OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

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

06622

United Nations Industrial Development Organization

[illegible] EXPERIENCES [illegible] MASS [illegible] ASSEMBLY [illegible] PREPARATION AND EXAMINATION [illegible] PREFABRICATED [illegible] —

by

[illegible]*

* Head of Scientific Section, Institute of Building Science, Budapest, Hungary.

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards even though the best possible copy was used for preparing the master fiche

CONTENTS

"Number in parentheses refer to the corresponding numbers in the reference list at the end of the paper."

HUNGARIAN EXPERIENCE ON LOW COST (MASS) HOUSING ASSEMBLY OPERATIONS AND EXAMINATION ON THE SITE FOR PREFABRICATED HOUSES

INTRODUCTION

1. It is not accidental that the terms "low-cost" and "mass" were put beside each other in the title. The price situation is a determinant not accurate enough. That which is inexpensive for developed countries, is expensive for the developing ones. Because of its economic parameters, it does not suit the given socio-economic circumstances. Consequently, low-cost housing means that the solution selected is the most favourable, the most economical, thus inexpensive from the point of vies of

(a) material,

(b) manpower,

(c) capital

utilization for the country concerned.

2. If this optimum solution, or solutions have been found, then mass construction has a basis. The satisfaction of the housing requirements of the masses can be solved only in this way. It may occur that less expensive solutions could be also found, however, it is not possible to meet the mass demand by them because e.g. there is not enough manpower. Therefore, if a country is forced to select a more expensive solution because she is able to meet the social demands only in this way, then one can speak only of relatively low-cost housing. For this reason, it must be suggested, to adopt the term "mass housing", and

then it will be known that this means that, every country will produce that structure, from that material, with that technology which meets the socio-economic demands and facilities to a maximum extent, consequently which can be produced on the largest scale, which is the most favourable, realtively the "less expensive". The residensial typology of Zambia is used for the verification of this theorem (Table 1). It can be established from this, that the proportion of low-cost housing is 54 %, thus it is on the largest scale. It is also proved by the illustration, that the low-cost dwelling types of the developed countries are medium-cost dwellings in the developing countries, and are not produced on the largest scale. After such thoughts, how strange the inadequate term "low-cost" used for a long time appears. (1)

3. This reasoning appearing academic was necessary, why in Hungary it was not the cost of the solutions, that was primarily decisive, but the facilities of satisfying the demand of the masses in the shortest time possible, of course, with the most optimal material, manpower and capital investment.

4. The methods applied belong to certain known categories of the industrialization of building, according to the combination and proportion of the three above socio-economic parameters (material, manpower, capital). The structural systems and material-intensive, labour-intensive, capital-intensive technologies, respectively, have developed in connection with this.

5. In the follows chapter it is analysed:

(a) the principles of the development of building structural systems for mass housing

(b) the points of view of the selection of building methods and technologies

(c) the creating the conditions of mass housing in Hungary

(d) the technical and economic analysis of mass housing methods

(e) conclusions as lessons for the developing countries.

I. PRINCIPLES OF THE DEVELOPMENT OF BUILDING-STRUCTURAL SYSTEMS FOR MASS HOUSING

6. During the history of its building activity, mankind has used primarily the local building materials available in its environment. Technical qualities of the given building material determined the structural system in addition construction method, its material- and labour-intensive technology (MSM system). Today, the former, natural technical sense, experience and professional knowledge, strive even more with a conscious, complex design work, lead to the perfect technical solution, to assert the unity of material, structure and technology. The effective range of applicable material has become wider: in the course of development of society, on a certain level of scientific, technical- and economic progress, nowadays it becomes possible, by the international division of labor, to use not only local materials for building, but also products most suitable for the given building demands technically and economically according to the degree of development, as well as a capital-intensive technology. That is the main reason that in the developed industrial countries of the 20th century no national, or regional architectural style could develop which would be characteristic for the given geographic location for its style-prints, according to the particular material-, and in connection with it, according to the structural- and technological system as it was natural at the time of the historical styles. The application of concrete, steel and other up-to-date materials creates an international, material-centered style - or cosmopolitan architecture - after the historical styles of nations, countries and geographical units, respectively. It brings in its train the structural system, as an exact technical solution and to a certain extent as a technology, which is already the function of the given place, the technical development level, farther the labour or capital intensive consequence of the national economic circumstances.

7. The structural system becomes a uniform system with, to the load-bearing structure assigned supplementary structures. On the level of industrialized building, unity is carried by dimensional coordination and by the jointing system. The existence of large series is justified by these two poles. The building method is the epos, the technology the assembly operations of the given structural system. According to the application, material, labour and capital content of the theoretical technology, several systems can be distinguished within the method, which completely determine, when the object belongs technically and technologically.

8. Mass housing, especially low-cost mass housing as a demand for large series, is also conditioned upon these principles, striving of cours to use local materials in as great extent as possible. According to the character of the load-bearing structure, the building system accommodating to the local materials represents linear, or point-like load transfer. The physical-mechanical properties of the materials of wall structures determine the linear or point-like vertical structures, and the materials applied as horizontal load-bearing, covering structures determine the distance between the vertical load-bearing structures, the span. The repetition of the vertical and horizontal load-bearing structures constitute the load-bearing part of the building system. Such solutions of the load-bearing structural system determine the materials and solutions applied for the space--enclosing structures and select according to the technical and economical parameters of the load-bearing structure.

9. The application of materials and structural systems most favourable technically and economically, determines certain operations, means that is the technology of realization, consequently the building method as a complex structural--technologycal category. The building method, as an agglomeration of activities bringing about the object necessary for the users, should also meet a requirement system which can be concentrated in two poles. These requirement poles are of technological and technico-economical character.

10. The variability of the building method can be derived from the variability of the structural system. By means of the dimensional order applied, the components of the building system posess the ability of variability which should be made possible by the modes and equipment of the production of the elements. Thus, the building method should follow the dimensional order of the building system as an ability of structural variability, and it should follow the varying optimal production method expressing the development level of the industry, as an ability of technological and economic variability. Thereby, on a low level of development, building systems based on mass production by traditional building methods, parallel with economic development will be possible to replace, by more industrialized building methods. In countries possessing a manpower surplus, the aim of industrialization is attributable either to time-saving, or material-saving purposes, or rather, industrialization is justifiable only if these aims are satisfied.

11. It follows already from the foregoing, that mass-produced low-cost, whether it is based on total, or partial financing by the state, or on the private resources of the population, may take place only by the application of a material-saving building system and an economical building method. The utilization of local materials with material production located in a decentralized manner, is necessary in order to save transportation costs and because of unsatisfactory quality and quantity of transportation routes, respectively. It is expedient to select such building methods which can be performed under the direction of few skilled workers, by unqualified manpower coming from agriculture. In consequence of its ability of variability, the economical building method can be applied in the utilization of the local materials to be found in the different regions as well.

12. When formulating the building system, it is necessary to coordinate the structural system and the constructing method to an ever increasing extent, according to the degree of industrialization of assembly operations. In the case of

In traditional building systems, the tasks can be performed with more improvisations, on-site solutions, ideas, of course, in such cases the experiences of well-trained experts are desirable. By the industrialized methods, the specified technology, the series of operations fixed in time and space can be performed by a less trained, semi-skilled labour force as well.

13. A definite structural system realizable from given materials can be created with different time, labour and cost inputs as a function of the given building experiness and equipment. The proportion of productive forces, necessary for the realization of the different structural systems varies: the proportion of manpower and means of production, the developments level of the means of production is various. The different building processes (traditional, rationalized, industrialized) can be applied according to this in countries being on different levels of economic development.

14. Different degrees of industrialization are known according to the development of the national economy. The most ancient housing activity, after the occupation of spaces by nature, was creating artificial spaces. The local materials, as a function of the geographical conditions, resulted in the creation of heavy, or lightweight structures. Although it is not the purpose of low-cost housing to apply the most ancient methods, their modernized versions can be utilized excellently, whether monolithic wall structures made in shuttering, or masonry wall structure, or pile dwellings are taken into consideration. Geographical conditions frequently enforce the mixed application of these as well (for example, in India threatened by floods stabilized dirte walls are made between prefabricated reinforced concrete framwork, as very economical structures. The flood damages only the filling wall, the load-bearing structure of the building does not suffer damage).

