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05039



United Nations Industrial Development Organization

Distribution
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ID/WG.20/10
5 August 1968

ORIGINAL: ENGLISH

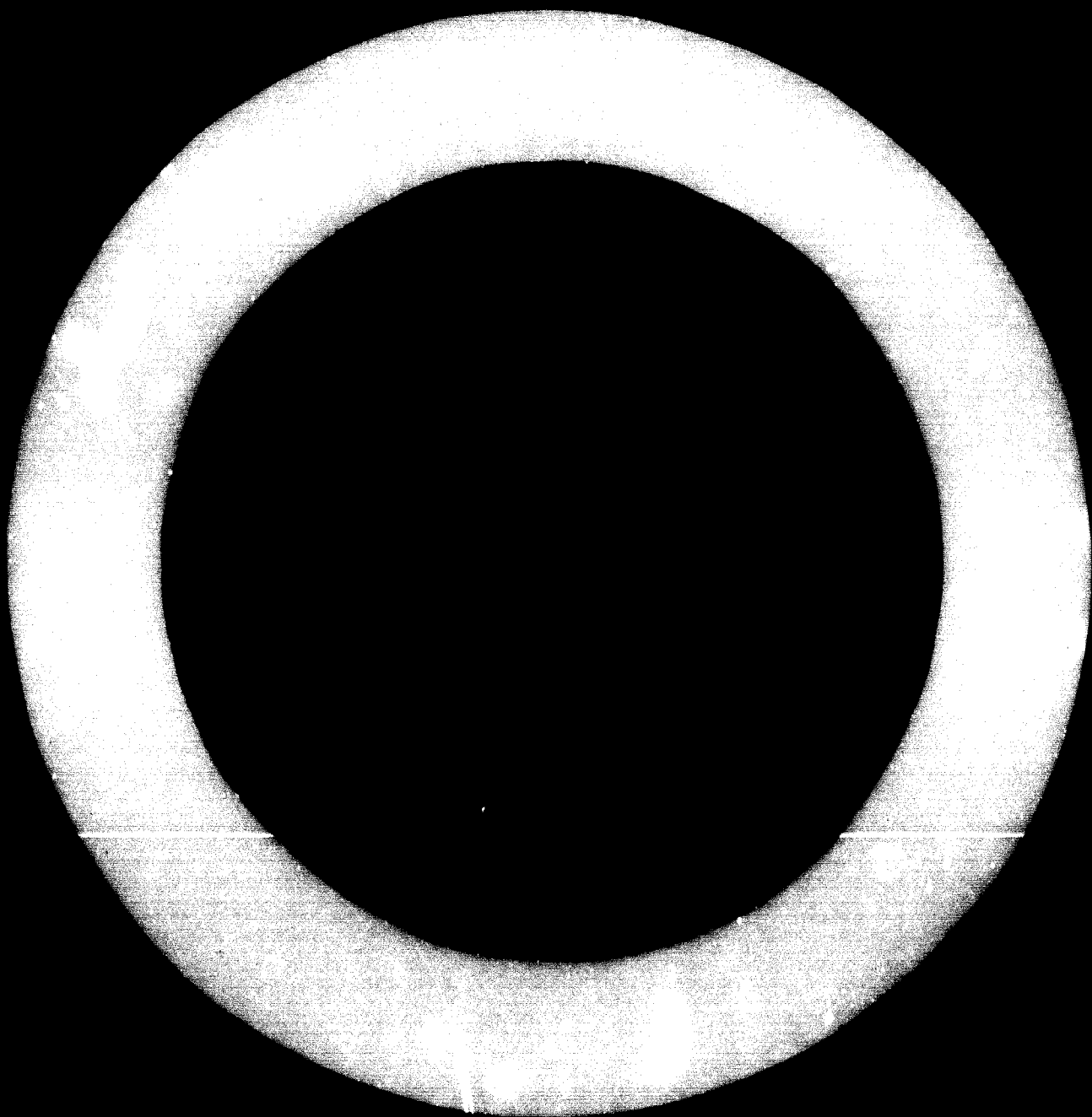
The Workshop on Organizational and Technical Measures
for the Development of Building Materials

Moscow, 25 September - 19 October 1968

INQUIRY INTO THE USE OF MATHEMATICAL METHODS AND AUTOMATIC
COMPUTERS IN THE FIELD OF HOUSING, BUILDING AND PLANNING

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Distr.
RESTRICTED

HOU/Working Paper: No.188
14 March 1966

Original: ENGLISH and RUSSIAN

ECONOMIC COMMISSION FOR EUROPE

COMMITTEE ON HOUSING, BUILDING AND PLANNING

(Item 4(b) of the provisional agenda for the
twenty-seventh session, 24-27 May 1966)

