BEAM PROGRAM

INDUSTRIALIZED BUILDING

LECTURES AND PROCEEDINGS
OF A NATIONAL CONFERENCE ON
A SYSTEMS APPROACH TO BUILDING
APRIL 29-30, 1968

held in cooperation with:
The Royal Architectural Institute of Canada
The Association of Consulting Engineers of Canada
The Canadian Construction Association

CANADA DEPARTMENT OF INDUSTRY OTTAWA

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ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
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MINISTER OF INDUSTRY

CANADA

MINISTRE DE L'INDUSTRIE

October 24, 1968.

As Minister of Industry, and Trade and Commerce I am pleased to be associated with the BEAM PROGRAM. It was as an integral part of this continuing departmental program that the conference on "A Systems Approach to Building" was held last April in cooperation with the Canadian Construction Association, the Royal Architectural Institute of Canada and the Association of Consulting Engineers of Canada.

This type of industry - government cooperation is highly commendable. It was encouraged by my colleague and predecessor, the Honourable C.M. Drury, now President of The Treasury Board who had an enthusiastic regard for the BEAM PROGRAM and took a leading part in this Conference. His opening remarks at the conference are included in this publication and reflect his deep appreciation of the need for increased productivity and efficiency in the building industry. It seems to me that the industry - government cooperation demonstrated in this endeavour is a pre-requisite to the attainment of our economic goals.

Such conferences as gave rise to this publication cannot help but stimulate the greater development and application of new technologies, thereby contributing toward greater productivity and economic growth.

Jean-Luc Pepin

Jean-Luc Pepin

INTRODUCTION

The term "A Systems Approach to Building" implies the identification and breakdown of a building program into all of its basic parts followed by a synthesis or build-up of the parts into alternate solutions aimed at meeting the user requirements of the buildings. Within the context of a systems approach to a building project studies undertaken include those necessary for determining performance specifications of, for example, structural, heating and ventilating and lighting systems. The performance specifications then become the deciding factors in the actual designs of the components and sub-systems. The fabricating, erecting and post-erection operating requirements for the various components and sub-systems may thus be analysed and determined

The systems approach also requires an accurate appraisal of the attitudes of labour and management to work which may require the application of multi-craft skills and new contractural relationships for optimum productivity and efficiency. The appropriate inclusion of newly developing technologies is of fundamental concern as are considerations of the humanistic and aesthetic aspects of the project. All of the above should be directed to be within predetermined cost constraints based upon the qualities that the building provides for its users throughout its total life.

The purpose of the conference which gave rise to this publication was to impart an appreciation of a systems approach to building to a broad representation of those concerned with building in Canada. It was to this end that the program was organized and the lecturers selected. Therefore the publication of the proceedings which is really an extension of the conference, having the same purpose, follows the order of the program.

The lecturers, each distinguished in his field came from Denmark, England, the United States and Canada. Their formal lectures are recorded here in full. As a group they represented the design and teaching professions, production and site management, labour unions, business administration, government and industry. Their lectures form a linkage for understanding the subject and the reader is urged to consider them as a group even though each stands on its own merits.

There are two notable examples of the application of a systems approach to building programs in Canada. Both of these relate to the provision of schools. The first known as the Study of Educational Facilities (SEF) of the Metropolitan Toronto School Board is under the technical direction of Mr. Roderick C. Robbie. The second, being conducted by the Institut de Recherches et de Normalisations

Economiques et Scientifiques Inc., (IRNES) in Montreal, is identified as the Recherches Aménagement Scolaire (RAS) Program and is directed by Mr. Gerard Corriveau. The two projects were described in detail at the conference in papers presented by Mr. Corriveau and Mr. Robbie. Their contributions, included here, impart an excellent understanding of their respective projects.

Much of the conference was devoted to open discussion. These periods were characterised by intelligent questions, comments and answers from both the floor and from the panelists. Virtually all of these discussions have been recorded herein in almost unedited form. Except in cases where questions or comments were completely repetitive nothing has been omitted since it was felt that to do so might impair the overall value of the conference in some way.

The conference was attended by more than 450 architects, engineers, teachers, building materials manufacturers, contractors, financiers, representatives of labour unions and government representatives, all having positions of importance and influence in the building industry. Their presence in Ottawa indicated a wide spread interest in the advancing technologies now being employed in building.

The conference consisted of three main sections. Each section had a rapporteur who recorded the essentials of the lectures and reported his appreciation in summarized form towards the end of the conference. Their reports, when published as a quick follow-up to the conference, were widely acclaimed. It is approrpriate that these reports consitute a conclusion to this publication. They merit special mention.

Special thanks are due to the members of the Industry Advisory Committee on Industrialized Building Techniques and Systems. It was they who proposed the conference and recommended its form and subject matter. Many of the members acted as session chairmen and the rapporteurs also were chosen from the membership of the Committee. It is fitting that their names, positions and affiliations be recorded and this has been done in an appendix to this volume.

Dean John P. Eberhard, School of Design, University of New York states that, "The systems approach - correctly understood and correctly used - provides a means of utilizing the techniques of the scientific/architectural/engineering community in the service of the artist/humanist community. It is an inclusive concept that requires for its truest application the linking of our ways of feeling to our ways of knowing - to realize emotionally what we know intellectually."

Ultimately that is what this publication is all about.

P R O G R A M

NATIONAL CONFERENCE

ON

A SYSTEMS APPROACH TO BUILDING

MONDAY, APRIL 29, 1968

Opening Session

Chairman: Deputy Minister of Industry

Welcome and opening address - Honourable Charles M. Drury,
Minister of Industry, Ottawa

"L'Aménagement d'un milieu plus humain"
- Mr. Guy Desbarats,
Dean of the School of Architectu[re]
University of Montreal

Morning Session

Chairman: Mr. Hector Asselin
Rapporteur: Mr. David C. Aird

"The Need for a Systems Approach to Building"
- Mr. Ezra D. Ehrenkrantz,
Building Systems Development Incorporated,
California, U.S.A.

"The Role of the Designer Team in Developing a Systems Approach to Building"
- Mr. Roger T. Walters,
Director General of Production,
Ministry of Public Building and Works,
London, England

"The Manufacturer/Contractor and the Systems Approach to Building"
- Mr. Kenneth M. Wood, Chairman,
Concrete Limited,
London, England

MONDAY, APRIL 29, 1968, cont'd

Luncheon

Chairman: Mr. Camille Dagenais,
President,
Association of Consulting Engineers of Canada

Address: - Mr. William Ladyman,
Vice-president,
Canadian Labour Congress and International Vice-president of the International Brotherhood of Electrical Workers

Afternoon Session

Chairman: Mr. Herbert C. Auerbach
Rapporteur: Mr. H. Brian Dickens
Panel Moderator: Mr. Frank J. Nichol

"A Systems Approach to Housing and Urban Development"
Case study of a major housing development in Denmark by:

- Mr. Marius Kjeldsen, Architect, Ministry of Housing, Denmark
- Mr. Johannes F. Munch-Petersen, Engineer, P.E. Malmstrøm, Consulting Engineers, Denmark
- Mr. Jens C. Holm, Managing Director, A. Jespersen & Son International Limited, Denmark
- Mr. Erik Andersen, Engineer, Site Division, P.E. Malmstrøm Consulting Engineers, Denmark

Panel discussion on case study with audience participation

MONDAY, APRIL 29, 1968, cont'd

Dinner

Chairman: Mr. A. William Purdy,
President,
Canadian Construction Association

Address: - Dr. William M. Armstrong,
Dean of Engineering and School of Architecture,
University of British Columbia

TUESDAY, APRIL 30, 1968

Morning Session

Chairman: Mr. John V. Lefebure
Rapporteur: Mr. Guy Saint-Pierre
Panel Moderator: Mr. Robert Halsall

"A Systems Approach to School Construction"
Case Study of school development projects in North America by:

- Mr. Jonathan King,
  Vice-president,
  Educational Facilities Laboratories,
  New York
- Mr. Ezra D. Ehrenkrantz,
  Project Architect,
  School Construction Systems Development,
  California
- Mr. Roderick C. Robbie,
  Technical Director,
  Study of Educational Facilities,
  Toronto
- Mr. Gérard Corriveau,
  Technical Director,
  Institut de Recherches et de Normalisations Economiques et Scientifiques Inc.,
  Montreal

Panel discussion on case study
with audience participation

TUESDAY, APRIL 30, 1968, cont'd

Luncheon

Chairman: Mr. James E. Searle,
President,
Royal Architectural Institute of Canada

Address: - Mr. Lucien Lalonde,
Deputy Minister of Public Works,
Ottawa

Afternoon Session

Chairman: Mr. Ronald Clarke
Panel Moderator: Mr. Ralph D. Hindson

Rapporteurs' Reports

Panel discussion with audience participation

Panelists:

Messrs. Erik Andersen
Gérard Corriveau
Ezra D. Ehrenkrantz
Jens C. Holm
Jonathan King
Marius Kjeldsen
William Ladyman
Johannes F. Munch-Petersen
Roderick C. Robbie
Roger T. Walters
Kenneth M. Wood

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ERIK ANDERSEN

Mr. Andersen graduated with an M.Sc. degree in civil and structural engineering from Technical University, Copenhagen in 1952.

Following a short period with a firm of general contractors, he was called to military service, which he completed as a lieutenant of the reserve, field artillery, in May 1954.

He then joined the firm of P.E. Malmstrom, consulting engineers, of which he has been Manager of the site management department since 1964.

In his specialized field of design, supervision and site management he has been particularly concerned with industrialized building. The firm of P.E. Malmstrom is in partnership with A. Jespersen and Son, International in the "Jespersen System" of industrialized building.