15. The application of such rationalized means and methods by the on-site construction of traditional structural systems, make the sequence of operations, ma-

terial production, material handling, installation, transportation more rapid, better organized and, not in the last place, easier. Human labour is becoming more expensive even in those countries which still possess large surpluses at present. Therefore the rationalization of on-site labour, though with a low capital-intensity yet, is already a question which can no longer suffer delay. By these equipment, the quality of the building, as a social demand, can be achieved better, and building time can be reduced. These means include the different dimensionally coordinated shutterings applicable several times, without expertness, panel formwork systems, aids facilitating and accelerating walling, concrete mixers, minor transporters and lifting devices, as well as the small machines of finishing works.

16. It is expedient to solve the rationalization of on-site works by increasing the dimensions of certain structural elements, by the application of hand by blocks, two-handed blocks, (by possible on-site production and in minor, decentralized building element factories, respectively), or by floor beams, floor elements, floor blocks, filling elements manufactured at on-site prefabricating plants. By this partial prefabrication, the market can be supplied with variable components. The concentrated production of structures eliminates the qualitative defects occurring in the case of unit production, and assembly - by training - can be also performed with less qualified labor.

17. The mass housing of the developed industrial countries, the so-called social-welfare housing, applies the prefabrication of large elements, the large panel systems, on a large scale for the relatively low-cost housing there. This degree of industrialization requires building element production more or less concentrated, good road system for transportation, a park of vehicles of transport, as well as a series of lifting machines, thus a rather high degree of general industrial development. Almost the same level of industrialization can be achieved by the panel-forworks and tunnel shutterings system usable several times as well. For these methods, the link of the structural system involves

the application of non-local materials too, the application of concrete and steel, assembled, interlocked structures. The development of these structural system is conditioned upon a properly trained team of technicians and engineers, whose schooling for the developing countries is also a task to be solved. (2)

II. POINTS OF VIEW OF THE SELECTION OF BUILDING METHODS AND TECHNOLOGIES

18. The choice and or the decision of appropriate technology can be based either on economic considerations or on social examinations. Generally, in order that the choice has sound economic basis, economic considerations are given considerable weight. There is need to identify the various combinations of labour, materials as well as equipment requirements as alternatives for undertaking specific construction operations and to reduce it to the same economic base for purposes of comparison. The use of shadow prices, and thus the national economic costs in costing public works construction or materials costs can have two important consequences in the choice of appropriate technology. First, a method of accomplishing a specific construction operation which might be considered uneconomical in terms of financial costs alone may be found to be desirable or economical in terms of national economic costs, and secondly if various construction methods vary in the degree of labor or capital intensities are considered for a given project, the least national-economic-cost method is likely to be more labour intensive than the least financial cost method.

19. In considering the economic considerations for economic aspects of the choice of appropriate technology for construction therefore, these various concepts of cost must be taken into account in the collection of data. Therefore the various cost data using all these consepts of cost must be adopted for all the costs components.

20. Cost of materials in terms of both financial and economic costs. With regards to the cost of machines, account should be taken of operating costs as well as the availability of power or the correct fuel for its operation. The probable life and amortization costs as well as costs of maintenance and repairs. There are other factors which are of tremendous importance in the choice of machines in developing countries and these relate to the availability of mechanics to operate such machines and to make the necessary repairs as well as the availability of spare parts. These, however, have direct effects on the operating costs, on the probable life as well as cost of maintenace and repairs which can be assessed.

21. Regarding labour costs such additional costs may have to be taken into account and added to the actual wages. These include social benefits, special transport and in many civil engineering construction special accomodation when the construction site is far from the workers' residence. Where productivity is very low as a result of more skilled amongst workers and where improved efficiency and productivity can be achieved through training, this should be taken into account. Techniques such as on site pre-fabrication using non-mechanised methods for the production of some components and careful planning and control of actual operations may reduce labour costs further. (3)

22. Besides the socio-economic points of view of location, taking the appropriate shapping of the environment into consideration, the building system and method of low-cost housing should conform to the local material sources in a maximal degree.

23. In addition to the local material sites, the detail solutions of the system building are determined by the geographical endowments and other environmental effects. The economic development, the rate of employment are essential criteria of the consideration of the building method. (2)

24. The provision of dwellings can be regarded as a service almost paramount to human rights, is the task of every government. This objective can be achieved with different degree of equipment, in different qualities, in different schemes, according to the given economic conditions: as a full allocation by the state, with a long-term credit for people with low and medium income. (Site and Service Programmes - S+S Programmes). (1)

25. The objective should contain the building programme of communal buildings: kindergartens, schools, health centres, libraries and occasionally - according to the requirements of the society - even churches.

III. CREATING THE CONDITIONS OF MASS HOUSING IN HUNGARY

26. During the elaboration of industrialized building methods, this in the case of mass housing as well, the solution of the folbwing tasks is necessary:

(a) material research, the exploration of raw material sources,
(b) determination of the technical characteristics of materials,
(c) exploitation on an industrial scale, allocation of the fields of material utilization, solution and organization of material production,
(d) assurance of the production of material of permanent quality,
(e) research on structures and building method, technology,
(f) laboratory testing of prototype structures,
(g) construction of a model part of a building,
(h) construction of prototype buildings and their technical-economic evaluation,
(i) making the plans of type buildings, or type structures which can be built on a large scale by the industrialized building method, on the basis of the evaluation.

28. The process of the industrialization of the building industry is much slower than that of other industrial branches. There are financial and conceptual reasons for this too, but frequently the compelling effect of circumstances also does not assert itself in the same way as in other industrial branches. Technical development under the uniform state-direction and the nationalization of the building industry made their effect felt in Hungary, too.

28. After World War II, the industrialization of building had neither material, nor structural, nor production, nor research basis in Hungary. In the course of reconstruction, primarily the possibilities of the industrialization of the traditional building methods - as the lowest degree of the industrialization of building - had to be created. The available low-capacity handly blocks manufacturing devices (Rosakometta, etc.) and floor beams manufacturing moulds formed that production basis which was destined to lay the foundations of the industrialization of the traditional building method.

29. The industrialization of building manifested itself in the application of new material, lightweight concrete varieties differing from the traditional materials, using larger structural elements, but still with masonry character. The first step was taken in the 1950's with the material technology research activities (cinders, fly-ash, tuff varieties, blast furnace foam slag), with the application of up-to-date block manufacturing equipment (e.g. Waimer) and with the elaboration of a block form satisfying the up-to-date requirements of masonry technology and thermal insulation. On the basis of experiences gained with experimental buildings constructed with different up-to-date handly blocks, it became possible to spread the handly block building method - having left the experimental stage - generally, primarily for builders of family houses. In the Second Five-Year Plan, this need had to be satisfied by a production capacity corresponding to 75 million brick units. (4)

30. For the construction of the 1 million dwellings and communal buildings belonging to them, envisaged between 1961-1975, the industrialization better approaching methods also had to be adpoted.

31. These methods representing a higher level of industrialization - such as the block, large-panel, cast in-situ, etc. building technologies - will be discussed in detail further on, following with attention the development of the industrialization of building, too.

IV. TECHNICAL AND ECONOMIC ANALYSIS OF MASS HOUSING METHODS

A. Block building method

32. In the city, the new housing estates of towns in the framework of state investments - were constructed with traditional building methods (mainly with 2-3 story dwelling houses having brick wall structures) until 1960. The 15-year housing construction programme adopted in 1960 provided also for the rationalization of the technical methods of mass housing. In accordance with this, in the 1963-63, the first stage of housing with prefabricated structure, the so-called Block technology (building elements of medium and story height, resp.) was introduced on a national scale, by means of which approximately 120 thousand dwellings were constructed in nearly 100 settlements of the country in 13 years. Fifteen outdoor plants "polygons" (manufacturing the wall elements of 400-1200 dwellings annually each were established, which manufactured elements with max. 800 kp ("medium block") and 1600 kp ("large block") weight limit by a uniform ("typified") production process, worked out experimentally in advance. At that time (between 1960-62) the task of type designing was the development of the ground-plan and structural systems of block-type residential buildings, - the harmonization of of the requirements of dwelling function, urban design, production technology and economic efficiency, - the drawing-up of series of uniform type designs valid all over the country. The series

consisted of 27 alternatives of 5 basic designs. (The alternatives contained solutions with different number of storeys and heating systems). A uniform structural catalogue belonged to the series of designs, containing the designs of floor, stair, lintels, etc. reinforced concrete elements, joinery and locksmith products etc. produced in large series.