INQUIRY INTO THE USE OF MATHEMATICAL METHODS AND AUTOMATIC
COMPUTERS IN THE FIELD OF HOUSING, BUILDING AND PLANNING

Report by the Group of Rapporteurs

PRELIMINARY NOTE

1. The Committee on Housing, Building and Planning, at its twenty-sixth session held in May 1965, considered the preliminary results of an exploratory inquiry on the use of mathematical methods and automatic computers for the solution of housing, building and physical planning problems. The discussion showed Governments' interest in this work, which was considered as being timely and important. It was agreed that a fresh inquiry should be launched, as rapidly as possible, on the basis of an outline and a model reply prepared by Mr. V. CERVENKA (Czechoslovakia), in his capacity as General Rapporteur (document HOU/Working Paper No. 180). It was understood that countries so interested would nominate rapporteurs to assist the General Rapporteur in the preparation of a provisional report for consideration by the Committee at its next session. The Secretariat was requested to contact other organisations working in this field, in order to avoid duplication of work. (document E/ECE/HOU/111, paragraph 9).

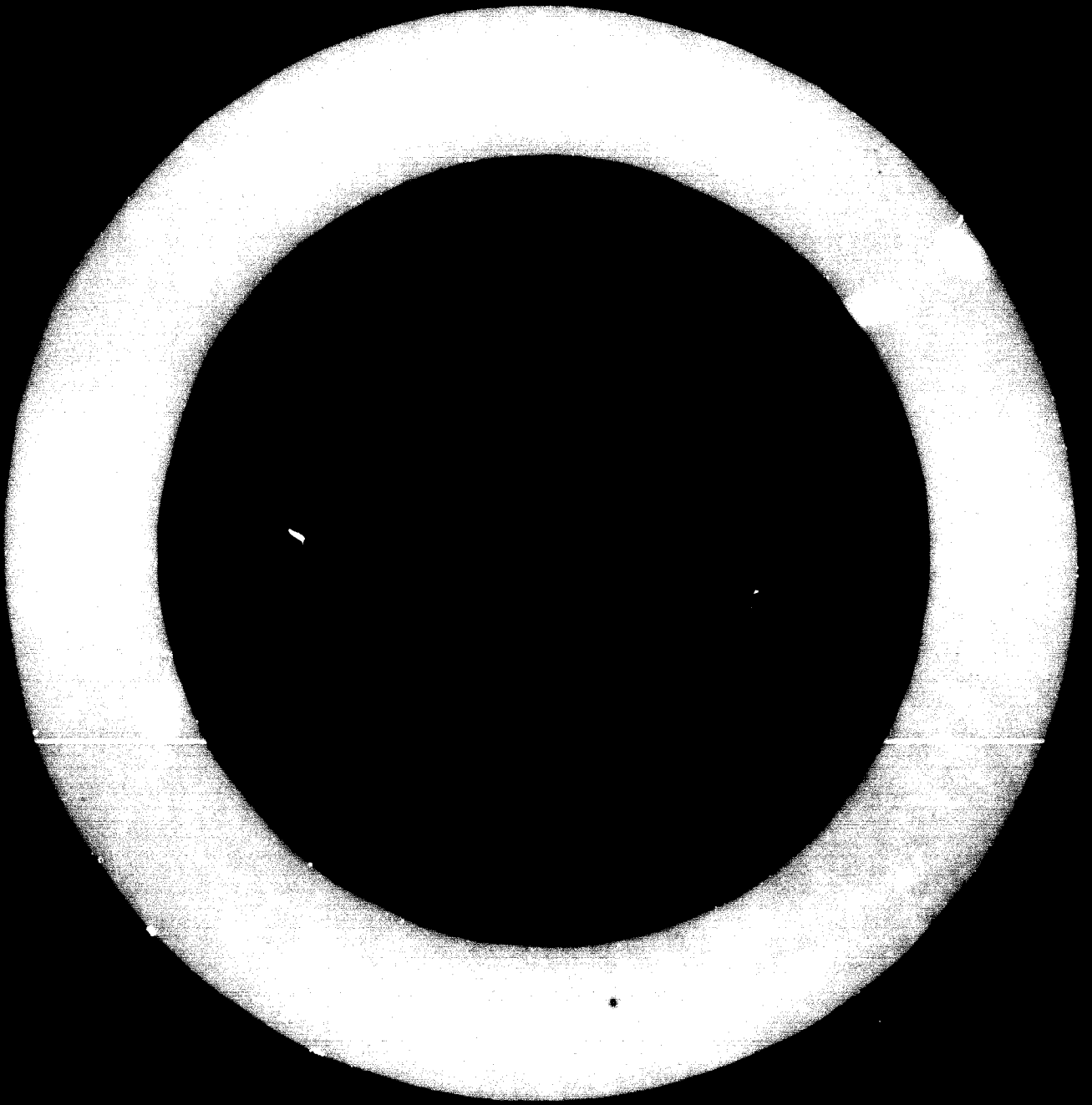
2. Pursuant to these decisions, the Executive Secretary of the ECE, in a circular letter of June 1965, invited Governments to instruct their appropriate specialised authorities in this field to prepare national monographs along the lines set out in document HOU/Working Paper No. 180 and to send them to the Secretariat before the end of October 1965. In reply to this request, national monographs or comments on the subject were received, some by the Secretariat and others by the General Rapporteur, from the following countries: Belgium, Bulgaria, the Byelorussian SSR, Czechoslovakia, Denmark, Finland, Ireland, Italy, the Netherlands, Norway, Poland, Sweden and the United Kingdom.