Mr. Andersen is a member of the Institution of Danish Civil Engineers and of several public and governmental committees and boards. He was Chairman of the Institution of Consulting Engineers in Denmark.

WILLIAM McCOLL ARMSTRONG

A native of Hamilton, Ontario, Professor Armstrong was graduated from the University of Toronto with a B.A.Sc. (Honours) degree in chemical engineering in 1937.

Following graduation, he joined Steel Company of Canada as supervisor of metallurgical laboratories, and in 1943 he went to the Ontario Research Foundation as a Dofasco Research Fellow in metallurgy.

Professor Armstrong was appointed Associate Professor of the Department of Metallurgy of the University of British Columbia in 1946, became Professor in 1954 and head of the department in 1964. He was named Dean of the Faculty of Applied Science in 1966.

Professional appointments have included those of Chairman of the Council of Continuing Education for Engineers, 1966; President of the Canadian Council of Professional Engineers, 1966/67; Secretary of the Board of Governors, U.B.C., 1967; Deputy Acting President, U.B.C., 1967; Vice-president, Metallurgy Division, Canadian Institute of Mining and Metallurgy, 1967/68; and Conference Chairman for the Conference of Metallurgists, 1968.

In addition, Professor Armstrong has acted as consultant for a number of steel producers in Canada, the United States and Germany and has served as an expert witness in numerous legal cases involving metallurgical problems. He designed and directed construction of the Western Canada Steel electric furnace and rolling mills in Vancouver.

A registered professional engineer, Professor Armstrong is a member of leading metallurgical, ceramic and electrochemical societies in Canada, the United States and Europe. He was awarded the International Teaching Award of the American Society for Metals in 1953, and the Canadian Centennial Medal in 1967.

GERARD CORRIVEAU

Mr. Corriveau received his academic training at Laval University, Quebec, from which he received his B.A. in 1937, his B.Ph. in 1939, and a Bachelor of Applied Sciences degree in 1943.

At the conclusion of his academic work, Mr. Corriveau joined Sorel Industries Ltd. where he performed laboratory analysis of steels. In 1944 he became a technical adviser to the French Government in Washington, D.C. and in 1947 became chief of its Steels Division, responsible for the replacement of French standards for steel, wood and coal by American standards. In 1950, he became Chief of the Energy Division.

Mr. Corriveau joined Defence Construction Ltd. in 1951 as resident engineer for the construction of the Saint-Sylvestre radar station. In 1953, he became regional engineer for defence construction in the province of Quebec, and in 1955, was appointed Associate Director of European Operations. In this position Mr. Corriveau was responsible for all Canadian defence construction in Europe. He became Director of European Operations in 1958.

Mr. Corriveau was appointed to the NATO Expert Committee on Construction in 1959 and chaired the committee from 1962 to 1966. In this period he was responsible for headquarters construction, many military hospitals, and systems of school building, including the CLASP system in Great Britain.

Since 1966, Mr. Corriveau has been Executive Director of the Institut de Recherches et de Normalisation Economique et Scientifique Inc., a consulting firm involved in systems design for school construction in greater Montreal.

GUY DESBARATS

Mr. Desbarats studied civil engineering and architecture at McGill University from which he was graduated in 1948 with the degree of Bachelor of Architecture, and was winner of several awards for academic excellence.

After four years' employment with the Ottawa architectural firm of Abra, Balharrie and Shore, he did research on post-war housing in Montreal on a CMHC fellowship. This was followed by five years of teaching as a special assistant at McGill during which period he set up the architecture and construction laboratory of the School of Architecture. Mr. Desbarats was associated with the laboratories of architecture organized by H.T. Fisher in Lake Forest, Ill., and at the Virginia Polytechnic Institute.

In 1953 he joined R.T. Affleck of Montreal in a venture which led to partnership in the firm of Affleck, Desbarats, Dimakopoulos, Lebensold, Sise, formed in 1954. Since January, 1968, he has acted as consultant to the firm.

Mr. Desbarats was named Dean of the University of Montreal's new Faculty of Architecture in 1964, and in May 1968 he became Dean of the Faculty of Planning, comprising the School of Architecture and the Institute of Urbanism.

Many of the projects in which Mr. Desbarats has been involved have won awards for excellence of design. Among them are the Queen Elizabeth Theatre of Vancouver and the Fathers of Confederation Memorial Building in Charlottetown.

He has been a member of many consultative committees on architecture for governments and universities, has served on several architectural juries and has been active in professional organizations. He was made a fellow of the Royal Architectural Institute of Canada in 1963.

Mr. Desbarats is author of several published lecture series and has written numerous articles for professional journals.

EZRA D. EHRENKRANTZ

Professor Ehrenkrantz is Associate Professor of Architecture at the University of California, Berkeley Campus. He is also principal of Leefe and Ehrenkrantz Associates of San Francisco and Washington, D.C., President of Building Systems Development Inc., San Francisco and Washington, and Director of the Organization for Social and Technological Innovation, Cambridge, Massachusetts.

In his professional work he has been responsible for the programming and design of a number of important schools, university and housing projects and has acted as consultant to federal and city administrations, and to the Government of Israel.

In his academic work, Prof. Ehrenkrantz has lectured extensively to groups in the United States on the subject of systems building and other architectural subjects. As consultant to the U.S. Federal Department of Housing and Urban Development, he helped develop the concept of the Urban Development Corporation. He is also a member of the White House Task Force on Cities, the National Commission on Urban Problems and the Research and Engineering Advisory Council of the U.S. Post Office.

Prof. Ehrenkrantz is the holder of a number of special awards for his work, including the State of California Governor's Design Award, 1966 and a gold medal for school design presented by the American Association of School Administrators and American Institute of Architects in 1967.

He is a member of the American Institute of Architects and the International Council of Building Officials, and is a director of the School Facility Council.

JENS C. HOLM

Mr. Holm is a graduate of the Royal Technical University, Copenhagen, where he obtained the degree of M.Sc. (Engineering) in 1935.

He joined the firm of F.L. Smidth & Co., Copenhagen, designers and manufacturers of cement machinery and plants, as an engineering trainee in 1935. and subsequently held appointments as Resident Engineer in charge of construction of cement plants in Eire and India.

In 1940, Mr. Holm went to the United States as Operating Manager of National Portland Cement Co., Bethlehem, Pa., and moved in 1948 to the Marquette Cement Manufacturing Co., Chicago, as Director of Engineering.

He became President of the Riverton Lime and Stone Company in Virginia in 1956, and returned to Denmark in 1960 as Export Manager of Atlas Refrigeration Company. Since 1966 he has been Managing Director of A. Jespersen and Son International, of Denmark.

Mr. Holm is a member of the American Institute of Mining and Metallurgical Engineers, the American Society of Civil Engineers, the Danish Institute of Civil Engineers and the American Concrete Institute.

JONATHAN KING

Mr. King is Vice-president and Treasurer of Educational Facilities Laboratories, Inc. of New York. He is a graduate of Lincoln School of Teachers' College and of Columbia College, Columbia University from which he obtained his B.A. degree in 1949.

During the Second World War he served as a staff sergeant in the U.S. Army in the Pacific Theatre.

From 1949 to 1952, Mr. King was an associate editor with G.P. Putnam's Sons, publishers, and from 1952 to 1958 he was a staff associate of the Ford Foundation and the Fund for the Advancement of Education. He joined Educational Facilities Laboratories as Secretary and Treasurer in 1958.

He has published a number of books in the field of educational facilities, as well as articles in such publications as the Saturday Review, Architectural Record and Canadian Architect.

Mr. King is a member of the Acoustical Society of America, the Building Research Institute, the National Council on Schoolhouse Construction and the Society for College and University Planning. He holds the 1965 award of the American Builder magazine for innovations in building.

MARIUS KJELDSEN

Mr. Kjeldsen is a graduate of the School of Architecture of the Danish Royal Academy of Fine Arts, and a graduate engineer in building construction who began his working life as a skilled bricklayer.

After two years in private practice from 1948 to 1950, he joined the Danish government's Ministry of Housing, where he has worked mainly in the fields of industrialized building methods, rationalization and standardization techniques, long-term house building programs and productivity in the building industry.

Mr. Kjeldsen is a member of the Association of Danish Architects and of the Ministry of Housing's Productivity Committee.

WILLIAM LADYMAN

Mr. Ladyman became a member of the International Brotherhood of Electrical Workers in 1932, when he was employed by the Manitoba Telephone System.

After holding local Union offices, he was appointed to a full-time staff position in 1948. He organized electrical workers across the prairie provinces and northwestern Ontario until, in June 1963 he was appointed Canadian Vice-president, the top Canadian position in the Union. Three years later, he was unanimously re-elected by the delegates.

A member of the Economic Council of Canada, Mr. Ladyman is also Vice-president of the Canadian Labour Congress, a Director of the Ontario Housing Corporation and the Polymer Corporation and a Regent of the Ontario Council for Colleges of Applied Arts and Technology.

He is active on a number of industrial and labour relations advisory committees, notably the Ontario Union-Management Council, the ECC Advisory Committee to the federal Task Force on Labour Relations, the University of Toronto Industrial Relations Centre and the Canadian Construction Association.

G. LUCIEN LALONDE

Mr. Lalonde was born in Montreal in 1908. He obtained his Bachelor of Laws degree from the University of Montreal in 1930, and was admitted to the Quebec Bar the same year, practising in Montreal until 1939.

Joining the Regiment de Maisonneuve as a reservist in 1930, he was commissioned and enlisted with the rank of Captain when the regiment was mobilized in 1939. He served overseas throughout the campaign in north-west Europe, and was appointed first Second-in-Command and later Commanding Officer of his regiment in 1945.