33. The growth of the volume of state housing necessitated the rapid development of building technology, the significant reduction of building time, on-site labour-intensity and building costs. In view of the fact that approximately 30 % of the total volume of housing envisaged all over the country consisted of three and four-storey buildings, in the framework of state housing, prefabrication had to be developed to the greatest extent in this category. We had to spread the medium and large block building method using lightweight concrete as basic material. Where the application of lightweight concrete was not economical because of the great transportation distances, the building method using prewalled brick blocks had to be introduced. Practically, the floor structure of these buildings may be of floor panel type prefabricated in plants. Of course, the new building methods required appropriate mechanization both in the field of transportation, loading, lifting, as well as finishing and sanitary engineering works.

34. The introduction of the block building method, already at the time of starting the programme, was the first stage of the industrialization of state mass housing.

35. The correctness of the programme announced in connection with the block building method is proved well by the figures concerning the dwellings constructed with this method (Table 2.)

36. As it appears from this brief review too, the building department has realized an extremely well-considered, purposeful concept of which it can be subsequently established that it has been successful, by the introduction of the block building method.

37. In the preparation of this programme - which can be traced back in many cases to the years 1955-56 - as well as in its implementation, building research has played an important part. It can be established that, in close co-operation with the designing and building organizations interested in the programme, it significantly contributed:

(a) to the exploration and evaluation of foreign examples which could be taken into consideration in the determination of the way of Hungarian development,

(b) to the adaptation and further development of well-proved foreign solutions,

(c) to working out experimentally the orlginal solution suited for the Hungarian conditions and to their industrial introduction.

38. Attention turned towards lightweight aggregate concretes already at the beginning, of which the most precious ones, namely, expanded clay gravel and fly ash gravel concretes could not be taken into consideration because of their high production costs. Of the tuff and slag concretes which could be still taken into account, finally foamed blast furnace slag concrete was introduced generally as a solution approaching the technical-economic optimum best. Prewalled and vibrated brick blocks were made in those regions where this was justified by the transportation problems of foamed blast furnace slag, while cinder blocks were made where this was made possible by the reliable quality of the available local basic material. The production of the latter remained insignificant compared to the total volume of block production.

39. Our research organization, accommodating to the territorial distribution of housing, has made the technological designs of an aggregate-type medium block

producing plant with 20 m^3/shift capacity and of a stand-type one with 45 m^3/shift capacity, as well as of stand-type large block producing plants, together with the necessary sanitary engineering and auxiliary equipment (two-cantilever portal crane, moulds, star-type metering devices, block-clamping scissors, containers for concrete transportation, etc.). By the adaptation of the type technologies of the plants with 20 and 45 m^3/shift capacity and their generalizable execution plans, respectively, seven medium block producing plants were constructed in the years 1960-61, at the following places in chronological order: in Dunaujváros, Kazincbarcika, Miskolc, Győr, Tatabánya, Budapest, and Debrecen.

40. The next stage of development was meant by changin over to the production of large blocks. As a result of the realization of the comprehensive concept determined at the beginning of the development of the building method and of the successful solution of the large block formwork presenting the main problem, it was possible to carry out the change-over with the replacement of the formworks and certain manufacturing tools, but without the interruption of continuous production, and with retaining the original machinery. Such change-overs took place in Tatabánya, Miskolc, and Debrecen, while in 1964, the Kecskemét plant transferred from Dunaujváros because of the starting of the mass production of foamed blast furnace slag panels, started originally with the production of large blocks.

41. It was in the framework of this development work that the new-type, reinforced, two-vibrator formwork was introduced as against the six-vibrator solution used until then. The medium block producing plants still operating also changed over to this type of formwork, and in consequence of this, it was possible to prove the qualitative improvement of the products and the increas of the service-life of the formworks in all plants.

42. In achieving the results which can be already proved by factual data today a decisive role was played by the fact that the building department was able to ensure the close and lasting cooperation of research, designing and building or-

ganizations, the rapid and efficient assertion of interactions, in the framework of a definite development concept. Ultimately, it was possible to achieve everything which has been realized in this field as a result of the joint work of all the cooperating and directing organs. (5)

13. The characteristic data of block type designs are as follows:

(a) 2, 3, and 4-span sections, 4-span box houses;

(b) 1, 1 1/2-room bachelors' apartments, 1, 1 1/2, 2, 2 1/2, 3, 3 1/2-room dwellings with full household, with 28-75 m^2 footing area;

(c) prefabricated wall blocks of mezzanine and storey height, with blast furnace slag, cinder and brick basic material, with 29 cm wall-thickness, with 60, 90, 120 cm block width;

(d) prestressed reinforced concrete floor boards, for 2,40 m and 3,60 m cross wall span, with 0,60 m and 1,20 m width;

(e) prefabricated reinforced concrete flight of stairs, landings, crown formwork elements, loggia-floor slabs;

(f) standardized series of wooden door and window structures, steel stair and balcony rails, staircase windows;

(g) traditional finishing works;

(h) traditional sanitary engineering structures and prefabricated banks of pipes, respectively, or prefabricated mechanical erection boxes;

(i) alternatives of type designs of central radiator heating, gas convector and individual (stove) heating;

(j) energy-carriers for cooking and hot-water production: gas and solid fuel, resp.;

(k) built-in kitchen furnishings and storage cupboards;

44. The main technical and economic efficiency results of block-type housing carried out on the basis of the type designs were as follows:

(a) compared to the traditional building with brick structure, the on-site labour requirement was reduced by 400 man-hours (20 %) per dwelling, and the on-site building time of 5-storey dwelling houses decreased from 12 months to 9 months;

(b) the savings in costs achieved by means of the first 50,000 block-type dwellings was nearly 2 thousand million forints between 1961-70.

45. The adaptation of the block type designs to the site was directed by the building department by relatively rigid regulations. Essentially, the designs had to be applied without modifications, and this fact - in consequence of large-volume building on a national scale - led to a monotony in urban design, though at the same time it undoubtedly ensured the uniform, rapid development of interior decoration on the one hand and of building technique on the other.

46. The example outlined is a characteristic case primarily of strictly centralized typifying, determining the entire building process. It was necessary to evaluate the entire building method and the individual questions of detail in every stage of the introduction of research for the programme. The evaluation included the experimental buildings (for example: Hamzsabég Road, experimental buildings in Dunaujváros), type designs, the location of prefabricating plants, their design, equipment, the individual structural elements, the blast furnace slag basic material, the devices of block production, etc. The Ministry of Building and Urban Development established the prefabricating bases on the basis of our evaluations, and the large-scale change-over from medium-block construction to large-block construction also took place on the basis of this. It was the continuous analysis of block-type building which contributed to the fact that the building method requiring a considerable state subsidy at the beginning has become more and more efficient.

47. Our investigations analysed the advantages of block-type building, which manifested themselves primarily in a great increase of productivity and in the reduction of costs. Block-type building increased the productivity of the production of the wall structure to six-fold of the former, and it reduced costs [illegible].

48. Courses were organized to spread the building method all over the country, where the experts of construction acquired the knowledge concerning on-site operations.

49. The Technical Specification published at the time of the introduction of the building method prescribed to achieve the results. This regulatory publication contains the [illegible] principles of [illegible], the rules of the structure, the practical and statical concrete [illegible] specifications concerning the production, quality and assembly of the blocks.

50. On-site construction work should be started by the collation of the working plans. For the assembly operations, it is necessary to prepare the partial time calculations of the plans of lifting-in, of the assembly schedule, the assembly and transportation plan, the summary table of time, the assembly schedule, the schedule of truck consignments, the layout plan, as well as the specification of the technology of the assembly of elements.

51. Assembly may be started after the acquisition of the necessary machines and working tools, after the preparation of assembly and the organization of the continuous line of transporters.

52. Prior to starting assembly, the surface of location should be prepared, the block walls should be aligned by means of a land chain. Assembly should be started by the location of the master elements. The stay frames may be removed and the assembly of the floor panels may be started after the solidification of the morter binding the wall blocks.