GE.66-3353

3. The material received, together with similar information prepared and submitted in connexion with the exploratory inquiry by Austria, Portugal and the USSR, was examined at a rapporteurs' meeting held in Prague in January 1966. The meeting was attended by Mr. F. BREDSDOREFF (Denmark), Mr. G. JANDY (Hungary), Mr. W. REINERS (United Kingdom) and the following experts from Czechoslovakia: Mr. V. CERVENKA, Mr. E. KOHN, Mr. O. STRADAL, Mr. O. LICAR, Mr. J. HOUČKA, Mr. J. ROUBICEK and Mrs. BENDOVA. Mr. STRADAL was in the chair.
4. The present report was prepared by the Group of Rapporteurs at the meeting in Prague. It contains three parts: an introduction; a summary account of the material received with recommendations for further work; and conclusions. The summary account covers fifteen main fields of application.
5. Many other international organizations are carrying out work on the subject matter of the inquiry, the most important being: the Econometric Society, the International Council for Building Research, Studies and Documentations (CIB), the Institute of Management Science (TIMS), the International Federation of Operational Research Societies (ISORS), the International Statistical Association (ISA) and the International Union of Architects (UIA). A first step towards co-ordinating ECZ's work programme in this field with that of other organizations will be taken in Prague, in May 1966, on the occasion of the third meeting of the CIB Working Commission W.37 on Operational Research. The ECZ Group of Rapporteurs on the Use of Mathematical Methods and Automatic Computers has been invited to take part in this meeting and the present report will be circulated to all participants. It is expected that the meeting will bring out clear-cut recommendations regarding the division of work in this field between the two organizations.
6. The present report does not attempt to provide a comprehensive description of the present situation as regards the use of mathematical methods and automatic computers in the field of housing, building and planning but, rather, to summarise this situation and to offer a number of recommendations for further work in different directions, both national and international. The Committee may wish to consider whether an attempt should be made to prepare a more comprehensive and consolidated report on the basis of all the material collected - and possibly of further obtainable information - or whether ECZ's further activities in this field should be concentrated on one or more selected fields of application. It should be recalled in this connexion that in May 1965 the Committee decided to consider at its next session - after assessing the work accomplished in the meantime - a proposal to hold sometime in the future a seminar on the subject of the inquiry.

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I. INTRODUCTION

With the exception of demographic investigations, the utilization of highly developed mathematical methods and techniques has not yet attained any tradition in the field of housing, building and planning. At present, these methods and techniques are penetrating into the field in two directions. On the one hand, they are fostered by the initiative of the computing organizations or the producers of computers who are interested in the maximum possible utilization of their skill and their machines; on the other hand, experts from the field of housing, building and planning, who are dissatisfied with the contemporary standard of methods and aids in their respective branches, are seeking to exploit possible uses of mathematical methods and computers in the context of their own work. In either case, it is necessary to overcome difficulties which always arise when endeavours are made to introduce mathematical methods into a branch relying on conventional methods. This is the necessity of formulating its problems in an exact manner and expressing them by means of mathematical symbols, followed by the necessity of selection of a suitable method of calculation (algorithm) and the choice of a suitable computer for various types of calculation required.

Great progress has been made in recent years in applying the methods of operational research and econometrics to a wide range of problems of government and industry, particularly those concerned with investment, production planning and control. In construction, progress has been relatively slow, corresponding in part to the complexity of the problem it offers. In recent years, however, there have been examples of fruitful developments of these methods in all countries. Since these methods depend on the logical formulation of the problem before its expression in mathematical terms, it provides new opportunities for the exchange of experience on an international basis. The first stage in such international co-operation would be to concentrate attention on the problems of expressing in mathematical theories the characteristics of building processes at all levels.