During his war service, Mr. Lalonde rose to the rank of Lieutenant-Colonel and was made an Officer of the Order of the British Empire, was awarded the Efficiency Decoration and was mentioned in Despatches for courageous leadership.

On his return to civilian life, he set up the law firm of Lalonde, Dansereau and Marchand in Montreal in 1946, and in September of the same year was appointed Enforcement Counsel of the Wartime Prices and Trade Board for Montreal District. He was appointed Assistant Deputy Minister of the Department of Veterans Affairs in March 1949, and became Deputy Minister in 1955, remaining in that position until his appointment as Deputy Minister of Public Works in September 1963.

Since the Second World War, Mr. Lalonde has been active in ex-service organizations, having been Vice-preside of the Canadian Legion Council 1946 - 1950, President of the Jean-Brillant V. C. Branch of the Legion in 1947 and Vice-president of the Canadian Infantry Association in 1948. He commanded the Régiment de Chateauguay (Militia) from 1947 to 1949 and was made Honourary Colonel of the Hull Regiment in

Mr. Lalonde is a member of the Canadian Club, United Services Institute, Cercle Universitaire d'Ottawa, Ottawa Curling Club and Rivermead Golf Club, and has served as President of the Montreal Canadian Club (1948) and of the Federal Lawyers Club (1957).

He is married to the former Berthe Barcelo of Montreal, and they have six daughters.

JOHANNES F. MUNCH-PETERSEN

Following his graduation with the degree of M.Sc. in civil and structural engineering from Technical University, Copenhagen in 1951, Mr. Munch-Petersen was appointed Assistant Professor in the hydraulics laboratory of that university.

In 1953 he joined that staff of Ramboll and Hannemann, consulting engineers and in 1954 moved to the firm of P.E. Malmstrom. In 1963, he was appointed Manager of that firm's department for contracts abroad.

Mr. Munch-Petersen has been Secretary of Denmark's Committee for Rationalization of Building Activities, a member of committees for dimensional standardization, and has taken part in studies of industrialized building in Czechoslovakia, France, Britain, the United States and the U.S.S.R.

He is a member of the Institution of Danish Civil Engineers.

RODERICK C. ROBBIE

A native of Poole, England, Mr. Robbie served with the Royal Engineers in Egypt from 1947 to 1949 before beginning his architectural studies at the Portsmouth College of Art and Architecture.

He was graduated with honours from the Regent Street Polytechnic School of Architecture, London, in 1950 and was graduated as a town planner from the Regent Street Polytechnic School of Planning in 1954.

Before emigrating to Canada in 1956, Mr. Robbie worked for five years with British Railways on railway and industrial projects and was section leader for the development of building and equipment systems.

From 1956 to 1959, he was a junior partner in the firm of Belcourt and Blair, Ottawa architects and planners, where he was responsible for the design of the national headquarters of the Boy Scouts Association of Canada, one of the country's earliest wholly-precast major buildings.

In 1959, he joined the Ottawa office of Peter Dickinson Associates, where he was responsible for the feasibility, research and design studies for the new town of Frobisher Bay, N.W.T., involving the application of system building techniques to high-rise projects in remote, regions and cold climates.

In 1961, Mr. Robbie became a founding partner of the firm of Ashworth, Robbie, Vaughan and Williams (now Robbie, Vaughan and Williams), concerned with housing, commercial, educational, industrial design and exhibition projects in Canada and overseas. He represented the firm as director of the feasibility study for the Canadian government's participation in EXPO 67, and until August 1966 was project director for the design and construction of the Canadian pavilion. He then took over the position of Technical Director of the Metro Toronto School Board Study of Educational Facilities for the duration of that study.

He is a member of the Royal Architectural Institute of Canada, the Ontario Association of Architects, the Province of Quebec Association of Architects, the Town

Planning Institute of Canada, and the Architectural Association. He is also an Associate of the Royal Institute of British Architects and a member of the Department of Industry's Advisory Committee for the Industrialization of the Building Industry.

ROGER T. WALTERS

Mr. Walters received his formal education at Oundle School, England, and his professional training at the Architectural Association and Liverpool Schools of Architecture.

From 1946 to 1949, he was Architect to the Timber Development Association in Britain, and for the following 10 years was Principal Assistant Architect, Eastern Region, British Railways.

Mr. Walters was appointed Chief Architect (Development) in the Directorate of Works, War Office in 1959. In 1962 he moved to the Ministry of Public Building and Works as Deputy Director-General of Research and Development, and was appointed Director-General of Production in December, 19

He was made a C.B.E. in 1965.

KENNETH M. WOOD

Mr. Wood is Chairman and Joint Managing Director of Concrete Limited, manufacturers of precast concrete structural products at nine plants in Britain.

Beginning his formal education at Barnstaple Grammar School, he won an open scholarship to Trinity College, Cambridge, and qualified as a chartered accountant after taking his degree.

Mr. Wood served in the Royal Artillery during the Second World War, after which he joined Concrete Limited, becoming a Director in 1946. He left the accounting field to concentrate on precast and prestressed concrete techniques and development, became Joint Managing Director of the company in 1950 and Chairman in 1958.

From June 1966 to August 1967 he was on loan to the Mihistry of Housing and Local Government as Industrial Advisor to the Minister on house building, and he was also appointed a director of the National Building Agency. In October 1967 he was appointed Chairman of the British Standards Institution's panel responsible for planning the change to metric in Britain's building industry.

REMARKS BY THE HONOURABLE C. M. DRURY, MINISTER OF INDUSTRY AT THE OPENING OF THE NATIONAL CONFERENCE ON A SYSTEMS APPROACH TO BUILDING

It gives me a great deal of pleasure and considerable personal satisfaction to welcome to this conference so many prominent Canadians from all parts of the country - senior representatives from industry, from the architectural, engineering, and teaching professions, from labour, from Provincial Governments and from the Federal Government. I am also particularly pleased to welcome the representatives of the industry and professional associations, which are indispensable not only to the industry they represent, but also to government. It would be very difficult for government to come to grips with an industry as large and as diversified as the construction industry without the help of such organizations as are represented here today. All of these associations, both national and provincial, have been of considerable assistance to my department in the formulation and implementation of the BEAM Program - a co-operative program between industry and government to increase efficiency in the manufacture and use of building equipment, accessories and materials. This conference is a further example of how industry associations and institutes can work together with Government to achieve a common purpose.

The three gentlemen who are sharing the platform with me today are presidents of national organizations which represent a large and important part of the construction industry. They are:

Mr. A. W. Purdy	- President of the Canadian Construction Association
Mr. James Searle	- President of the Royal Architectural Institute of Canada
Mr. Camille Dagenais	- President of the Association of Consulting Engineers of Canada

As you know, these gentlemen and their organizations are co-sponsors of this conference. On their behalf, as well as on my own, I welcome you to this national conference on a "Systems Approach to Building", the first of its kind in Canada, and as far as we know, in the world.

This conference was organized at the suggestion of the Industry Advisory Committee on Industrialized Building Techniques and Systems. It is one of three industry advisory committees which were established over a year ago to help my Department formulate and implement the BEAM Program. Manufacturers, architects, engineers, contractors, labour representatives, specifications writers and educators from across Canada are actively participating on these committees. Many committee members are with us today and I would like to take this opportunity to tell them how much we appreciate the co-operation and help that they are giving us.

You are a very influential audience. All of you are in positions of responsibility within your respective industries and professions and your decisions have an important direct bearing upon the development of the Canadian building industry. The purpose of this conference is to exchange views and experiences of a systems approach to building with the objective of developing ways in which all of us concerned with the construction industry can carry out our tasks and responsibilities more efficiently and effectively.

Mr. Searle, Mr. Dagenais and Mr. Purdy join with me in commending the subject matter of this conference to you as an essential step in overcoming some of the problems with which the construction industry is faced. We hope that when you return home, you will share your knowledge with others and join together with them in implementing the concepts which will be discussed at the conference. The success of this conference will only be determined by the action it generates.

There is nothing very mysterious about a "systems approach to building". It does not refer to any single part or aspect of the construction industry but to the co-ordination of all parts and all aspects. In other words, this conference is concerned with a rational and logical way to co-ordinate the total building effort, whereby all segments of the construction industry are working in unison to enable proper planning and systematic organization to be applied to the construction of a single project or a series of projects. The end result will be greater efficiency and lower costs in the construction industry.

Let us consider the breadth and scope of this industry. It comprises a wide spectrum of equipment and material manufacturers, architects, engineers, labour, financial institutions, contractors, service establishments, land developers and many others. During the past twenty years, construction expenditures have been an extremely important factor in Canada's total economic growth. The long-run course of Canadian construction activity has been strongly upward and in recent years construction outlays have grown to about 16 per cent of the Gross National Product. This proportion is higher than that of any other major industrial country. It is obvious that any industry which bulks so large in terms of dollars expended and includes such a variety of industrial activities, exercises a major effect upon the levels of total economic activity in Canada. It is only logical, therefore, that we should be vitally interested in searching for new ways to improve the efficiency and productivity of our construction industry.

The significance of the industry within the Canadian economy is certainly not likely to diminish in the foreseeable future. The Economic Council has given us a good indication of those factors which are at work in the economy that will affect the future demand for construction. The Council has projected an increase of some 5.8 million people in urban areas by 1980. In the largest urban centres, the Council believes that there will be a 60 per cent rise in population over the next thirteen years. The Council's report goes on to point out that, even if the major cities were already functioning efficiently, growth of this magnitude would involve substantial new investment, much of it in construction. In reality, however, there is widespread concern about the mounting deficiencies of our cities and the heavy backlogs of needed improvements. Such problems as inadequate housing, traffic congestion, decaying business and shopping areas, the need for better control of water and air pollution are receiving increasing attention and indicate clearly the pressures that will be placed on construction activity.