54. The number of the group of persons performing the assembly is 12. At the depot 1 person selects the elements, and fits the clamping device on them. 3-4 persons receive, locate the elements, and spread the bedding morter. 1-2 persons fill the grooves and the joints. In the location of the floor panels, 1 person selects the elements at the depot, 2 persons, standing on the scaffolding spread the bedding mortar, 2 persons receive the elements on the floor level. When the floor section has been completed, 1 person fills the joints. The foreman does the alignments, directs location, controls transportation and assembly. 2 scaffolders assemble the cantilever protective net.

B. Large panel building method

1. It is our intention to give some information about the method of research too by reviewing the research activities. The early period of panel-type building in Hungary falls between the years 1952 and 1958. Laboratory experiments were performed primarily in respect of applicable building materials. The housing estates of Csepel and Tát consisting of so-called medium-panel, single-storey fly-ash concrete houses, moreover the two storey dwelling houses in Budaors Road with the same structure were built as a result of these experiments.

55. Parallel with the construction of the experimental buildings, the designing of the structures of large-panel building and the testing of their heat power engineering properties were in progress at the Institute of Building Science. As a result of the research, design documentations of framed and frameless multi-storey buildings were completed. The alternatives of the design solution with "cellular-variation," with optimal element family, were aimed at the realization of differentiated dwellings, buildings with different number of floors and panel-type town districts which can be forme from these. The primary objective lf laboratory research activities was to determine the heat power engineering and permiability properties of the joints of externel, facade elements, respectively

the method of improving the solutions, among others, on models of 1:1 scale placed in climate chambers, as well as by means of thermaltechnical measurements carried out on the already completed experimental buildings in Csepel, in the winter of 1959-60. These activities laid the foundation of Hungarian panel research, and they were significant and initiative internationally, too.

59. At that time, research included the studying of foreign panel systems, and a proposal was made on the basis of foreign experiences for the introduction of panel systems based on Hungarian raw materials. In addition to the layer designs of the facade wall - examined from the termal technical point of view -, the proposal contained the detail solutions of gusset joints, as well as the most important technological principles of manufacture. Consequently, e.g. the method of [illegible] of the panels for the stratification of intermediate [illegible] from the point of view of acoustics and thermal insulation, respectively, and in the interest of a less restructed ground plan, the unidirectional load-bearing floor was included in the proposal. Another proposal was made for reducing the quantity of partition-walls and for the designing of a bathroom box unit ensuring a combined sanitary engineering shaft.

58. The panel buildings in Pécs and Dunaujváros, constructed in 1959-61, may be regarded as the prototypes of mass housing based on local material as Hungarian systems. Here, because of the problems in connection with the production process and the immaturity of the assembly technology, the "traditional" structural methods of the block building method were applied (joints filled with morter, butt-jointing, etc.).

59. The experiences gained with the experimental buildings were already in the possession of research, the results of research became known in the industry too, thus their effect manifested itself in the field of mass housing as well.

60. In the course of further development, the earlier results of the research work, such as the system of dowelled floor beams, were introduced with the type of panel houses of medium height.

61. The filmlike sealing method proved to be suitable in the repair of the prototype building in Pécs was applied on the other defective buildings too. For new buildings, the foreign Secomastic HP putty was used as a sealing mastic for joints.

62. In the early 60's, the foundations of mass panel construction were laid by the location of imported Soviet housing factories. The thermal insulation and acoustic investigations performed in connection with the technical-physical evaluation of the experimental building constricted from the elements produced by Budapest Housing Factory No. 1, as well as the compression tests of the slag wool insulation layer called attention, among others, to the deficiencies of the heat-insulated facade panels - which can be eliminated during manufacture - as well. The large-panel buildings of the new housing estates were constructed by making use of the results of the investigations.

63. Research had to answer further questions - depending on the structures, materials and technology selected - in the period of the designing of high-capacity housing factories. For instance, in connection with the Győr-Miskolc Housing Factories, it was necessary to prove and to evaluate the novel fixing method of wall panels on the basis of experiemtns: experiments concerning facade finishes which could be fitted into the production process planned were also needed in addition to the strength, heat power engineering and wind driven rain tests. (6)

64. In respect of brick panels, the technological designing of the polygon in Békéscsaba, for which the structure of the panel, as well as the joint solutions had to be elaborated, also took place in this period.

65. The establishment of Hungarian housing factories requires research activities - laying the foundation of the future replacement and renewal of the manufacturing plants - on behalf of the production process research team.

66. In 1962, in the course of the investigation of the designing and production process problems of panel manufacturing plants, parallel with the problems of building technology, research was already concerned with assembly operation and with the development of side of assembly existing in the industry, respectively with the development of new aids of assembly.

67. The characteristic data of housing factories and panel plants operatin at present and being in the process of preparation, respectively, are given in Table 3. As evidenced by the table, Hungary will possess a panel production capacity of approximately 35,000 dwellings/year by 1975. (7)

68. In the beginning, the type designing programme in connection with panel-type building consisted of housing blocks of medium height, containing six 3-span sections, with 180 dwellings. In general, the technological system of the housing factory and the structural solutions of the type design were determined by the original Soviet type technology. Later, the modification of the 3-span type sections and the introduction of the type design of the 6-span, 5-section buildings of medium height also took place. In the course of reconstruction, the horizontal 5, 6, 8 and 10-section blocks of medium height in housing estates were built with a crosswall span increased to 3,60 metre. By the type design developed for Housing Factory No. 2, housing estates consisting of 4 and 6-span building blocks of medium height, with central corridor, joined by a separate staircase tower, were established, in which two-room dwellings with internal kitchen and 2,5-room dwellings with external kitchen were constructed. Here, the cross-span was 4,20 m and 2,70 m, respectively.

69. In the course of development and in order to meet social demands on a higher level, the principles of typifying were determined in the following, revising the cell variation system of typifying suggested already during the late 50's (see 55.), according to the following principles:

(a) it should be made possible that, by the optimal utilization of the production process, a comprehensive series of variations could be envisaged in the functional solution of dwellings and in the architectural design of the buildings, already at the time of the determination of the programme of typifying.

(b) A relatively small number of alternatives of prefabricated elements, the establishment of a uniform series of moulds, the productivity and economic efficiency of manufacture should be ensured by the specification of ground plan and structural type elements ("functional cells").

(c) The possibility of the various application of type-cells should be ensured by the preliminary elaboration of dwelling, section and building alternatives.

(d) Type-cells should be determined in such a mannaer that they should be in conformity with the optimal footing area data envisaged in the guiding principles of dwelling design on the one hand and that they should accommodate to the structural dimensional order following from the production process on the other.

(e) The module dimensions of the cell series of the ground plan determining the dwellings are as follows: 5,40 m x 3,60 m, 5,40 m x 2,70 m, 5,40 m x x 2,40 m, 5,40 m x 2,10 m.

(f) To these, as an auxiliary internal dwelling field, 3,60 x 3,60 m, as a corridor field, 1,80 x 3,60 as a staircase field, 5,40 x 4,20, and 5,40 x 7,20 m were added.

70. With the panel-type building method too, especially in the early period, local, natural and artificial (industrial wastes) materials were used: blast furnace foam

slag, "keramzit", etc. These materials were applied for the construction of five-storey buildings, as homogenous structures. In general, the structure of buildings of medium height is the reinforced concrete structure applied all over the world, and the external wall panels consist of three layers, with mineral wool, or polystyrene foam thermal insulation. Formerly, the external horizontal and vertical joints were made with elastoplastic sealing mastics, but around 1970-71, the open joint solution was generally nationalwide introduced.

71. In order to spread the panel-type building method all over the country, the team of skilled workers and engineers acquired the necessary knowledge of the production process and the assembly technology on a study tour in the Soviet Union lasting for several months. As a result of this action, respectively by imparting the knowledge of the experts trained there in courses organized in Hungary, today sich a designing and executive team is already available, whose activity can be instructive in many cases even for the master.