The purpose of this enquiry has been to consider what benefits would ensue from the exchange of experience acquired so far in the individual countries in the field of the use of mathematical methods and computers for the solution of problems concerning the field of housing, building and planning.

II. SUMMARY ACCOUNT OF THE INFORMATION RECEIVED
AND RECOMMENDATIONS FOR FURTHER WORK (1)

A. Macro-economic Models

- (a) Several countries have developed mathematical models of the course of the total economy, taking into account the relationships between all sectors. These models are dynamic in the sense that the solutions trace out the development in time of all variables. In most models the development is made to depend in part on the decisions on investment in construction made by the government. It is then possible by means of the models to study the effect of government decisions on the future development of the economy. As examples may be given, the model developed in the United Kingdom by the Department of Applied Economics in Cambridge, and the models developed in Norway at the University of Oslo (Institute of Social Economics). For some purposes it is important to study the submodels for the construction industry, mentioned below, within the framework of a general model of the total economy.
- (b) International co-operation in this field is organized through the Econometric Society. It is recommended that the ECZ should keep in contact with this work in so far as the relation between investment in construction and the total economy has to be taken into account.

B. Assessment and Forecasting of Building Requirements

- (a) Many countries recognize the need for making long-term forecasts of population and economic growth and have made extensive use of mathematical methods and computers, not only in handling the original census data but also in predictions of future populations developments allowing for migration. In Denmark, Sweden and the United Kingdom these forecasts have formed the basis of long-range forecasts of the demand for building work. Census data also form the basis of sampling studies in which mathematical and statistical methods are used to make special investigations in the field of housing and urban life.
- (c) Every section concerned with a certain problem is always subdivided in the present report into part (a), comprising a survey of problems under consideration as they were presented in the individual national reports, and part (b), suggesting proposals for the solution of those problems which can be considered most important in the given field and which can be most favourably influenced by an international exchange of experience.

- (b) A problem of importance is the methods of prognosis for the purpose of capital construction, for which in particular the Swedish and the British experience should be known more widely.

C. Planning of the Construction Sector

- (a) The time schedules of investments within a region are prepared in Czechoslovakia by means of network methods: the demands made by individual users on resources are summarized by a special computer programme. Co-ordination of investment programmes of different industries, on the basis of network analysis methods, forms the subject of research in Bulgaria, Czechoslovakia and Hungary. Allocation of scarce resources is in the research phase and is being verified experimentally in Czechoslovakia. The extent of the problem of the co-ordination of capital investment necessitates the application of computers, especially for the allocation of scarce resources which has involved the preparation of special computer programmes. Planning of design work by network analysis is being used in the larger design organizations of Sweden and the United Kingdom.
- (b) Research carried out in this field by Czechoslovakia and other countries is particularly worth attention.

D. Physical Planning

D.1 Town planning statistics

- (a) The first condition for the application of mathematical methods in the field of physical planning is to obtain records (data) of physical population contents of all the physical units of any region which is going to be planned and also to obtain current information on changes going on in the basic units. A system of co-ordinates for recording changes in population and physical characteristics is being developed in Sweden. Valuable data for physical planning are obtained in the course of the preparation of economic plans on the regional basis in the USSR. Further detailed data, required for physical planning, can be obtained either intermittently, as in the case of Czechoslovakia, or by means of the systematic recording of changes in the given territory (town-planning statistics) which is carried out in the United Kingdom by means of data-processing machines.

- (b) The national reports do not mention any examples of mathematical methods applied to the actual process of physical planning, but it is known that mathematical models of communities are being developed which would enable the effect of different planning decisions to be examined.

D.2 Models of traffic systems

- (a) Several countries - e.g. the USSR, the United Kingdom, Denmark, Sweden, Hungary and Poland - report that programmes have been developed for the analysis of traffic statistical data, for traffic forecasts and for the evaluation of alternative traffic systems designed for urban areas or regions. Most programmes for the evaluation of traffic systems have been developed along the lines originally worked out for Washington, D.C. Although computer programmes for traffic analysis, for the prediction of traffic generated by the various zones in an area, for the simulation of the distribution of traffic on individual roads in a planned traffic system etc., are now internationally available, most programmes will have to be modified to local conditions.
- (b) International collaboration in this field has already been established and would not seem to call for any initiative on the part of the EEC.