It is imperative, therefore, that all of us concerned with the various aspects of construction activity should co-ordinate our efforts to use resources in the most efficient way. While the successful development of new products and new methods has in the past 20 years made the industry more productive, I am sure that few of us are by any means satisfied. During the period 1961 to 1967 productivity in terms of output per person employed increased over 21 per cent in manufacturing industries as a whole, and in agriculture by over 100 per cent. In this period productivity in the construction industry rose by only 6 per cent.

A feature of this industry, not necessarily unique to construction alone, but one which has an important bearing on the industry's over-all performance is the large number of contracting firms in Canada. For example, in 1964 one out of every seven persons employed in the contracting trades was either the head of an unincorporated business, or the head of a corporation. In 1964, there were about 53,000 individual contracting enterprises in Canada of which less than 1 per cent had assets of over $1,000,000. The revenues of this 1 per cent group represented about one third of the total revenues of all contracting businesses.

Small business is admirable in a great many respects. At the same time we must recognize that such an industry structure creates problems of co-ordination in construction activity, problems in applying new techniques, and problems for obtaining the most effective use of skilled manpower.

Finally, the construction industry is by its nature one of the least capital intensive of our industries. In periods of expansion it cannot apply capital to achieve greater production as readily as many other industries. It depends heavily upon an adequate supply of skilled workers. In this connection, I would like to congratulate the Canadian Construction Association for undertaking the Canadian Enquiry on construction labour relations. It perhaps should be noted that during periods of construction expansion most new entrants to the skilled trades have been immigrants. During the 14-year period from 1951 to 1964 immigrants accounted for 90 per cent of the new bricklayers, 80 per cent of the new carpenters, 60 per cent of the new plasterers, and 38 per cent of the new plumbers and pipefitters. However, the problems of employment security and the need for frequent moves to new construction sites create difficulties for maintaining an adequate and efficient skilled labour force. This situation not only has an immediate effect upon productivity but, in addition, results in a weaker base from which good middle-management can be drawn during periods of expansion.

Your ability to expand in the future in order to satisfy the increased demands for your services may well be limited by the availability of skilled manpower. It seems clearly evident that since the increased demand for housing and other construction is not being accompanied by an appropriate increase in the working force that other methods must be quickly found to increase the capacity of your industry. It is of interest to note that an increase in productivity in the construction industry of 10 per cent would increase the country's wealth by more than one billion dollars per year.

The industry's ability to compete for capital will depend in considerable measure on its resourcefulness in operating at a level of efficiency which makes investment in construction an attractive matter. Capital is, as we all know, a scarce resource, and there is keen competition to attract the available supply into many alternative uses.

Many other problems beset this large and fragmented industry. Obviously, the collection and dissemination of up-to-date information on all aspects of construction activity is a major problem. However, as in any other industry, up-to-date information is essential for effective and productive operations. The problem is not only one of being aware of the great many new and improved products and materials coming onto the market every day, but also one of knowing of those that are being withdrawn from the market. The need for a central information source that would provide an efficient information service, organizing and disseminating information related to building equipment, accessories and materials, is, therefore, being given serious consideration.

Since its formation in February, 1967, the Industry Advisory Committee on Construction Information Systems has commissioned a comprehensive study to determine the precise needs and priorities for construction information in Canada and to identify the possible ways in which an information system might be developed.

Another problem is the lack of widespread use of accepted standard modules and this continues to cause the proliferation of unco-ordinated sizes and specifications and has resulted in short production runs and lack of rationaliza and specialization. I do not need to mention the higher inventory costs and the wastage which go hand in hand with this lack of standardization. You are all too aware of it.

The great advantage of the modular concept is that it makes possible the design of systems in which materials, component products and equipment fit together easily and with a minimum amount of alteration on the site. I am told, however, that the adoption of the system does not limit the architect or the designer in freedom of planning.

The modular system has the further advantage of requiring the designer to think in terms of dimensional co-ordination at all stages of the design process. This factor greatly facilitates the co-ordination of overall planning, manufacture and assembly operations.

I am sure that you were as pleased as I was when the Minister of Public Works of Canada recently announced tha his Department intended to adopt modular co-ordination. As we all know, federal public works constitute a significant portion of construction activity.

Another problem area I should mention is the need for the more general adoption of a uniform building code. As you know, a number of federal agencies are giving this matter a high priority.

These are some of the factors influencing producti in the construction industry. The problems arising from thes and other factors must be resolved in the future if the construction industry is to substantially improve its productivity.

I believe that we have made a good start on this task through our joint work within the BEAM Program. With yo help this program is having considerable success in identifyi areas where government and industry can participate to increa efficiency in the construction industry and in initiating appropriate action. Programs are being developed to establis a construction information system; to promote the adoption of standard building measurements; to foster the greater industri ization of the building process; to achieve the adoption of more uniform building regulations throughout Canada; and to assess new materials and techniques.

This national Conference on a Systems Approach to Building is an integral part and a logical extension of our work so far. It is obvious that the various activities aimed at improving productivity in the building industry are highly inter-related. Thus while the theme of this conference is a Systems Approach to Building, of which industrialization is only a part, the other factors, objectives, and programs which I have just mentioned will also enter our discussions.

We have worked with you in helping to organize this conference because the benefits which can result from the application of a systems approach to the construction process must involve co-operation between all the various sectors of the industry. Architects, engineers, designers, contractors, developers and labour must work as a team if the system is to work properly. Various levels of Government also have a role to play in planning and in adopting appropriate standards and codes which will facilitiate a systems approach, not hinder it. The fact that this conference is taking place, at which so many key persons in the industry are participating, indicates a willingness to consider the problems of the industry on a co-operative basis. I hope that this spirit of co-operation will continue so that we can jointly formulate and implement activities to improve the position of this important industry.

On behalf of the Canadian Construction Association, the Royal Architectural Institute of Canada, the Association of Consulting Engineers of Canada, and the Department of Industry, I wish you every success in your deliberations.

THE DESIGN OF A MORE HUMAN ENVIRONMENT

GUY DESBARATS

I would like, in expressing my sincere thanks for this invitation to speak to you, to mention, however, the Honourable Minister's guile who, as a skilled statesman nimbly throws to me this great problem of the system approach and of its definition. I must say he is right in so asking because it is incumbent upon us as technicians, to enlighten all, on these concepts of systems which, nowadays, can be interpreted almost as magical solutions. As an amateur very interested in these questions during the last years, I will try first to choose a definition of a system among the existing ones, and after, more precisely, to present a systems approach to building in a broad context, broader than the one offered by the remarkable BEAM PROGRAM of the Department of Industry.

Leonard C. Silvern, Education and Training Consultants Co., gives this definition in the publication called "Audio-Visual Instructor", May, 1965:

> "A system is the structure of organization of an orderly whole, clearly showing the interrelationship of the parts to each other and to the whole itself."

And being cautious, he adds:

> "It has been our inability to relate elements to each other that has hampered our progress on comprehending and controlling complex systems."

Among the important writers on this subject of a systems approach to building, let us mention Hall, Ackoff, Churchman, Arnoff and others.

It is important here, to understand the distinction between operational research, systems engineering and systems design.

The analysis of these systems, in the most liberal sense of the word, is derived from two patterns of activities. The purpose of the operational research is to offer to the heads of industrial concerns a scientific approach which will provide the best solution to their problems characterized by the inter-relationship of the parts to each other in the best interest of the enterprise. While systems engineering, less easy to define, is the most recent of procedures aimed at organized creative technology by which scientific discoveries can be effectively used.

Even if the next speakers can express different points of view on this subject, I am sure that nobody will mind if I say in a simplified manner that the systems approach means the whole of systems engineering and of systems design on large entities composed of many parts.

The use of a systems approach to building will generally conform to this format of operational research.

- a statement of the problem
- the working out of a model representing the system to be studied
- the testing of the model and of its solutions
- the development of means to verify its accuracy
- the application of the solution in practical ways.

Systems engineering displays the following steps (here, I am quoting the book written by Hall, "A Methodology for Systems Engineering"):

1. Program planning: reaching agreement on program of work.
2. Exploratory planning:
   a) Problem definition
   b) Selecting objectives
   c) Systems synthesis (many solutions)
   d) Systems analysis (reviewing solutions)
   e) Selecting the best systems
   f) Communicating results
3. The development planning - to formulate a plan of action.
4. Development of test installation or pilot operations.
5. Feedback.

These sequences, separately or relatedly would seem to me to be roughly the "systems approach."

I have ventured to define "systems" and "systems approach" only in order to situate more clearly the main theme of my talk, which touches upon some aspects of the building industry's relationship to society.

I will elaborate briefly the following ideas:

1. That the total building industry system should include its market, and that improvements in the working efficiencies of the industry itself must be measured in terms of the total system performance, i.e. including users.

2. That this market, which is mainly urban, has goals and problems: social and individual goals and problems.

3. That if the building industry wishes to increase its efficiency and begin to plan its future, it will have to participate in the definition of urban goals.

4. The industry can gain a real participation in the definition and selection of urban goals through its own problem-solving activities and by innovations, by inventing some goals of its own for society.