72. The Technical Specification published already in 1967 also greatly facilitated the realization of the building method. This regulatory publication contained the designing specifications, the knowledge concerning the designing of the structural system, the dimensioning for strength, laving great stress on the specifications of the content of building technological designs which are indispensable with this building method and which should be made especially in great detail. The Technical Specification contained detailed principles of product testing, qualification and acceptance as well. It discussed with high priority the safety specifications, reviewing in detail the operations of building technology, the necessary devices and machines. Last year, the Specification, discussed in the foregoing, was revised on the basis of practical experineces of more than 5 years, and a regulatory publication consisting of 3 main parts will be available to the experts of designing and constructing organs concerned with the panel-type building method. This revised Specification summarizes the questions of designing and dimensioning, tolerance values, and qualitative requirements on the basis of Hungarian and foreign

sperience, taking the new dimensioning standards into consideration. The part concerning testing and qualification provides for ensuring proper quality serving the interests of the society by specifying the entire system of quality control, from the testing of the basic materials and semi-finished products of factories, through the qualification of finished panels, to the acceptance of panel buildings at the building site. The part concerning technology, specifies in detail the knowledge of collation, drawing-up and contents of the designs of the production process and building technology, it discusses the basic principles of assembly, the surveying operations preparing the construction of panel buildings to be performed continuously during assembly, all the operations of the production process, the method of the production of products of trades and sanitary engineering products produced in plants. It also regulates the technology of transportation, the technology of building assembly, together with the machines and aids, as well as their dimensioning specifications, thir use, safety technique, specifying in detail every phase of the assembly of panel buildings, touching upon assembly in winter, then the regulation of the technology is closed by specifying the technology of on-site finishing works.

73. In order to spread the panel building method in a wider field, it can be applied in the field of private housing as well. The designs of apartment houses and family houses have been completed, and some of the housing factories have constructed the first prototype single-storey family houses. In our view, the method can be also used for the construction of communal buildings, namely, communal buildings of dwelling character, motels, hostels with panel structures. By these solutions, this high-level solution of the industrializatio of building can be extended to these edifice types on the one hand and the capacities of panel factories can be utilized more uniformly by the extension of the range of products on the other.

74. To increase the productivity of the panel building method, especially the construction of bathroom and kitchen units will be introduced, and bathroom units will be applied at every Housing Factory and Panel Factory by 1975. By this solution, the building of the bathroom is reduced to about one-fift at the building site.

Further [illegible] units were applied at the Dunaujvaros and Gyõr Panel Factories, [illegible] elements.

. [illegible] economic investigation of the panel-type building method, in [illegible] necessary to take into consideration the social need already mention[illegible] according to which the quantitative satisfaction of the housing [illegible] qualitative one was expected in the middle of the second half of the [illegible] even if the building method selected is not the [illegible] be established that the primary advantage of [illegible] cost reduction, but the production of the dwelling is [illegible] average working area into consti[illegible] additional building [illegible] slower execution of [illegible] It is [illegible] the number of workers and experts necessary [illegible], the application of the large panel build[illegible] Hungary is a vital social interest.

C. Cast "in-situ"- monolithic building method

76. The cast "in-situ" building method, as one of the industrialized building proces can be put into the service of more productive building, with the possibility of mechanization, with a lower skilled worker requirement, with a shorter building time, with continuous organization, thus, all these considered, with a reduction of costs. In this case, industrialization is not the on-site assembly of elements but the possibility that the load-bearing structures can be made in a formwork system usable several times, with mechanization on the site.

77. The degree of preparedness of the cast "in-situ" structures can be increased by development, and it may approach the high degree of preparedness of elements

produced in series. However, the investment cost of the cast "in-situ" building methods is considerably lower, the applicability of formwork units produced in series is more differentiated. The distance of transportation required by the less concentrated building sites situated far from each other is also a slighter loading factor both technically and economically.

78. The rubble and industrial waste materials available in large quantities after the First, but especially after the Second World War justified and promoted the construction of no-fines, lightweight concrete buildings cast between formworks in several European countries (Poland, GFR, Austria, Rumania, Croat, Britain, etc.).

79. The so-called plan "C" of 1957 of Hungarian housing assigned an important role to the on-site industrialized monolithic building method, the cast "in-situ" building method as well among the technical development objectives concerning the Second Five-Year Plan besides the industrialized, prefabricated building methods. Though at that time its significance was not quantifiable, its technical application for single-storey and multi-storey buildings was considered to be adequate in a wide field of the industrialization of building.

80. The cast "in-situ" buildings of medium height of housing estates produced advantages in town planning, too. In addition to this, this building method was in conformity with the current concept of economizing with steel, for it made possible the construction of 10-storey buildings without a reinforced framework structure, but with lightweight concrete load-bearing walls without reinforcment.

81. The cast "in-situ" buildings handed over during the Second Five-Year Plan and structurally completed made up 3 % of the volume of state housing. The Third Five-Year Plan already envisaged state housing with a rising tendency, 8-17 % of it annually (13 % on the average) with the cast "in-situ" building method: in areas outside the boundaries of panel-type building districts with ÉTI-N build-

ing technology or with a developed version of this, up to 10 storeys, and constructed partly with panel forms, partly with sliding shuttering over 10 storeys.

2. According to economic efficiency analyses, there was 14 % cost reduction compared to the traditional method, 7 % compared to the Hungarian norm. Compared to the traditional method, there was 25 % reduction in labour requirement, 20 % in building time, and 9 % in building weight. By the application of the ÉTI-DOLFPOD panel form building method providing a finish not requiring plastering, in order to reduce labour requirement on the site, technical-economic indices improved further, by approximately 20 % compared to the level achieved by the ÉTI-N technology.

3. Systematic research started in 1958 at the Institute of Building Science. Such a building method had to be elaborated which could be spread all over the country. As an objective, the formwork system usable several times, the assembly operation and the concrete technology had to be elaborated in a complex manner. The basis for starting, the fixed point of research was to produce a homogeneous wall suitable from a structural point of view (load-capacity and building physics). An analysis of international practice showed that the load-bearing, heat-insulating cast "in-situ" walls can be made expediently from concrete made with lightweight aggregate. After the starting of the production of blast furnace foamed slag in Dunaujváros, primarily this aggregate seemed to be most suitable for the realization of the objective: for the production of no-fines concrete. (8)

84. Following the elaboration of the formwork usable several times, ensuring the up-to-dateness of the building process, taking the properties of the no-fines concrete, the requirement of the manual movement of the formwork into consideration, the result of the research was a dimensionally coordinated, small-panel formwork system of storey height, with metal frame claded with ex-panet, which - together with the starting basis of the concrete technology - means the ÉTI-N building system.

type design MOT I. 1 167/61, then the designs of the type technology of the ÉTI-N building technology were also made the basis of experiences gained in the course of construction. The cast "in-situ" houses of medium height, constructed with the ÉTI-N building technology became general all over the country. The formwork sets usable several times have been used by the building enterprises in the Five-Year-Plan-period according to a schedule prepared in advance, even until now, handing them over to each other, in accordance with Technical Specification, with renewals of the expamet, depending on the maintenance during use.

86. The up-to-dateness of the cast "in-situ" building method depends on the degree of mechanization of on-site operations as well. The experiences gained with the production of concrete in the case of experimental buildings war extended, among others, to the mechanization of the transportation of concrete too, in addition to the stirage of classified aggregate, the transportation of aggregate with power shovel, and the production of lightweight concrete with forced mixing machine. Concrete was transported by conveyor for single-and two-storey buildings, by freight elevator for three-storey buildings constructed with small-panel formwork, by crane for the experimental building constructed with horizontal panels not movable manually, by pneumatic equipment for the prototype detached multi-storey buildings at Árpád Bridge, and by tower crane for the detached multi-storey buildings in Lágymányos. In the case of the ÉTI-N building technology generally used all over the country, concrete is transported by a tower crane. (8)

87. In 1962, after the construction of the load-bearing, monolithic wall and floor structures of the first multi-storey buildings, it became necessary to eliminate plastering increasing on-site labour requirement. The solution lies in the modification of the composition of lightweight concrete and in the alteration of the formwork clading. It was necessary to elaborate the the composition of the concrete providing a homogenous load-bearing and heat-insulating wall structure, as well as a plasterless surface (ÉTI-NEVA) and to find that shape-retentive formwork clading material usable several times, respectively outer clading, as a buried

formwork, which makes the interior wall and floor plastering, respectively the rendering work dispensable. Essentially, the objective was a change-over to the panel formwork because in this case the irregularities due to the differences of table joints can be also reduced to minimum.