D.3 Location of housing and other urban facilities

- (a) An optimum location of housing on the regional level is being investigated in Poland, Hungary and other countries, while in Czechoslovakia these investigations are carried out on the level of the individual housing estates in an industrial district. Local technical and transport conditions are considered by these methods in Portugal, Poland and the Byelorussian SSR. The location of storage buildings and factories with the help of mathematical methods is being investigated in Czechoslovakia and Hungary at present. The problem of the optimum height of buildings in an urban development, investigated in the USSR and the United Kingdom is also connected with that of the location of housing.
- (b) Although the solutions of the problem of location differ according to the type of investment and the type of social system, the methods used are essentially the same and we recommend the widest possible exchange of experience in this field. Material contained in the Portuguese report represents very concrete information on this branch of activity.

3. Engineering Design

- (a) In the field of engineering design, a very large number of standard programmes for computers have been developed by international and national computer companies, by engineering institutes and engineering associations. These programmes make it possible to leave the tedious routine calculations to the computers and also to use more refined and realistic structural models than those which are used for manual operations. International co-operation in this field takes place partly through the various specialized international engineering associations and through the International Union of Testing and Research Laboratories for Materials and Structures (IILM).

Design algorithms and corresponding complete sets of programmes are, for example, available within the following fields: analysis and design of determinate and indeterminate structural stability analysis, transmission tower design, heat transmission calculations, design of distribution systems for district heating, design of air-conditioning pipelines and mains, hydraulic analysis of flow in pipe networks, design of highway constructions, design of irrigation systems, geodetic calculations etc.

- (b) The possibilities of transferring operations of engineering design do not appear to be utilized anywhere near the extent that would seem advantageous. In some countries government agencies are stimulating development in this field by creating co-ordinating institutes with the following purposes:
- (i) to form expert committees with the task of formulating problems and developing calculation and algorithms for computer programmes;
 - (ii) to assist engineers in the selection and application of available programmes.

It is recommended that governments should consider whether or not such initiatives would be useful in their countries.

4. Optimal design of buildings and housing estates

- (a) In the United Kingdom computers are used for the design of the layout and shape of buildings with the minimum circulation, and to provide rapid methods for rational design with building systems based on the assembly of components. In the USSR, a qualitatively new level of use of

mathematical methods and automatic computers is being introduced at present, viz. the automation of design of buildings and structures, including a graphical representation of the results. This method will concern not only the individual structural elements of the buildings, but also an optimum design of the building and its layout. In the United Kingdom, automation of design is being applied to the preparation of drawings and to the analysis of costs.

In Czechoslovakia, in some cases, an optimum selection is made from the number of standard sections of flats by means of linear programming, regard being paid both to demographic conditions and to the town-planning concept of the housing estate under consideration.

- (b) The trend which aims to automate the design process, followed in the USSR and in the United Kingdom is worthy of particular attention.

G. Standardization and typification

- (a) The attainment of an optimum solution in a typified design is considered a very important field of application of mathematical methods, the same evaluation applying to decisions in the field of standardization, especially in the building industry. According to the USSR report, one use of automation of the design process is in research on the flexibility of the structural systems or layouts suggested. This criterion is complied with, to a certain extent, by the method of an optimum selection of a set of standard (typified) layouts (the so-called "sections") applied to the verification of the flexibility of the variants of structures intended for experimental housing construction in the USSR. In Finland, tests of materials are being evaluated with the help of computers, as a basis for elaborating standards and for quality control. The Swedish report emphasizes the significance of the use of mathematical methods in this field, i.e. for the design of modules.

H. Project evaluation

- (a) A conference on this subject, in the field of industry, the Inter-regional Symposium on Industrial Project Evaluation, was held in Prague from 11 to 24 October 1965. The conference was organized by the United Nations Centre for Industrial Development, which likewise has custody of all material relating to the symposium. A number of contributions by experts describe or refer to the possibilities of the application of mathematical methods in the sphere of housing, building and planning.

- (b) It is recommended that Governments should take note of the above-mentioned proceedings and consider the application of the methods concerned.

I. Analysis of the market, perspective planning and inter-industry balancing

- (a) Mathematical methods which could be applied in the field of building have not yet been developed, despite the fact that they are necessary on account of the length of the construction cycle. In addition, in planned economies, there is a need to determine the capacity and specialization of the individual constructional corporations with regard to the aims and extent of capital construction programmes. The actual elaboration of perspective planning by means of input-output tables, structural branch models and their optimization with the use of sensitivity analysis and shadow prices is being carried out experimentally on the industry and enterprises level in Czechoslovakia and Hungary.

In Czechoslovakia a prognosis of the size and assortment of production basis of construction has been carried out in the form of an analysis of a perspective programme of capital construction, including its projection into the individual types of production basis (according to the principal materials). On the basis of this analysis fundamental consideration was given to investment policy in the building industry.