5. To do this, industry needs "design research" which I will try to define, developed on an unprecedented scale.

6. What should be the objects of the research and who should go about it, and what can it do for industry?

Let us consider the first idea, that the definition of the building industry systems should include its own market. Allow me to quote Mr. P. E. Dalton, former CCA President, who is no doubt here present, and I hope he will forgive me! In the Report on Business Outlook, 1968, of the Toronto School of Business, University of Toronto, Mr. Dalton says: "The building industry is a service industry. It devotes its energies to turning the dreams and demands of others into realities. Its activities are very largely dependent upon the decisions of others in the fields of government, finance and business."

Now, the very often quoted Mr. Galbraith, in his analysis of the new industrial state, describes the process whereby large industries have developed their ability to plan in order to maintain stability and to foster their own development. His conculsions make much sense at least to an economic layman like myself: he describes the mature corporation as that which has passed from the so-called "accepted sequence" to the "revised sequence." Those who have read the book will forgive me paraphrasing it, but, in brief, the "accepted sequence" is the condition of the less powerful producer, who is in theory completely dependent on the free choice of the market, the "revised sequence" is the more sophisticated condition of the advanced technological corporation, which has acquired a measure of control in planning its future, by convincing society that its goals and those of the corporations are one and the same. Galbraith's thesis is that a corporation that is reaching for an advanced stage of technology with all the capital, labour and research and development expenditures that this level implies must gain a level of planned stability and gain it by having society and government share in the realization of its own goals. Some of us may see a sinister aspect to the notion of an industry penetrating so deeply into the conscience of society; I would agree if we were discussing a consumer fashion product and not basic shelter and the city, as we are; the kind of influence that the building industry could exercise on its market is not such that it need be sought through advertising or immediate consumption incentives. The industry is an essential one, and already benefits from a very strong consumer interest. I suggest therefore, that a long-range aim for the industry can well be a growth of its own awareness of its potential ability to set social goals.

The last and 6th article of faith of the BEAM Program leads to my present position by extension.

It reads: "The establishment of an awards program to foster improved design in new materials, methods and techniques."

It suggests an improvement in the existing products but it does not touch the formative needs of the industry: what existing products, and what new products are required for the development of entire new cities or total environmental systems conceived by the industry to the limit of its technical and design potential.

I suggest that it is only by including the users in the system of the building industry that the system will be complete enough for fully effective action, made possible by a convergence of social dreams and the dreams of the industry!

I submit here that I am not going at all beyond the implicit purpose of this conference, but that I am trying to give a broader vision, a stronger future orientation to the painstaking and essential approach that the Department of Industry has proposed to us.

Now my second suggestion, to the effect that the industry, now re-defined to include its clients, should participate in the definition of the users' goals, does not imply that the industry does not know anything about these goals now. Of course not. I say simply that the industry has not organized itself formally to participate in the study, or to benefit directly from studies of the goals and problems of its clients. Here, I am talking mainly of the city: industry and government have planned and will plan their needs to a growing degree. The city has more trouble defining its goals. But it is beginning to acknowledge its suffering, its problems, and their magnitude. Our countries' leaders, in the U.S. and Canada, have suddenly become aware of the technocrats' visions of the past decades and exclaim that we must build entirely new cities. But we are only becoming aware of the awesome complexity of our poor old cities - let me quote first, to define the magnitude of the problem, the 4th annual report of the Economic Council of Canada, that has this to say: "Mounting deficiencies and shortages and inadequacy of urban housing, traffic and transporation problems, air and water pollution, the confused jumble of conflicting land uses, decaying neighbourhoods and monotonous suburbs, urban poverty and social disturbance, steadily rising property tax burdens, and the frustrations of municipal administrators...... In the light of these problems, and of the enormous cost of coping with them, the council suggested it might be wise to try to define the city of optimum size...... To deal with urban problems, the council recommended long-range planning of urban spaces, modernization of local government, strengthening the training of and incentives for public administrators and engineers, fiscal planning embracing all levels of government, improved statistics, and a general recognition that Canada is now a predominantly urban country."

The economic council bravely recommends things that many wise men have been pondering, and have this to say about, and I quote Evert Clark in the New York Times, reporting on the very recent AIAA */ORSA ** conference

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* American Institute of Aeronautics & Astronautics
** Operational Research Society of America

in Washington: "The systems analysts and engineers who have brought efficiency to global war came close to admitting defeat this week as they confronted the problem of social change; during a recent forum of the American Institute of Aeronautics and Astronautics, and the Operational Research Society of America, one of them said: 'As we move closer and closer to human beings, human life, and to its goals, we find that we are dealing progressively, with more and more difficult problems.' Several of these men have already explored the living problems of riot control, slum removal, waste disposal, mass transportation, but they find little of the cool logic of mathematics, or what one speaker called. 'the inertness of complex military machines.' Mr. Engel, who is the incoming president of Operational Research, said in summary of the Washington meeting: 'We are very good at hardware and tactical problems and starting well-defined research and development programs; we're lousy at strategic and philosophical programs.' At the same conference, Major Henry W. Maier, of Milwaukee told a panel on the cities: 'I don't think people really know what a mess we're in.'"

Our market, then, has problems - what are its goals? (Now you would think I don't have an idea in my head, but it's fun to put quotes together to form a new picture, so here goes again.)

Regarding pollution, in the Montreal Star some weeks ago, Dr. W. R. Dryden, of the Research Institute, University of Waterloo, said: "First we have to define the goals of society. Technology now exists for an 'acceptable' level of pollution control, first a value judgement has to be made, and then society has to decide whether or not it is worthwhile to spend the money. Pollution control is a matter of establishing priorities." These priorities are, gentlemen, I suggest, clearly a part of the building industry system.

These goals, in part, it seems to me, can and must be set by the industry when it comes to realize its own technological potential. This approach lands us squarely into an area of the broadest kind of planning. May I quote Mr. Dalton again: "The lack of long-range planning, particularly at the governmental level is one of the major problems of the industry. Better planning would result in greater stability in the industry; indeed if there was stability in the growth rate of the construction programs, there would be less need to use housing as a regulator of the economy and subject this part of the industry to so many short range fluctuations."

My third point is therefore again stated that an industry that represents 1/5 of the G.N.P. * and is valued at 11.2 billion a year, has an interest in participating in the planning of its consumer areas. The definition of the goals of this area is an extremely difficult task, as we all know, but I fear that an attitude on the part of the industry that would see itself as a passive service industry will not answer the need it has for planning its future - a marketing attitude that seeks only to satisfy a present level of aspiration in housing for example, will only succeed in compounding atrociously the problems of the suburbs.

Detroit has been producing cars with that attitude, for many decades now; this attitude leads to environmental failures that will cost us all dearly; the building industry is concerned with the total human built-up environment; it must not try to optimize any one of its sectors at the expense of a better total environment.

My fourth argument is this: that the real game for the building industry is to "create new needs, or better still new levels of aspiration" by technological and design innovation - solve existing problems by boldly stepping out of the present deadlock. Such steps will require of the industry a new level of understanding of urban problems - a participation in urban analysis and synthesis, that is, involvement of the industry in its total systems development. The recommendation of the Department of Industry Advisory Committee on Industrialized Building (techniques and systems) has recommended that "an orderly and efficient industrialization of the building process cannot take place without first considering the development of an overall systems approach to building, of which industrialization is only a part." And now, I claim that an over-view of the system of social goals must be included in this concern - the understanding of present goals of urban society and the creation of a new level of environmental aspirations, based on present high levels of available technology is absolutely essential to the planning of the future of the building industry.

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* Gross National Product

The Honorable Paul Hellyer in a recent speech which can be taken to reflect current top level aspirations, states the need for innovation even more dramatically than I have, by suggesting that the only answer to our urban problems lies in the creation of new cities of over 1 or 2 million inhabitants.

That the theme of this conference "A Systems Approach to Building" is relevant to this level of aspiration, is clearly accepted in the conclusions of the Woods Hole conference of top brains assembled by the U.S. Government to study the city and its problems, and reporting in Science and the City, published by H.U.D. * which has this to say: "The space agency integrated the efforts of government, universities, and industry to put our country into the race to the moon. It did this with newly developed control and management tools. They showed what innovations were needed to produce spacecraft and ways were found to bring them about. The new agency in other words, took what is called a systems approach to bringing together the diverse talents of thousands of persons. The city consists of systems and sub-systems. It has systems for assuring people's health, mobility and cleanliness, systems for fighting fires , enforcing laws and educating and entertaining its populace, all of which interact with each other.

When specialists in this and that realized how all the little things had to work together to put a man into orbit, it did not take them long to improve the performance of the sub-systems.

With new combinations of old but now more effective devices, stout-hearted men have begun to give us new views of the whole solar system.

The city is a much more intricate combination of systems and sub-systems than a space-ship. Urban people's safety and happiness depend not only on physical structures but also on their own biological needs and on the performance of economic and social systems. Our woes, they concluded (the Woods Hole gathering, that is) have resulted quite largely from our frequent indifference to the interactions between the many systems in the machinery that makes the city tick. We have tinkered with this, that and the other thing under the hood without knowing what each one could or should do to make the engine run smoothly. What really must be done has not been demonstrated yet. And that is the

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* Department of Housing and Urban Development

problem that the industry faces. In answer, my argument continues: The industry must plan its future through understanding and sharing social goals sufficiently to be able to innovate for society and to chart a course to the future through its research efforts. What needs to be done, is the building industries' business, and that 'what' can only be found through research.

