

Since prefabricated structures are expected to represent 77 per cent of the total number of dwellings in Romania in 1975, continual co-ordination must be practised between the activities of design and research, production of prefabricated elements and the assembly on the building site. The principles underlying the Romanian development are explained. To avoid a monotonous façade while maintaining a sufficiently large series for an industrialized process, the design allows variations in the assembly of panels.

The choice of technology, the degree of mechanization and the production of large panels are discussed. They are all related to the volume of production as well as to the available technology and labour. Stress is placed on assembly operations that directly effect the desired quality and output. Organization and careful planning are essential both for the fabrication of panels and for assembly on the construction site.

THE DEVELOPMENT OF THE PREFABRICATION INDUSTRY IN ROMANIA

I. Vasilescu

In Romania, industrial buildings, residential housing and agricultural buildings are built from prestressed concrete elements. The maximum size of the elements is 24 m and the maximum weight 16 ton. The prefabrication of elements shortens the construction time, increases labour production, simplifies the over-all organization at the building site and reduces the consumption of steel and wood.

Prefabricated elements are produced in factories, on open areas near construction sites and on the sites themselves. Series production in factories is achieved with the use of metallic moulds. Most of the operations are mechanized.

The Central Industrial Department of Prefabricated Elements is responsible for most of the production of prefabricated elements. It is a group of large prefabrication factories with its own design and research centre. The production organization ensures that the transportation costs are less than 5 to 6 per cent of the value of the product. The production is based on the following conditions: standard components with diversification and economic efficiency, and sales planning. The production of reinforced and normal aerated concrete is developing as well as the production of elements from light aggregates such as granulite.

SITE PREFABRICATION

J. Hiller and I. Balashazy

The paper discusses the industrialization of the building industry in Hungary with emphasis on the development of open-air prefabrication methods, and gives examples of industrialized building products and simple, mechanized technologies that could be applicable in developing countries.

This industrialization was based on the following activities:

Specialization of design
Typification of the building elements
Development and improvement of structures
Use of new materials
Adoption of new building methods and technologies
Development and extension of mechanization
Training of workers

Among the advantages of the prefabrication of reinforced concrete elements on the building site itself are a reduction in the use of scaffolds and of the time required for the construction to be completed with corresponding savings in manpower. Furthermore, there is no lag in the production of structural elements.

PRESSURE PIPES OF PRESTRESSED CONCRETE

M. Halmagiu

The large quantities of water that must be transferred over large distances for the water supply of towns and industry require the production of pressure pipes. The technical and economic advantages of pressure pipes made from prefabricated concrete are compared to those of iron and asbestos-cement pipes. They include durability (about 100 years), safe operation, economical investment, rapid installation of the pipe with simple means, as well as the fact that no maintenance is necessary during operation.

After indicating the principal materials necessary for the production of prestressed concrete pipes (sand, gravel, cement and steel wire), the technological process is described as well as the method used for the control of production. The rapid method of joining the tubes into a pipe by using rubber rings is then described. The methods used for testing the pipes are also mentioned.

THE DESIGN, MANUFACTURE AND ASSEMBLY OF PREFABRICATED ELEMENTS IN INDUSTRIAL BUILDINGS

C. Ciolacu

Precast concrete elements are used in the construction of industrial buildings in Romania. The structures are made of truss girders and precast panels. The roof is either reinforced concrete caissons or cell concrete plates.

In 1972, more than 1.5 million m^2 of industrial buildings have been manufactured and assembled from prefabricated components. These buildings are being used in industries where metal constructions have been exclusively used previously, for example metallurgical plants and machine shops.

The versatility of the prefabricated elements has been furthered by the following measures:

Manufacture of large precast elements

Manufacture of secondary roof elements for prestressed concrete

Reduction of the number of parts and joints

The manufacture of reinforced and prestressed concrete elements can take place at the building site. This is advantageous because the same lifting equipment can be used for both mounting and assembly. Furthermore, the transport of the elements inside the building site is eliminated.

Annex

DESCRIPTION OF THE PLANTS VISITED

House Factory No.3, Budapest

The plant started operating in 1970 with a capacity of 4,200 flats per year, or 15 flats each day. At present seven different building types can be assembled from the elements produced in the factory.

The elements are produced one after the other in a continuous line. The concrete is delivered to the corresponding production bay by automatically operated carts. The production technology includes the following main stages:

Cleaning of mould
Steel assembly
Application of concrete and insulation layer
Levelling
Holding time
Steaming
Removal from mould
Application of surface finish
Installation of the doors and windows
Dispatch
Storage

About 5,000 bathroom units are also manufactured annually. Four different types of bathrooms can be delivered to a site completely fitted with pipes and electric equipment.

Plant No.1 Concrete and Reinforced Concrete Works (CRCW), Budapest

The network of CRCW plants is distributed throughout Hungary. The annual capacity of precast concrete components is 1 million m^3. The varied production includes the following products:

Industrial halls
Frame structures (2 to 10 storeys)
System buildings (up to 10 storeys)

Cellular prestressed concrete floor elements
Roofing slabs
Roof beams
Fill-in elements between roof beams
Reinforced and prestressed concrete pipes for sewage and fresh water
Subway tubing units
Precast piles
Lighting and power transmission poles
Light concrete blocks

Reinforced Concrete Sleeper Plant, Labatlan

Prestressed concrete railway sleepers are manufactured for the Hungarian Railways as well as for export. The sleepers provide a bond system that is suitable for meeting the stress requirements of heavy railway traffic.