- (b) With regard to the character of capital construction, perspective planning and inter-industry balancing must be considered as factors of great importance. For this reason it is recommended to propagate the experience acquired in Czechoslovakia and Hungary with input-output branch models and their optimization.

J. The evaluation and control of cost

- (a) Computers have been applied successfully in many countries, both in evaluating the cost of buildings at the design stage, and, within the building organizations, in recording and controlling the cost of building work on site. In Denmark and the United Kingdom bills of quantities, which are used to evaluate cost on a uniform basis, are increasingly prepared by computers with great saving in labour. The use of computers in this way also facilitates in many different ways the analysis of the cost of building.

according, say, to the building element and its location in the building, and simplifies the preparation of schedules. In Finland, costs of alternative designs are compared by computer and by statistical methods employed to identify the factors affecting costs.

The use of computers for cost recording and analysis within building organizations is providing for the first time in many cases an effective system of cost control whereby the costs of specific tasks may be analysed during the course of the work. The reports of the United Kingdom, Sweden and Hungary include examples of this kind of application, which should provide a basis for the comparison of estimates with actual costs and so improve the accuracy of estimating.

- (b) Although the basic principles of the systems for cost evaluation and control may be the same in all countries, the actual applications of these principles and the computer programmes developed to facilitate operations will necessarily vary considerably from one country to another, because of differences in wage-systems, conventions of specifications of quantities and operations etc. Nevertheless the experience accumulated in countries where computable methods of cost evaluation and analysis have been developed may be of interest to other countries, and in such cases it may be recommended that direct contact be established between them.

K. Management of the production process

- (a) Most countries report that network techniques are now frequently used for co-ordination scheduling and control of the sequence of activities which make up the building process, including in some cases project design activity. The techniques used include the various available CPM and PERT-programmes (network ranking, input generator, dating routine, PERT-COST etc.). These programmes were originally devised for the scheduling of unique projects, taking into account the many uncertainties connected with such projects. Several countries report that they are aware that the existing programmes do not take into account some of the specific problems connected with the scheduling of building activities, e.g. interlocking and limitations of resources for the various activities. The difficulties are partly overcome by the RAIPS, RPSM and other programmes developed in the United States for

scheduling networks with limited resources; and by the programmes developed in Czechoslovakia (RPZM) and in Hungary. However, even these programmes make simplified assumptions, which should be done away with. Various new programmes are therefore being developed, based on more adequate models of the building process.

Some flow-line methods using computers are being used in the USSR, Czechoslovakia and Hungary.

For repetitive building projects scheduling by cyclical programmes is being used in some countries.

In order to devise a scheduling method which takes into account the specific problems of the building process the Building Research Station in the United Kingdom (BRS) is making research on a computable model which simulates building activities and which is based on queue-theory.

In Denmark a scheduling method has been developed which allows for changes in the project and for the requirements of activities in the planning phase in order to obtain an even work-load during the whole process of industrialized building. The formal model has, however, not been established and the method is so far not computable.

- (b) In the field of management of building production it is particularly the programming and scheduling of the work-load and co-ordination of resources with provision for feedback that are of general interest. On the basis of results so far attained in the various participating countries this field can be considered one of the most developed. An exchange of experience concerning the difficulties of applying these methods and possible improvements would be valuable. This could take the form of a short seminar.

I. Communication systems in building

- (a) The increasing use of computers for all stages of the building process, in design, cost calculation, planning of building, operations and recording and analysis of their cost, has focused attention on the need for a co-ordinated system of communication. The key to development in this field is the establishment and common agreement upon a uniform system for classification of all basic data on input and activities in the building process: building

materials and components, specification of operations, geometric position in building etc. The use of a common coding and classification system in design, cost calculation and production would have the immediate advantage of avoiding the existing duplication of activities such as the estimation of quantities from drawings. By suitable computer programmes all necessary documents for bills of quantities, specifications, costing and cost analysis, network schedules, delivery plans and so on could be printed on request by the computer on the basis of the same primary data for any individual building project.

The ultimate objective is much more fundamental and is to provide an integrated system of information flow in construction and, by so doing, to facilitate the feed-back of information from site to planning and estimating procedures and also to design. This would provide a basis for the designer to improve his control of the cost of the building and the contractor his control of the cost of site processes.

A system for co-ordinated building communication (the CBC system) has been developed in Denmark and is in use there and in the United Kingdom and Ireland by individual architects. In Sweden a related system is also in course of development. Research into the problems of communication is in progress in Czechoslovakia and the United Kingdom.