I will give you an interesting statistic I picked up at the AIAA conference in Los Angeles last December; this is a comparison of the innovation rates of some major industries: the 'innovation rate', if my memory serves me, as I could not re-locate my source, is the rate at which an industry, through opening of new areas of activity, by invention or adaptation, doubles its field of activity, not in size, but in type of activity. A few sample rates are:

Electronic Industry.	2 years
National Industrial average. .	20 years
Housing Industry	40 years

The difference is research. To give you an example of what this could mean, the Woods Hole sages had this to say, I quote again: No one is certain, how much more space American families must have than men in barracks. Everyone guesses that single men and women, the very old, and the very poor frequently demand much less room than prosperous growing families, but no one knows how widely such requirements vary. Builders are still striving to meet this wide range of needs in ways reminiscent of those by which the alchemists tried to make gold. With computers, mathematicians can generate models to help us review and compare many of the effects of clustering various kinds of people differently and in different areas. Are we using these new tools?

"Men will galdly risk a trip to the moon because researchers have measured the hazards, and engineers have built a long roster of reliable devices to reduce them. Anthropologists and financiers and statesmen could work together with other specialists to survey the hazards of urban life similarly. Then ways might be found to minimize many of them."

You see where the action is. The industry must find ways of working with all the experts in physical and social environment. Now a very recent European study of U.S. science policies states that they found "....in the formation, implementation and achievement of U.S. science policies......first and foremost......a convergence of interests and motivations to construct the future: the adventure of scientific and technical research appears as the main way of access to this future, in which the drive and ambition shown by a whole nation will be expressed."

I am not claiming that no research at all is being done by the building industry, taken in its widest definition. But just as I say the BEAM program can be widened so I say that though some materials and components and techniques have been well-researched or its ground-transport, or housing sub-systems; components have received some attention, but assembly of components has received almost none (and I was saying the same thing here in Ottawa in 1953).

To clarify the ideas of innovation and research in the building industry, I want to describe to you a kind of research that appears to me to be much needed if we are to satisfy old and new goals in the city: This is design research or better "systems design research". I mentioned earlier the 4th exhortation of this conference and the 6th commandment of the BEAM program.

Let me read to you:

"New methods of co-ordinating the building requirements of clients and new contractual and working relationships among clients, architects, engineers, builders, labour and manufacturers" and "the establishment of an awards program to foster improved design in new materials, methods and techniques."

These are essential steps, but they need to be read very broadly to satisfy a total systems approach, the only approach that might answer the egg-heads from Woods Hole or the stirring call to action of the Honorable Paul Hellyer. A new dimension of research, for the building industry, is needed here. As this design research is relatively new ground, and as it will in my opinion require new attitudes on many sides, I will have to describe some of the existing attitudes and institutions that, in my opinion, are hindering this essential growth.

Foremost is the "bits and pieces" research attitude that has prevailed so far; the industry is fragmented and operates as sub-systems in isolation. Material research in the large corporations, chemical, lumber products etc., moves well ahead; assemblage innovations come more slowly;

the subs are bigger than the generals in this industry; and building design innovation occurs only on the one-shot basis of architectural participation. The architect and professional consultant-engineer is to all effect and purposes outside the system. He traditionally represents the client, he lacks industry data input, he is not really in the loop. An eminent aerospace engineer, Julius Lukasiewicz, who came to my School of Architecture two years ago, thanks to a CMHC grant, to analyse our researche potential, came to this conclusion regarding architects: "They perform research all the time, they practically do nothing else, but they don't record the problem statement, they seldom analyse alternative solutions, they don't record performance and don't publish results." Well, I think this comes close to being the truth for the whole of the assembly and component manufacturing part of this build ing industry. BEAM should go a long way toward improving those habits - and, thereby answer the hopes of M.R.M. Larocque, president, Canadian Home Manufacturers' Associati when he states in "New Dimensions" that "The home manufactu ing industry should use revolutionary new ideas and product

In this statement, the architect, the designer, is as usual, being considered a stylist, a man from outside the industry. This is not a "system" or aerospace approach

Our professionalism, consulting engineers and architects alike, and the industry's disparate "market approach" are both centrifugal compared with the new approach needed by the industry.

The systems approach and the aerospace business were not built up in answer to small scale business necessi

Government-backed, industry-wide research provide the leverage to innovation.

The housing industry alone is receiving $1,000,0C this year in federal funds. I would be happy to be proven wrong if I say that design research will receive less than 1/10 of one percent of that amount.

Industry obviously needs broad research to innova - to solve some of the enormous problems of urbanization.

Architects and engineers have clear visions of other ways to live, other environments. Alternatives are th essence of a systems analysis; we must and we can afford research into these alternatives, before we design the Honorable Mr. Hellyer's new 2,000,000 people urblands - or they will be messes. They will just be extrapolations of our present ignorance. We have to design alternate new ways to live and we have to check them out for performance.

So while we are defining the industry and tidying it up by applying a systems approach we must also begin to organize systematic design research and development.

Now design research in the building industry is not an area of research that the classical scientist takes to kindly. I will tease one of them, in this audience, a, kindly man, but one who has often told me that architects research projects always had too many unknowns in them to be susceptible to correct scientific method. After each such encounter with virtuous science, I have retreated again, to further inadequate solving of insoluble equations. The building industry has always had to carry on without much scientific input.

Systems Design research, as I and others understand it, can contribute to the organization of the backlog of technical and scientific, but fragmented knowledge that the industry uses, or has available to it. Let me tell you an important note expressed by René duBos, eminent French biologist during the Smithsonian symposium on environment in Washington, in January '67, and I paraphrase him: "It is the very optimization of each specialty in science and industry that has practically always led to the aggravation and problems that we are now struggling with in our cities." Optimum economics in oil cracking give us smog; good car brakes give us cancerous rubber fumes; detergents kill wild life, etc.,etc. In a poetic kind of reversal of this trend, war and aero-space have given us the techniques of systems approach and systems design - none too soon.

The need, therefore is to complete the existing specialized and isolated research activity now performed in the industry mainly on materials and techniques, and specifically the target of BEAM, by integrated research projects on full environments, complete with inhabitants! Then and only then, will the designer, whether urban planner, architect, engineer or industrial designer, offer his knowledge of the good environment in a way that can help the whole industry in a concerted effort to participate in social goal setting! To back up my claim here, let me quote from a really solid authority: the Woods Hole sages, again! "We now have a wide range of options: the hewers of wood offer it now in new and attractive forms, the suppliers of metal can produce it to more specifications, and the glass-makers need only be told what we want from them. Corporations that exploit natural resources have reduced the cost and improved the quality of many of the products that they offer to builders. Most of this research, however, has, been piecemeal rather than comprehensive. Its sponsors purpose was to increase sales of certain components of housing, rather than to make the final product more functional.

"We could not have gotten into space by the piecemeal development of the parts of space craft with the hope that, one way or another, they would be put together into something that would fly and could rendezvous. Yet this is the way we have been trying to improve housing."

"The summer study group recommended that the Department of Housing and Urban Development orchestrate the efforts of scientists, public officials, academicians, and private entrepreneurs, as the National Aeronautics and Space Administration has done. Like that agency, HUD has inherited experienced agencies and skilled personnel. It can benefit, too, from what older brothers have learned about health services, transportation, construction, hydrology, and other facets of urban problems. The U.S. (or Canada) has no national, prestigious institute or center of knowledge in urban technology......A Government Center could identify, describe and assign specialists to plug holes in the current state-of-the-art. It could initiate the development of entirely new technologies. It could help transfer knowledge from laboratories to persons responsible for urban structures and systems. It could stimulate colleges to offer short courses, summer programs, and fellowships for students concerned with the mystifying aspects of urban programs. It could assist the small builder by assembling, evaluating and distributing the information that he needs to compete with a large company.

"Agriculture,too,was long dominated by small businessmen unable to study and experiment with enough new ideas. Government-sponsored research and development helped to multiply the fruits of the farmer's labour. Thanks to the Department of Agriculture's energetic dissemination of new knowledge in its bulletins, by word of mouth and by demonstrations in the field, we acquired food surpluses."

The Woods Hole group proposed that the national government provide a yardstick for builders "....by creating some kind of quasi-public institutions and procedures to provide opportunities for innovations and to demonstrate new techniques in urban development. The city builders' knowledge of how to fit things together is still largely empirical. We are surrounded by visible evidence of its inadequacy to meet people's rising aspirations. In answer to this, HUD is preparing pilot plants for urban progress; model city programs will be experiments in innovation, models for social scientists to study."

This, in my opinion, is design research.

And now, in my final point, where do we stand, in Canada, with our present resources, to get involved in design research - what should we research, who should do it and where? With what hoped-for benefits to the total industry...?

We will hear later of one American and two Canadian programs of systems design research, all in the field of schools building. These programs have accumulated a considerable amount of experience, and are innovating, through research. They will, I hope, confirm the rather summary and theoretical picture that I am giving you of the systems approach in building, and of building design research. So that I hope that the following attempt at defining the very broad main categories of design research will not contradict their later presentations. These are:

1. technology and industrialization design; that is techniques, components and assemblies.

2. ecological and ergonomic criteria and performance: biological, sociological, anthropometrical and psychological.

3. the design of total living environments or large assemblies.

The first and second categories have seen some small progress over the last 20 years - BEAM will help greatly, I am confident. The universities are getting interested in No. 2 but No. 3 is the toughest to organize.

It includes activities of types 1 and 2 and implies also the testing-out of large pilot operations, therefore it is by definition, a pretty large-scale activity. We may yet learn to check performance in model form, but for this we need to analyse real performances. There were no wind-tunnels at Kitty Hawk or at Baddeck, and that's the stage we are at, in the building industry. We need full-size mock-ups and years of study on their performance. Total performance and satisfaction for humans.

This 3rd kind of research needs: land, money, interdisciplinary scientific and building industry professionals, the building force, and residents: the total system of built-up environment in pilot operation.

It looks to me that the usual trilogy of institutions is required to fulfill this mandate. The operative industry in total, professionals included, the universities and government!