The production covers every step from processing the raw materials and semi-finished products to the shipment of completed units. The raw materials are graded aggregates, bulk cement, wire and mild steel reinforcement. The semi-finished products include timber and/or plastic inserts.

The production is organized as follows:
Production line
Assembly line
Concreting line
Heat curing treatment
Dispatch line
Electric facilities

The annual production is approximately 10 million units. The technological equipment for sleeper factories have been exported to Bulgaria, Czechoslavakia, Iraq, the Syrian Arab Republic and the Union of Soviet Socialist Republics.

Prefabrication Plant, Veszprem, Hungary

Prefabricated housing elements are manufactured in this open-air plant. Blast furnace slag is used in the production of light concrete blocks. The

blocks are cast in wooden or steel moulds, removed and cured for 14 days. At the building site, the blocks are laid in cement. The method can be used for structures as high as five storeys. It is one of the most economical methods used in Hungary since the equipment and moulds are simple. Ready-mixed concrete is supplied to the building site from this plant.

The annual output is as follows:

Blast furnace slag	7,500 m^3
Reinforced concrete elements	5,500 m^3
Ready-mixed concrete	3,000 m^3

The plant is a good example of a small, flexible plant that can be realized without costly capital investments. This type of plant and prefabrication method could be a feasible approach in the industrialization of housing in developing countries.

Prefabricated Element Factory, Buzau, Romania

The production of various prefabricated elements was observed. One production line turns out large panels for housing. The output of other production lines includes elements for industrial buildings and telegraph poles.

Industrial Central of Concrete Prefabricated Elements Exhibit, Sinesti

A variety of prefabricated elements and building materials are displayed. Their use in construction is shown. Attention is directed to applications in the agricultural sector and in rural areas.

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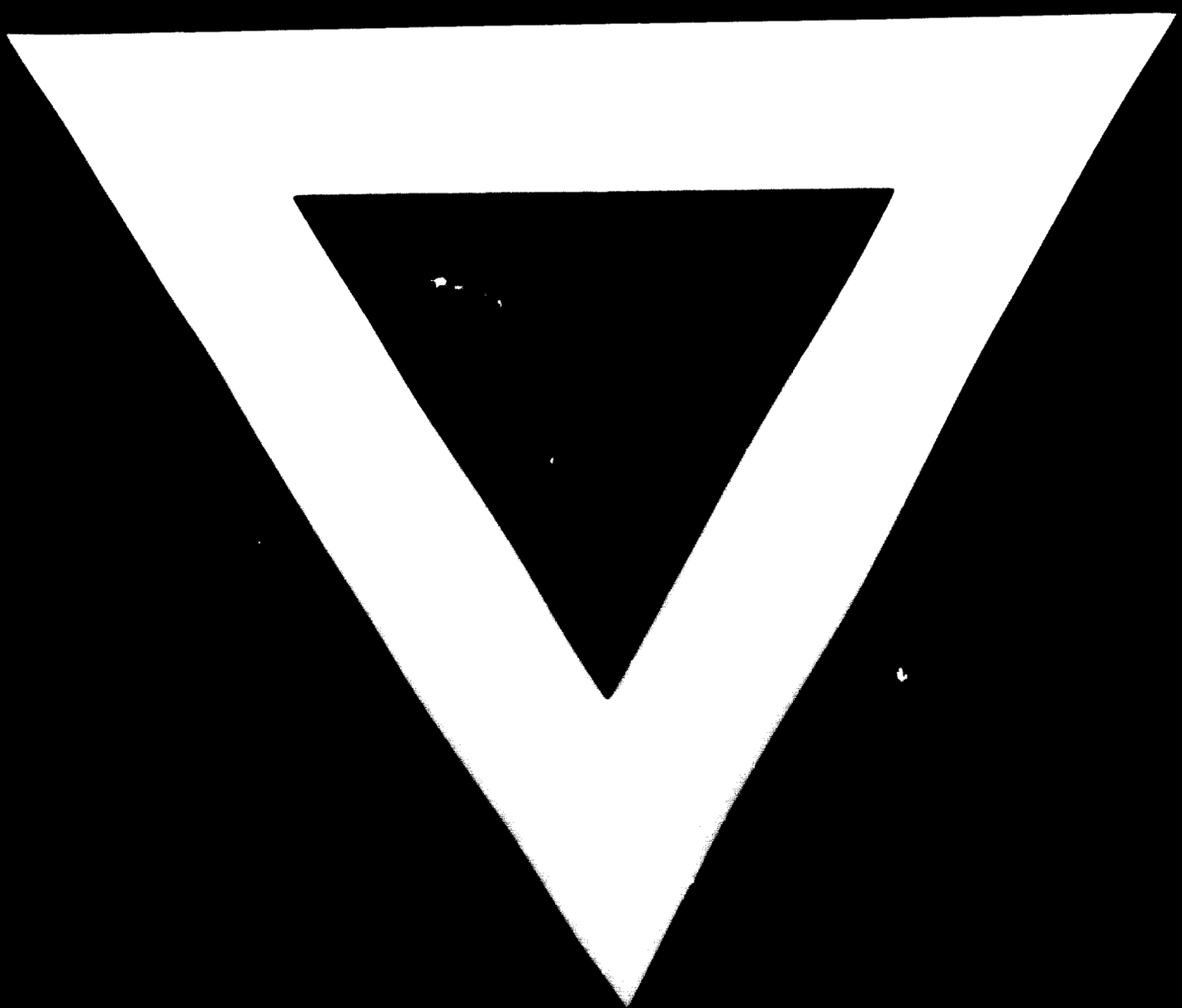

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