- (b) The fact that several countries report a great need for the establishment of comprehensive communication systems which may allow for planning and management of individual building processes by an integrated system of data processing by computers, together with the fact that this work is still only in the stage of development, indicates, that it would be very useful to organise an international exchange of experience and projects in this field, with a view to establish - if possible - a universal system of communication.

M. Production basis of construction

- (a) This sphere includes perspective determination of the production basis as well as the location of individual production capacities, transport problems and the determination of optimal stocks of materials maintained by the individual producers or consumers. With the increasing industrialization of building production also the importance of a timely building-up of the production basis of construction acquires increasing importance.

The problems of the location of building investments by means of operational research methods were solved, according to the country reports, in the USSR (Cement works, ceramic works), and in Czechoslovakia (precast concrete plants, concrete mixing plants, services for construction). The solution of transport problems in construction is also mentioned in the reports of these two countries; it may be presumed, however, that these problems were solved also in other participating countries. The problem of stocks and their optimum size in construction is being studied in Czechoslovakia.

- (b) It is recommended that a Group of Experts be set up within the framework of the ECZ to carry out a more detailed investigation of this problem and that the results of its work be published.

VI. Automation of production processes

- (a) The subject of automation of production processes is of primary importance in the production of building materials and components and in building production. Unfortunately it was not included in the original report; however, it would be advisable to exchange experiences among the individual participating countries also in this field. Efficient computing techniques should be comparatively easy to introduce into this field, since experience and programmes gained in other industrial branches may be applied. In the near future it will be possible to consider also automation of some processes on the site, such as the lift-slab method, etc.
- (b) It is recommended that the experience attained in the field of automation of production processes of related branches and similar production be communicated to the participating countries. Of particular concern here are recommendations on computer programmes or suggestions for their adjustment to the production of building materials, production of building components and building production. Automation need not be confined to complete production processes, but could be applied also to partial processes (such as batching, mixing, etc.).

0. Operation, maintenance and replacement
of construction machinery

- (a) Operational research methods have been found effective in many countries in improving the efficiency of use of construction machinery, particularly in civil engineering applications. Problems of the number and capacity of machines needed for a particular task, the correct position of static machines, the optimal sequencing of operations and the best routes and delivery points in transportation, may be solved by means of operational research. Other applications deal with the management of the machinery and plant pool of building organisations giving guidance on optimal size and composition and on the maintenance and replacement policy.

Examples of the application of operational research to constructional machinery are given in the USSR and Czechoslovak reports, in relation to the maintenance of machines, and in the United Kingdom report, in relation particularly to the operation of tower cranes.

- (b) Although reports on this important sphere of interest are scarce, a wider survey of this field is desirable in the near future.

III. GENERAL CONCLUSIONS AND SUMMARY OF THE RECOMMENDATIONS MADE IN PART II

General Conclusions

The development of powerful computers and computer-languages has opened up new possibilities of promoting the use of advanced mathematical methods for handling a vast number of re-current and intricate problems in management and design of construction and physical planning, not only at the government and industry level but also at the level of firms and local authorities.

The survey has revealed a great interest in these methods in all countries. In the past few years, rapid progress has been made in the replacement of routine clerical processes involved in costing accountancy and office management and in problems such as structural design for which existing mathematical model provides a basis for calculations. What is new is the development of mathematical models, which offer the possibility of applying scientific methods to the programming, organisation and control within the fields of housing, building and planning.

These new methods are already applied, in some countries, to planning an effective use of resources of the construction industry or of individual enterprises and also, in some cases, to the processes of design. Other countries will, however, need to intensify their efforts if they are to apply these methods. As in the natural sciences, however, the principles underlying these methods will be common in all applications and in all countries. International co-operation can thus achieve a new significance in that experience in different countries in the social and economic problems of housing, building and planning can be fundamentally correlated. Much research needs to be done, however, if the scope of these methods is to be extended. International co-operation could therefore also be effective by co-ordinating the research efforts of the different countries.

From the national reports it appears that in most countries the new possibilities of mathematical methods and computers have not yet been adequately utilized. There may be many reasons for this. Computers and computer techniques are a recent development and it is only normal that it takes time for new techniques to be generally applied. Furthermore, many of the standard programmes for computers which are by now internationally available, may not always be suitable for more than a few countries because the mathematical models implied by the programmes are not universally applicable.

Finally the overhead cost of development of mathematical models and computer programmes which might be generally applicable within a country will in many cases be too high for the individual user - and may also appear too high for computer firms - because the firms have difficulties in assessing the demand for such programmes.