The first area of research belongs mainly with industry with some assistance from university and government For the second, the universities can now begin to contribute new areas of knowledge, for instance: through social scienc and new architectural contributions such as of methods to check out human response to buildings - in terms of specific emotions, and satisfaction; or computer know-how to systems studies.

In No. 1 particularly the practicing building industry professional needs also to be given the chance to test ideas and to publish his work for which he needs respite from immediate pressure of profit necessity.

The crying need on both the side of the university and of industry is mainly to train researchers: they hardly exist in the business, whether in engineering, or in architecture.

The theoretical and systematic side of the building industry is truly a new frontier that the universities and the industry must attend to. The design side of the industry particularly must be brought into the scientific and rational context of modern industry, and out of the fashion game, for the sake of the whole industry.

The interesting semantics of the word design itse indicate to me the nature of the problem - to an aerospace engineer design means the system or process of creating a new instrument, a tool; to an architect and industrial designer, design means rather more to satisfy a socio-technique interface, a meeting of people with their made-up environment. To the public, I fear, it means a glossy surface treatment.

Canadian engineering has so far performed to best effect on the non-urban scene, through great works of road-building, dams, power plants, silos, harbours, railroads, all the muscle-flexing activities of machinery-energy development. The complex problems of human interaction in society with constructed works have been tackled less successfully.

H. E. Jarvie has redefined the architect recently as a "creative anthropologist." He is beginning to play such a role, after years of being reserved for the luxury trade like a jeweller. Jarvie pleads with architects and planners to be "bolder and freer in thinking through their ideas, yet more constrained in carrying them out."

Architects have, in intuitive empirical ways, been attempting with less and less success, as the city became more complex, to satisfy the needs for a human environment. The designer in the architectural and the engineering sense, is gaining, through systems approach, new tools to quantify his handling of all the unknowns that, like it or not, he must go on coping with.

Urban and housing design research, I wager, is a new activity that will be born of the systems approach. It is an essential component of the building industry; it will return a thousandfold, by helping to improve the innovation rate of the industry, what the total industry is willing to put into it.

The universities are already contributing to the training of the new researchers. My own new faculty has been re-shaping its architectural curriculum over the past two years, on the basis of a social-science enrichment to a systems-oriented applied science core, in an attempt to educate a new socio-technique-interface person, of the type required to provide the industry with researchers. Our progress in developing research is being hindered by the following facts:

1. lack of money to define problems for research - this is a time-consuming and very unrewarding initial stage of research.

2. lack of understanding from normal research granting bodies, of what design research can be, and could do.

3. lack of co-ordination between granting bodies - the existing definition of research fields between the Department of Industry, NRC and CHMC makes a pillar-to-post pilgrimage of grant-seeking; all design research projects are integrated by their very nature, not specialized, and if government bodies defer out of interdepartmental politeness to each other, nothing will happen to environmental design research.

4. An exaggerated fear of waste through failure due to inexperience in the field.

We will all need faith, hope and charity to get researchers trained and we will need much interdisciplinary patience here. The Harvard - M.I.T. Joint Center has said in conclusion to a statement of its founding policies that, "The true crisis in urban affairs is not that our cities are about to be destroyed by their problems but that the concepts, knowledge, and intelligence necessary for dealing with the problems which do exist are in such critically short supply."

May I conclude with a few concrete proposals: I would like to suggest that the Design Awards program, as defined so far, and government departmental research programs in general, be broadened to include the test designing of innovations, in the broader environmental field, and that this broadened Department of Industry program co-ordina its organization with CMHC and NRC in joint action to promot the design of large chunks of test environments.

May I suggest the immediate formation of an inter-departmental ad-hoc committee by these three agencies and any others that might be interested in specific research proposals whether agriculture or health or any other - to review rapidly the design proposals of individual universities or industry groups, involved in design work.

Maybe it is time now to set up the 4th advisory committee on integrated design innovations in order to apply the good work of committees 1, 2 and 3 to further the rapid improvement of environmental design.

I hope that these background ideas will serve the discussions of the participants at this conference, not by adding to everybody's confusion but by ensuring that detailed discussions will relate applications of system approach to the broadest context of the building industry.

THE NEED FOR A SYSTEMS APPROACH TO BUILDING

EZRA D. EHRENKRANTZ

It is my pleasure to be here at what I would like to call the beginning of the third era of systems design. As we look back through history, we find that a systematic approach to construction is really not new. In ancient times, proportion was the basis of most systems. The Greek temples with their fixed ratios, of numbers of columns, of length to width in buildings had a discipline based on craft techniques that was very much a system in the way in which the buildings were constructed. It was possible for architecture to evolve over time, for disciplines to be created and for the height of architectural developments to rise to the construction of the Parthenon and other temples which presented marked improvements over the initial work. These disciplines were related primarily to public buildings.

In later periods of history expression was found in terms of social architecture related to the way in which man built. The development of product sizes related to a man's hand span, the weight that could be lifted in Elizabethan days in England resulted in a new type of dimensional coordination whereby the products were related directly to anthropometric measurements both in terms of the construction process and in terms of the buildings which resulted. The early brick size was related to the man's hand span and for bonding purposes the 4 1/2" x 9" size developed.

The early fireplaces in the Elizabethan houses were generally 2 brick lengths in width or 18". Over time cordwood was cut 16" long to fit these fireplaces leaving room for the air to move around the cordwood. Thus a new technology began with cordwood being cut into wood lath. The 16" discipline commenced in terms of a new product, a new raw material.

The conflict between 16" and 18" or 9" dimensions continued for a long time and is still evident in the United States today. We have 4 1/2" x 4 1/2" ceramic tiles and 9" x 9" flooring materials. On the other hand, we have the 16" stud wall construction. There has been a great deal of evolution based on these product sizes in relation to particular craft techniques.

We are now faced with more complex problems in dealing with industrialized components wherein service sy tems play an ever increasing role within the building. T increase in terms of cost and complexity in order to mak them work. With respect to this problem, we find that we no longer dealing with buildings where the industrializat of products related primarily to windows and doors - fixe components which traditionally have been installed in a h crafted building. The ability to fit a given window into masonry wall wherein the brick itself can be cut or laid to fit is rather simple, but as we begin to put factory d igned components next to other factory designed component the requirements of tolerance and fit at the building sit become ever more difficult. Moreover, it becomes increa ingly difficult if we attempt to evolve slowly towards an increased use of industrialized products. We reach a poi where mortar and hewn products are no longer available an are forced to make a jump in scale to the point where fac produced components can mesh with other factory produced components at the building site.

This, I believe, is the present situation. It compounded by the fact that we no longer think of buildin as enclosures but as environmental and service systems as well. We have to make it possible for all of these compo to be used together. We are faced today with problems wh are obviously propelling us toward change at a very rapid This may be even more true in the United States than it i here, but in both countries the gap between expectation a performance is widening. It is normal for a society to h goals which are ever increasing and to which one can aspi but not actually reach. However, as aspirations increase more rapidly than our ability to achieve the goals, the g becomes one that cannot be tolerated. This, I believe, i one of the reasons we are experiencing some of the proble in our cities today.

The problem is compounded in the building indus by the fact that it is behaving much more as a service in than a manufacturing industry. Professor Bornhall of Pri ton University propounded this thesis, indicating that th actual cost of construction relative to other products wi our society is going up as is the case with all services In the automobile industry productivity has increased sin the end of World War II many times over. Labour unions h taken advantage of this and salaries have gone up. If we at other areas such as education, the teacher may have ha

30 students in a class in 1890 and still has 30 students today The productivity of the teacher has not necessarily gone up in quantitative terms but the teacher, looking at the salaries of automotive workers, has had salaries increase proportionately. Nevertheless, these increases have increased the cost of education and society continues unfortunately to support school bond drives in the United States as though these provide a solution. As the economy tends to develop and become more efficient the service side of the economy tends to cost more. This is something that we can actually afford because the increased cost is related to increases in national productivity. The major problem of the building industry is that it is looked upon by society as a manufacturing industry but it actually behaves as a service industry in terms of its ability to increase its productivity. It is for this reason that we are having a major problem in producing housing, schools and many other types of buildings in the United States at a time when we are looking for more sophisticated performances in terms of meeting needs. We find also that budgets are being cut back. In addition, our work is out of phase with current technology.

If we look for a moment at the aircraft industry, the last aeroplane built on speculation was in the 1930's. Since that time, every aeroplane has been produced to performance requirements established beforehand and to which the end product could be tested once complete. If we are to keep up-to-date, we must find new methods and ways to meet building requirements. If one were to build an aeroplane as we do a building, there would be great concern in going out to bid for general contract to the low bidder. The general contractor in turn would take sub-contracts for each of the services within the building; the propulsion system, the airframe, etc. Under such conditions, we would probably hesitate to enter the vehicle but we would not have to worry because it would never get off the ground.

As we face this problem, particularly in the United States, where our targets must be to build the equivalent of 14 new cities of 100,000 people a year starting now and continuing into the future as far as one can see, we must recognize that the present methods of work are not doing the job. Within the last six months there have been some major and encouraging changes. The Department of Housing and Urban Design is beginning to move towards two other approaches, two other ways of doing work. One is through an approach called "Turn Key Construction" where instead of going through the normal procedures for bidding new construction, the

Department is looking for projects to build on speculation to be bought by the eventual client. This is a model not very different from the automotive industry. It might be characterized by a group of developers with ten models. complete, these might be offered to supply housing projec the ten models being shown in a type of show room situati Individual clients may choose individual models perhaps ha ing the façade changed in much the same way as chrome is changed on an automobile to suit individual tastes. This approach may be a means of increasing the volume of constr tion and of increasing productivity in terms of output pe person as fewer persons perform the actual construction wo One might suppose in five years' time the housing industry will need a Ralph Nader.