88. The result of the research activities performed in the interest of formworks suitable for the development of surfaces usable several times and not requiring plastering is the ÉTI-DOTTROD type building system family. Experimental buildings were constructed to realize the previous research results. In 1964-66, the prototype of the microhotel of the hotel programme of Lake Balaton built scattered in the area, the workers' hostel in Veszprém were constructed by the ÉTI-DOTTROD I. building system elaborated in 1963, which proved that it is possible to build an aerated lightweight concrete wall and reinforced concrete floor with plasterless surface by careful work and with the improvement of the formwork clading too.

89. Since the strength of monolithic lightweight concrete walls providing a plasterless surface does not make possible the construction of high-rise buildings, research had to be extended to stratified reinforced concrete monolithic structures provided with a separate heat-indulating and surface-protecting layer. This startified monolithic wall structure already required minimum concrete technology research, but all the more careful structural, formwork and assembly operation research. The ÉTI-DOTTROD II. building system essentially elaborated already in 1962, with en interior plasterless surface and with a finished facade surface, was applied for the first time on the high-rise hotel building of Post Office No. 100 in Kőbánya, in 1966-68. During the experiment, both the internal and external wall structures were made with a plasterless surface. On the basis of these experiments, several significant buildings are being constructed in the country as different alternatives of the system. With the spreading of panel formwork building methods, the Hungarian building industry also possesses an industrialized building system - approaching the international standard -, and the results of research are being realized in practice with an ever increasing tendency.

90. The finish of concrete plasterless surfaces is determined by the formwork system. Conveniently, the plasterless surface is perfectly secured by self-rigid, panel formworks. The aim of the research was the elaboration of such stuctures and the formwork shell necessary for these. The supporting structures of the formwork system have to be designed with knowledge of the formwork shell. The modernization of concreting (more rapid casting, vibrator pouring, etc.) and the higher requirements concerning concrete have led to the differentiation of the construction of the formwork. (8)

91. The formwork of the monolithic floor is also made with the same formwork clading, also with panel form solution, in the case of open facades, rolling on overhead rails, or on framelike supporting structures as a formwork bridge, or formwork table, moreover as a tunnel shuttering built together with the wall formwork. In the case of closed facades, only a small-panel solution can be applied because of the restricted movement during dismantling.

92. In this case, the formwork shells should be dimensioned for shape retentivity, for an even, bubble-free surface. "Dimensioning" for uniform colour necessary in the case of decorative concrete, which is not a requirement at present, need not be taken into consideration in the investigations. There is no uniform specification, regulation for the testing and qualification of the formwork clading. The first complex investigations in Hungary were made and the methods used for other purposes were adapted partly on the basis of the data of literature in order to make a comparison between the traditional formwork and the formworks investigated. It was established on the basis of the evaluation of the experiments and on the basis of practical applications that the special formwork plywood with melamine resin adhesive and phenoplast surface treatment (BUFA III.), moreover the formwork clading with melamine resin adhesive and with mounting film surface treatment containing phenoplast (BUFA V.) were most suitable to achive the objective.

93. One of the solutions is the formation of the classical decorative concrete by leaving the dismantled concrete surfaces intact. Laboratory tests started in 1963

by getting acquainted with the mechanism of carbonization efflorecence and with the possibility of reducing it, with the role of supplementary materials, with the colour uniformity and porosity of the concrete surface, as well as the determination of the conditions of the production of "decorative concrete". The industrial experiment took place following this in 1967, at the high-rise building of the housing estate in Kacsóh-Pongracz Road. The layer arrangement of the wall structure following from the technology, the internal heat-insulation, is disputable from the point of view of the wall construction.

94. The perfect solution of the wall construction is the multi-layer monolithic wall structure, the mantel concrete structure. During the designing of the multi-layer wall structure, it was necessary to investigate the coaction of the layers: the adhesion of the heat-insulating sheath to the monolithic concrete core, moreover the solidifying effect of the heat-insulating (e.g. aerocrete) sheath, that is, to what extent it influences the strength of the monolithic load-bearing concrete core. It was proved by the investigations that the adhesive coaction of the only heat-insulating sheath without crust was suitable without separate bonding, on the other hand, it was necessary to provide for the bonding of the stratified sheath elements provided with crust separately. The research was extended to the thermal insulations analysis of the multi-layer monolithic wall structure alternatives as well. The thin (2-3 mm) coat-like surface treatment of sheaths consisting of small elements without crust can be performed by a spraying equipment on the site. Sheath elements consisting of small elements, with a heat-insulating layer, provided with a hard crust, can be prefabricated, with washed, burnt, etc. surfaces (e.g. ÉTI-UVA on the hotel building of Post Office No. 100 in Kőbánya). The heat-insulating layer may be polyurethane foam with monolithic foaming too (e.g. ÉTI-DURID I-II.). The prototype was manufactured. The vertical vapour ducts covered with wire netting serves for vapour diffusion. The wirework strips placed during foaming prevent the filling of the vapour duct with concrete during the concretaing of the monolithic wall. The sheath element considered to be a formwork tool in the course of building becomes a structural part of the building in this way.

95. The dimensions of the elements of the sheath material determine the structure of the external rarified formwork, as well as the entire assembly technology. In the case of a sheath consisting of small elements, the function of the external rarified formwork is to support safely the the sheath layer placed beside it by walling. Besides the requirement of shape-retention resisting the effect of concrete pressure, no other special requirements should be made concerning the quality of the material and structure of it as a secondary formwork not being directly in contact with concrete. During the subsequent surface treatment of the sheath consisting of small elements, the traces of distance pieces serving for shape-retention can be also made to disappear. In the case of sheaths with finished surface, consisting of prefabricated large elements, it is expedient to make self-rigid formworks. Thereby, it is possible to simplify the structural solution of the distance piece led through the joints of the sheath element. In this case, the cross-section of the external rarified formwork, though regarding its surface it is less than the rarified formwork of the sheath wall consisting of small elements, can be dimensioned for load-bearing because it supports the buried formwork consisting of large elements along a line. In most cases, this support along a line forms a two-directional system, which can be used as a scaffolding too (e.g. the ÉTI-DOTTROD II. scaffolding). Depending on the material of the sheath element, it can participate in taking concrete pressure as well.

96. These special alternatives of the industrialized building methods, the cast processes, the formwork equipment, and the mechanized machine units of building operations should be also developed continuously. In accordance with the needs of the society, if it is economically realistic, the equipment and machines should be withdrawn from production already before their physical wear and tear, when moral amortization takes place, and they should be replaced by more advanced new equipment required by technical development, coverable by less total social work, approaching the international standard better.

97. As a development of the productivity of up-to-date monolithic building systems, Hungary also started to apply the tunnel formwork building system in

the late 1960's. The relatively capital-intensive equipments necessary for the advanced on-site technology were imported. The OUTINORD, BATIMETAL, STIEM French systems are being applied.

98. For the introduction of the systems, it was necessary to carry out concrete technology and building technology research, as well as investigations concerning the adaptation of the equipments in Hungary. From the point of view of concrete technology, the research includes the possible application of cements with high initial strength as hardening accelerators in the interest of the optimal utilization of the formwork. Building technology research determined the introduction of the tunnel formwork as a tool into the production process and the parameters of other machines needed for the production process, respectively.

99. Various types of residential buildings that are made with tunnel formwork have been constructed with spanned and central corridor solution, or with the combination of these.

100. The tunnel formwork equipment possesses enough variability to form functions, which can be characterized by structural systems of crosswall character, with different spans. Office buildings and buildings of hotel character have been also constructed by this method.

101. For the construction of the monolithic ground floor of panel buildings, some enterprises apply a special version of the tunnel shuttering, on the basis of Hungarian designs. By means of this, it has been possible to develop a building method with approximate productivity for the construction of the groundfloor of the highly productive panel-type building method, too.

102. For this high degree of industrialization of the load-bearing structure, appropriate finishing structures, partitioning structures should be applied in order to be able to maintain productivity on a proper level in the field of finishing works

as well. Therefore, hollow gypsum pearlite partition boards, or other light weight partition wall structures are used for the partition walls. For the external walls, lightweight wall elements or wall panels made by housing factories are applied.

103. In order to increase the productivity of sanitary engineering works, the application of module units is expedient with this building method too, however, because of the peculiarities of the assembly operation, it is necessary to introduce and to spread the application of lightweight bath cells. Various prototypes have been developed for this in Hungary.