In these circumstances it seems that a more general use of mathematical methods and computers within the field of housing, building and planning might be accelerated by setting up in each country a co-ordinating organization with the following objectives:

- (i) to set up, within different fields of application, expert committees with the task of reviewing the application of mathematical methods and computers in their own and other fields, and formulating problems and developing methods and programmes for their solution;
- (ii) to identify and co-ordinate individual developments so as to establish as far as possible programmes of general application;
- (iii) to establish a library of available programmes, to assist potential users in the selection and adaptation of programmes and to promote through courses etc. the application of computers; and
- (iv) to participate in international collaboration in the fields mentioned above.

For example, there might be established in each country one co-ordinating organization or institute with sub-committees in fields such as engineering design, management of construction activities and methods of physical planning, including analysis and design of traffic systems etc.

As has already been mentioned, it is very important that effective international collaboration be established between such national centres. This collaboration could take the form of co-ordination of research programmes, exchange of experience and, in some cases, working methods, and distribution of information on new developments and applications. Such collaboration would seem to call for a permanent international centre within the frame-work of the ECE or the CIB and would probably require support for staff and other expenses. Another possibility of organising international collaboration would be to allocate fields of interest to some national centres which would then act as international centres under the co-ordination of the ECE or the CIB (for their specific field). Other solutions may be preferable, and it is recommended

that a Group of Experts be convened to consider the form and content of such international collaboration and to work out detailed proposals under the auspices of the Secretariat of ECE in collaboration with interested Governments.


Summary of recommendations made in part II

- A. Macro-economic models. We acknowledge the importance of using mathematical methods and computers in this field, but since international co-operation is organized by the Econometric Society, no action arises for ECE.
- B. Assessment and forecasting of building requirements. As the ECE has already established a Working Group on Effective Demand for Housing, it is recommended that the Secretariat transmit the material and suggestions contained in national reports on the problems of forecasting demand for consideration at the next meeting of this group.
- C. Planning of the construction sector. Network theory has been found very effective as an aid to the co-ordination of national and regional investment programmes. Countries are recommended to take into account the experiences reported by Czechoslovakia and others. It would be helpful if this experience could be made available in a report circulated by ECE in one or more of the working languages. The Secretariat should be asked to invite countries (Czechoslovakia for example) to prepare a report on progress in this field and to distribute it to the countries interested.
- D. Physical planning. The ECE Working Party on Urban Renewal and Planning should be asked to consider the material concerning physical planning and to decide how to include these methods in its programme of work.
- E. Design. It is recommended to establish national expert commissions and co-ordinating agencies. International co-operation could preferably be established directly between such national bodies. It is recommended that acceleration and organisation of international collaboration in this field be entrusted to CIB and RELEM and that a special CIB working commission be set up for this purpose.

- P. Optimum design of buildings and housing estates. We recommend that CIB convene a meeting of experts to decide the best means of accelerating this development and that these methods be included in the programme of CIB Working Commission #37.
- Q. Project evaluation. It is recommended that Governments take note of the results of the United Nations Symposium on Industrial Project Evaluation, which took place in Prague in 1965. The new methods of rationalising investment decisions in the field of public construction, presented at the Symposium, seem to offer great possibilities of fruitful application. It is therefore recommended that ECE set up a Group of Experts to prepare an international meeting or seminar on the further development and application of these methods, and that the reports of the meeting or seminar be published and sent to Governments.

It is proposed to submit the following conclusions to CIB and the ECE Working Party on the Building Industry for consideration together with the associated recommendations.

- I. Analysis of the market, perspective planning and inter-industry balancing. We recommend that an account of the experience acquired in the field of input-output models for the construction sector and their optimisation should be circulated by ECE. The Secretariat should be asked to invite countries (e.g. Czechoslovakia, Hungary) to prepare a report on the progress made in this field and to distribute it to the countries interested.
- J. The evaluation and control of cost. The experience acquired in countries where computable methods of cost evaluation and analysis have been developed may be of interest to other countries; in such cases it may be recommended that direct contact be established between the countries concerned.
- K and L. Management of the production process, and communication systems in building. We recommend that an exchange of experience should be organised through a meeting convened by CIB.

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- M. Production basis of construction. It is recommended that a Group of Experts be formed within the framework of the Working Party, to carry out a more detailed investigation of this problem and that the results of its work be published.
- N. Automation of production processes. The experience acquired by countries may be of interest. In such cases it is recommended that direct contact should be established between the countries concerned and that the Working Party should promote such exchanges.
- O. Operation, maintenance and replacement of construction machinery. It is recommended that CIB be invited to consider what further action should be taken in this field in order to promote an exchange of experience.
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