104. The industrialization of the thermal insulation and surface protection of end walls is a problem to be solved. Different solutions with the application of prefabricated covering elements, or the application of of the DRYVIT type on-site heat-insulating and surface-protecting layers, or a ventilated design have been suggested, but the end face design already mentioned in the foregoing in the mantel system the most productive both from the point of view of assembly operation and from a structural point of view.

105. The professional staff already possessed the practice for spreading the building method all over the country on the basis of the monolithic-cast "in-situ" building method applied for 15 years.

106. The productivity of the building method approached the productivity of panel--type building because the social work necessary for the construction of a dwelling with the tunnel formwork system is approximately 1200-1300 hours.

107. The publication of the pertinent Technical Specification was very helpful in achieving the results. This publication contains the designing specification, the dimensioning of load-bearing structures, the qualitative and dimensioning requirements, the contents of the working plan documentation, the guiding principles

of site work organization, surveying work, formwork erection and dismantling, concrete technology, as well as the knowledge concerning qualifying tests.

108. Cranes with different load moment should be applied for the different formwork systems. The crane parameters, of course, depend on the width and height of the building.

109. In the case of BATIMETAL formworks, up to 6 sotreys and 20 m building depth, a 60 m - 90 tm tower crane with 30 m hanling radius, and over 6 storeys, to 25 m building depth, a 70-100 tm tower crane with 25 m handling radius can be applied. The crane should be of the overhead travelling type, with 40 - 60 m/minute hook lifting speed, depending on the height of the building. Its load-capacity should be 2 and 3 tons, respectively, at extreme hook position.

110. In the case of the OUTINORD formwork, though the weight of the formwork is half of the former one, the application of a smaller crane is not possible because it would greatly reduce the output of concreting, and the utilization of the formwork would be less by 25 %.

111. The KC-type Hungarian container family, developed for this purpose, is suitable for concreting.

112. The application of a conrete pump in the tunnel formwork building method, since concreting is done only in one third of the cycle time and thus the utilization of the concrete pump is very low, would be uneconomical. A concrete pump mounted on a vehicle could be economical when several building sites are continuously supplied.

113. The most suitable solution of the curing of concrete is hot-air curing, with hot-air blowing into the tunnels. For the production of hot air, the application of oil, or gas fired hot-air blower is expedient. It is necessary to ensure that in the case of an average air temperature below + 10 C^{o}, the body temperature of the concrete should vary between 35-40 C^{o} for 10 hours.

114. The tunnel formwork building method, as an on-site technology, contains the following working processes: formwork, assembly of the reinforcement, placement of electric lines and boxes, cases, fixing elements, etc., concreting, dismantling, cleaning of the formwork.

115. Except electric fitting, a complex team can be organized, which performs the other work types jointly. Thus, the labour input is favourable. By this work organization, the proportion of semi-skilled work can be increased to 70 % as against the 30 % of skilled work.

116. In the case of work performed continuously, the scheduling of on-site work should be divided into stages in such a manner that one formwork set, constituting one cycle, should mean approximately 500-1,000 m^2 formwork surface area. This scheduling can be solved most favourably in the case of housing blocks.

117. In the case of buildings of multi-storey or high-rise tower buildings, the construction of several buildings should be started simultaneously, and one building should mean one cycle.

118. The tunnel formwork building method, as a supplementary industrialized technology, covers about 10-15 per cent of the present housing in Hungary.

119. Outside mass state housing, as a building method operating with tools applicable in a variable manner, it can be used in Hungary to advantage for cooperative housing and for the construction of apartment houses meaning about 30 %, where this lower-volume housing production can be satisfied by the construction of dwellings with a higher degree of equipment than that of mass requirements.

120. As the system of the construction of monolithic high-rise buildings, the conditions of the application of the sliding shuttering know from engineering

practice and envisaged in the long-range plans also had to be investigated by taking foreign experimentations into consideration and by evaluatin them. The research activities of the Institute of Building Science (ÉTI) in the field of assembly operation were especially significant concerning blast furnace foam slag concrete wall structures constructed with sliding shuttering. As a result of this, detached multi-storey buildings with different wall structures, at the Budafok Experimental Housing Estate were constructed between 1964-66, moreover with stratified reinforced concrete wall structure, and in 1965 in Miskolc the 15-storey, in 1966 in Miskolc the 21-storey, in 1967 in Budapest-Kelenfold the 17-storey high-rise buildings, and the walls of the Hotel Budapest were built with sliding shuttering.

V. CONCLUSIONS AS LESSONS FOR THE DEVELOPING COUNTRIES

121. In the course of the technical development of the building industry, the change in the structure of materials and structures accompanying the reduction of labour-intensive solutions is an essential phenomenon of structural change. The alteration of any of the factors of the material, structural and technological system leads to the modification of the entire system. The capital-intensive solutions applicable in the course of economic development, by making use of machines and equipments, as a technological modification, as a change of technology, lead to a change in the composition of materials and structures because of the undoubted relationship between the systems.

122. In Hungary, this change of structuree can be illustrated in Table 4. (7) On different degrees of development, traditional handly walling technology, by means of mechanical equipment, is transformed into walling which can be performed by auxiliary tools, by machinery, then into the assembly of elements movable by large lifting machines. In the period investigated, these development stages can be followed as stages reducing the labour-intensive content of the solutions applied. The socio-economic demand reducing the labour-intensive content first leads to the

alteration of the dimensions and composition of the walling materials, that is, the small-sized burnt walling elements are transformed into larger, hollow burnt elements, blocks, and later on concrete structures are made from basic materials which can be cast with less labour-intensive technologies, by mechanical aids. As this degree of development, cement consumption, the requirement of the different aggregates increase. The different properties of these materials and their parameters not always following the satisfaction of human requirements raise the necessity of other materials as well. The material structure is extended by different organic and inorganic heat-insulating materials, cladding materials, etc. in this way. The extensibility of the capital-intensive solutions by the possibilities offered by economic development, by the establishment of bases for the manufacture of structures, leads to structures integrated with solutions involving a professional structure originating from the alteration of the building site structure (e.g. panel, curtain wall), resulting in the alteration of the composition of structures.

123. Hungarian housing policy, takint into account the structural changes outlined above, will apply the further extension of panel-type building and, partly as a supplementary building technology, the tunnel formwork cast "in-situ" monolithic building method during the coming plan-periods.

124. The panel-type and tunnel formwork building methods, as capital-intensive solutions, are not recommended for the developing countries, partly because they require equipments which are import-intensive for them, partly because they make the rate of emplyment unfavourable for the developing countries due to its less labour-intensive character.

125. It is indisputable, however, that the lower degrees of industrialized building be taken into account by the developing countries, since the process or urbanization mentioned in the introduction is a reality in the developing countries too, and if they do not provide for building technologies having a proper, then the growth of slum areas will have the following trend (Table 5). (9)

126. Thus, of the Hungarian building methods applied on a large scale, the macadrum, or large-block building method made of local materials can be applied in the developing countries, as function of the lifting machine capacity available. For the introduction of the building method, the exploration of local material sources, the economical methods of the exploitation of materials, the technical properties of available materials, the structural designs which can be made of materials defined by parameters, the designing of dwelling types suiting the requirements of the given society should be solved by the adaptation of the forms of local architecture as a task of design and research organizations, respectively. Due to the continuity of the technology, the operations of production and construction can be easily mastered, and the trained local population can be emplyed under the direction of few leading skilled workers.

127. Moreover, of the cast "in-situ"-monolithic building methods, the building system (ÉTI-N) utilizing local materials, requiring a formwork system moved by hand and usable several times can be recommended. This on-site technology can be applied continuously under the meteorological conditions of the developing countries, and it requires even less qualification, for the assembly of the formwork systems can be mastered with minimum practice, and the concrete grade which is to be applied for the buildings having a small number of storeys permits a very large tolerance, consequently it is also an activity not having high requirements.

128. According to Hungarian experiences, the characteristics of the economical efficiency of both recommended building methods are also favourable because in Hungarian building practice these two building methods have been more advantageous from the point of view of costs too, compared to the traditional building method. Both of them are less capital-intensive and optimally material- and labour-intensive, accommodating to the present conditions of the developing countries.

REFERENCES

1. GÜNZEL, E., WOLF, G.K.: Wohnungen für Zambia; Deutsche Bauzeitung 1974/3

2. DAVID, J.: Building materials and construction methods; Interregional Seminar on Design and Technology for Low-Cost Housing Budapest 9-20 April 1974, UNO

3. de GRAFT JOHNSON, J.W.S.: Choice of appropriate technologies for "low-cost housing". Interregional Seminar on Design and Technology for Low-Cost Housing, Budapest 9-20 April 1974, UNO

4. DAVID, J.: Az iparositott épitési módok alkalmazásának előzményei; Építéstudomány és Építésiparositás. ÉVM Budapest, 1968.

5. VISY, Z.: Blokkos épitésmód; Építéstudomány és Építésiparositás, ÉVM Budapest, 1968.

6. BÉKÉS, M., KISS, T.: Panelos épitési mód; Építéstudomány és Építésiparositás, ÉVM Budapest 1968.

7. BÁN, K., TÖRÖK, Gy.: The housing situation in Hungary; ÉVM Budapest, 1973.

8. DÁVID, J.: Öntött épitésmód; Építéstudomány és Építésiparositás, ÉVM Budapest, 1968.

9. MACKENSEN, R.: Mondernisierung und Verstadterung in der Dritten Welt; Deutsche Bauzeitung 1974/3.

Table 1. Residential areas typology in Zambia

Residential density	Dwelling types	Number of parcel/ha	Building	Proffession of inhabitants before the liberation	Proffession of inhabitants after the liberation	Designed dwellings
Low Density Area	High Cost Housing	approx. 5	Garden suburb, Villas, Bungalows	Civil servants, Businessmen (Europeans)	Upper class (Civil servants), Businessmen	2 %
Medium Density Area	Medium Cost Housing	approx. 15	Multi-storey dwelling houses. Row houses, Detached family houses, Bungalows	Employers, Workers (Europeans)	Middle class, Employers	9 %
High Density Area	Low Cost Housing	35-40	Cottages	Workers, Employers	Workers (Africana)	54 %
	Self Help Housing (Normal Site and Service Schemes)	approx. 20			Self-employed, Tradesmen, Employers, Workers	35 %

Table 2. Block-type housing (1960-1970)

Years	Number of block-type dwellings	Block-type housing	
		In % of dwellings	In % of all dwellings
1960	779	5,98	1,34
1961	2415	14,23	3,58
1962	6059	33,99	11,20
1963	8625	47,01	16,36
1964	10235	53,65	19,16
1965	10826	55,94	19,83
1966		42,20	
1967		45,00	
1968		43,10	
1969		38,30	
1970		30,20	

Table 3. Panel manufacturing bases in Hungary

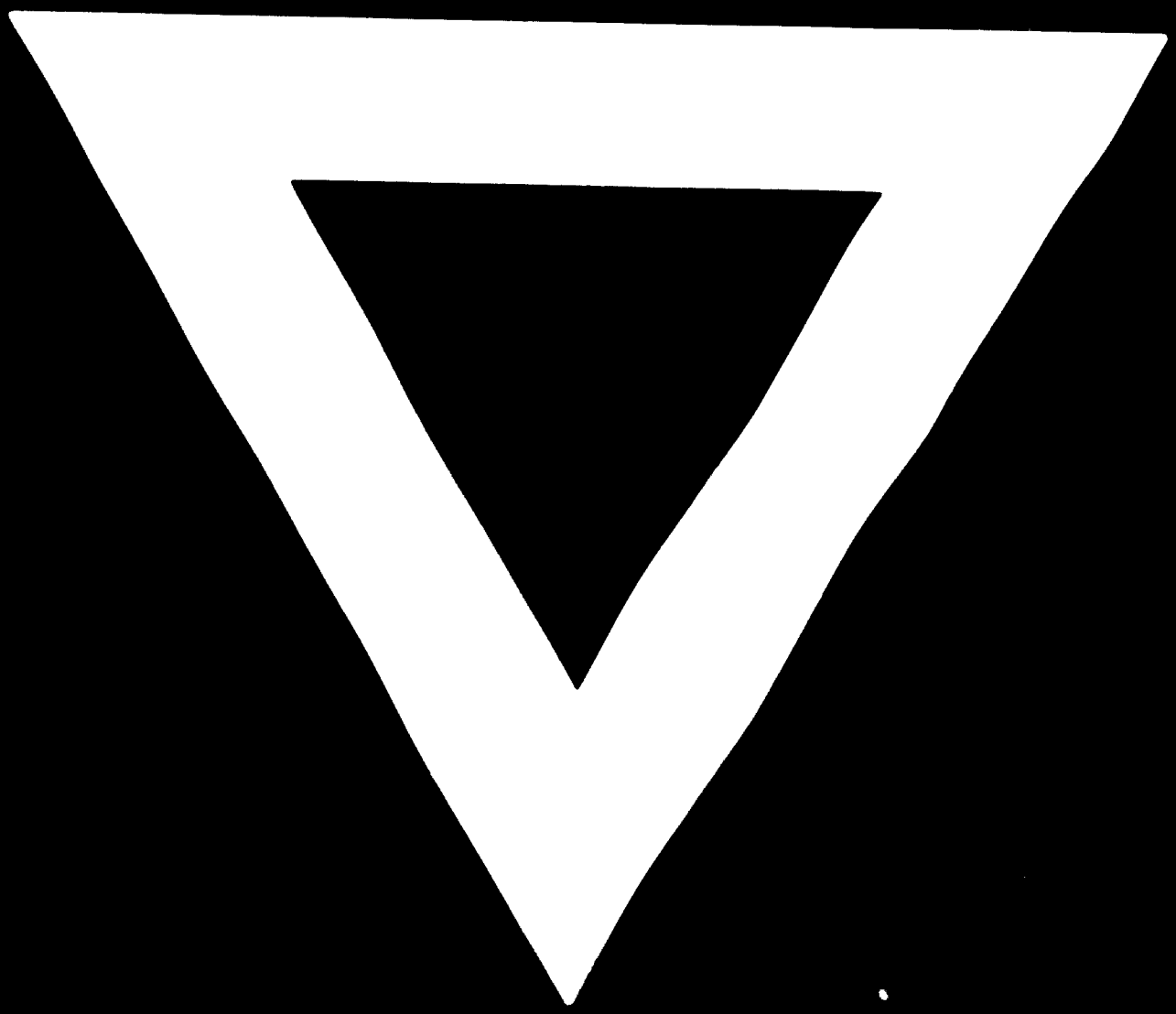
Housing factories and panel plants	capacity (dwellings) year	year of starting production
Pécs Panel Plant (Hungarian)	1500	1962
Dunaujvaros Panel Plant (Hungarian)	1300	1963
Budapest Housing Factory No.1 (Soviet)	3400	1965
Budapest Housing Factory No.2 (Danish)	2700	1967
Győr Housing Factory (Soviet)	3800	1968
Miskolc Housing Factory (Soviet)	3800	1968
Szolnok Panel Polygon (Hungarian)	400	1968
Budapest Housing Factory No.3 (Soviet)	3800	1969
Debrecen Housing Factory (Soviet)	2700	1970
Szeged Housing Factory (Soviet)	2700	1971
Békéscsaba Brick Panel Plant (Hungarian)	600	1971
Budapest Housing Factory No.4 (Soviet)	3400	1973
Veszprém Housing Factory (Soviet)	2400	1973
Kaposvár Panel Plant (Hungarian)	600	1975
Szekszárd Panel Plant (Hungarian)	600	1975
Kecskemét Housing Factory (Soviet)	2400	1976

Table 4. Change of structure of building technologies

Building technology	1965	1970
Building method with handly building blocks	21,6 %	5,9%
Medium- and large block building method	56,2 %	31,8%
Large-panel building method	6,3 %	52,6%
Cast "in-situ" building method	3,8 %	4,2%
Reinforced concrete frame building method	12,1 %	5,5%

Table 5. Urbanization structure

	Population (thousand million)	Growth (%)	Doubling (year)
Population of the world	3,600	2,0	35
Population of developing countries	2,600	2,7	26
Urban population of industrial countries	700	1,7	40
Urban population of developing countries	600	5,0 - 8,0	14 - 9
Slum population of developing countries approx.	300	7,0 - 15,0	10 - 5



75.10.09