On the other hand, we have an aerospace model j beginning. The Department of Housing and Urban Developme has, as its first request, a project out to bid for the development of low cost housing systems for the model cit program. This is a project put out for twenty model citi at one time. The methods being adopted are completely th of the aerospace industry.

At any time when we have a gap between the need supply of buildings that goes beyond tolerable limits, the must be approaches for corrections. These approaches wil take place with or without those involved within the basic building industry. It is rather difficult for anyone to c in from outside and try and invade the building industry a present. We still have work rules and procedures, differe building codes, etc., which make it difficult for those co panies which have not operated in the construction field. However, unless there is adaptation to the current require ments from within the building industry, it seems inevita that an invasion from outside will gain the upper hand.

This is an acute problem now facing us in the Un States. The question is open as to who will be the archi the planners, the engineers of the future as well as the s pliers and builders. Hence, we are faced with major chan pointing to yet another era of system building, which I ha called the third era of system building.

We find the fourth era in the wings. The connec between the use of the computer for design purposes and ma facture has been established in theoretical terms. All th is needed is the appropriate market to begin to link the t together and an entire methodology of both design and manu facture can change the ensuing process of construction. T is not to say, as we consider changes that may take place, that people today are not trying to do the best job possible; but there are many constraints which make the task difficult. If we are going to be able to do the job and fulfill the demands properly we may have to make major changes in our society in order to serve it. Such changes have to be related to the entire process of construction, the way in which we create markets, the way in which we take bids, the opportunities to manufacturers to benefit through inventions by owning their patents, by being able to take competitive bids while making it possible for people to operate with patented ideas.

Today there are two major groups which look to the required changes. The first are those basing their thinking on today's institutions and methods. It becomes extremely difficult to evolve at a sufficiently rapid pace if we remain tied to these institutions and methods. The other group includes those who envision what the future might be but have great difficulty in establishing practical means of getting there. What are needed seem to be some compromises between the two, related to periods of rapid experiment.

A systems approach - this has already been outlined with some considerable detail this morning - provides an excellent basis for experiment, provides an opportunity to develop a hypothesis and test the hypothesis, provides a mechanism to translate needs into spaces, into physical facilities to house people. If we examine any approach to systems building, we find an organizational hierarchy of different products at one end. We may talk of pieces, parts and components. Craft building is also a system, balloon framing is a system, at the other end of the spectrum. We may also be dealing with volumetric units that are put together perhaps as complete dwelling units one on top of another. In between, there may be problems of relating any number of different components, assemblies, and sub-systems, in one way or another.

There are not many points here that can be debated in terms of the virtue of different approaches. Should one ship large units enclosing much air to the building site for rapid erection, or components which can be packed much more tightly but which require more site labour? These are matters to be worked out with due respect to costs and alternatives must be tried at the same time on different building sites if there is to be an opportunity to evaluate the pros and cons of each approach. There are also different ways of breaking up the organization of products. One may be in terms of what might be described as an integrated systems approach where the services are pulled away from the structure, and each portion of the total building system is articulated s that it is easily accessible not having to share space wit buildings.

These are just a few of the different ways in wh one may break up an approach to the design of building, bu the primary interest remaining within any type of systems approach is first the definition of the needs of the user requirements in terms of space, environment, services and equipment. When these needs are known, they must relate t cost. It is all very well in the traditional design proce to program buildings without knowing fully how much it cos to perform the various tasks called for by the programmer. The architect, the engineer and the client, however, must know the cost of, for example, different levels of acousti operation, what the trade-off might be between more space air-conditioning, what the implications of different level of performance might be so that choices can be made effectively to establish a program which will optimize the use available funds.

When we are able to judge the best use of availa resources and the basic desires that cannot be met, we can discern the natural gap for which the promotion of technic innovation remains a prime function. In order to develop this innovation, it becomes necessary to group the volume requirements into a market of sufficient size so that ther is an opportunity to bridge the gap, and therefore, any approach to systems construction must be towards a program analysis of needs, costs and then to the development of mar kets to make possible technological innovations to bridge gap observed between the two. Such an approach provides t basis for work.

It is inevitable that at any given point in time of the needs and requirements cannot be met, but the goals must be established. We must take into account the effect of time; the life span of the building as well must be con ered in total cost, based on annual cost, on some of the n projects we are responsible for in California. The first cost does not enter into the bids but rather we consider t amount of money necessary to amortize first costs plus op tions and maintenance and allowances for alterations, so t the building costs can be current over time. The relation between performances, cost and time provides the opportuni for cost benefit control within our buildings. Doing this we must define very clearly not only the requirements for whole building but the requirements for each portion of the building. The interfaces between the different components, the way in which they work together and satisfactory jointing technology for the performance of the building over its useful life. I believe that this type of an approach is one that is feasible for most building situations. The more complex the building, the more valuable the approach. The more we become involved with services, the way in which they fit together, the way in which they work within the fabric of the building, the more important the coordination. Our present experience relates to educational, medical, commercial and residential construction. I am sure that there are opportunities for further amplification of the systems approach but it appears to have considerable value in these areas.

In our work, we have to start out by changing the way in which business is done within the building industry. As part of our first project, the school construction which I will have an opportunity to illustrate tomorrow through the use of slides, we first organized a market through the grouping of the demand of a number of school districts. This provided an opportunity for requesting industry to come up with the development of new products to meet performance criteria which could not be met within a cost context in previous school construction. It is fair to say that the average school built in California is obsolete on the day it is opened and deteriorates rapidly. In terms of an approach which relates the definition of the needs to a large market, and the translation of these needs to performance requirements there is an opportunity to assess whether the performance requirements are appropriate and whether they have performed in the completed buildings. It then becomes possible to up-grade performance over time, taking advantage of previous experience. This is essential if we are to provide an overall cost context and monitor, to ensure that this performance works not only in terms of the users' needs but in terms of the long run costs of the building.

There are a number of different ways of analyzing the School Construction Systems Development project to just one method of monitoring long run costs and performances. We are working on a number of others. Let me describe a few of them in some detail so that it may be seen that within any type of systematic approach to construction there are many options. In SCSD we requested bids from industry based on performance specifications saying what the building products should do but not what they should be. Manufacturers had to design, bid, develop and test the products to show that they met the performance criteria, then install the products an in certain cases be responsible for the maintenance of the products in the field for up to 20 years. In a second ap such as the one we are using now in Pittsburgh in the Grea Pittsburgh High School System project, the team which cons of a number of architects, planners, other consultants, as as our own firm is involved directly in the design of the tem which will be put out for bid. It has a different ti context and the way in which we worked was different from Another approach is the one that we are now contemplating terms of health facilities, where instead of going to bid a single system, we expect to take bids on what we could a "not to exceed" price and quality from 3 to 5 successfu bidders in each component area. These firms may then bid against each other on given jobs. Yet another approach, that is being contemplated for future projects related to development of performance specifications, embodies a dev ing tendency in the United States; the employment of what calls management contractors. This approach will include large general contractors who do not build on given proje but have a management contract and then take bids for bot general and sub-contracts on those particular projects. are only a few of the different approaches that we are ei working on or contemplating for different projects.

I am sure that those of you who had an opportun to think in this area have anticipated our thinking of ot ways of doing business, but there are many different ways this completely open field. Our experience to date on SC and on new projects has been relatively good. We now hav considerable discussion. We have people who believe the project has not been successful and those who are firm ad ents. For my own point of view, I would like to state wh we believe has taken place and I would be willing tommoro when we have the opportunity, to answer questions on this subject.

We believe that the actual cost of the componen that have been bid as part of SCSD has been reduced by 20%. The actual cost of the school if this money were fed back into other aspects of the design of schools woul have resulted in a 10% overall decrease in price. The sc that have been built in California using the system, have generally plowed these funds back into the building to ai condition schools not previously air-conditioned, to carp them and to supply at least 1/3 additional case work. In most of these schools, moreover, money has been used to p vide language laboratories and other facilities related t improved education. In some cases, however, the actual savings have been taken out directly and the cost reductions have been obtained for the school district concerned.

The basis of bidding in terms of long run costs has resulted in some districts now going through plan changes in their products within existing schools to introduce SCSD products as part of a maintenance program because their actual running costs are much cheaper. Let me give an example. When we went out to bid, we found a first cost of $2.9 million for air-conditioning would have a total cost at the end of 20 years of $12.8 million, when operations and maintenance costs were taken into account. This figure was related to a $20 million cost, if one used the actual components and costs that were the basis of most California school construction previous to SCSD. The first cost was reduced somewhat but the long run cost was reduced dramatically.

If we take a 40 year life for a school, the first cost is 1/8 of the moving out cost. It becomes easy to see what can happen if you improve the performance of the building. Reductions on 7/8 of the total cost of the building can be made.

The important thing as we look back now on SCSD is that the successful bidders on the project are now competing with manufacturers who were either bidders or non-bidders. Some of the successful bidders' products have now been put out of the market through competition by other successful bidders. The approach has been towards an open system whereby it has been possible for different manufacturers to compete with one another on performance. Within the last six months, we have had school project bids in the State of Florida wherein the costs of SCSD components at SCSD performances have been maintained over a period of 4 1/2 years despite the fact that the bids came from a completely new group of manufacturers. Instead of these initial costs escalating according to the national building indexes, the actual costs have gone down by 16¢ per square foot over a period of 4 1/2 years.

I think this gives some indication that once the basis for the development of an approach which permits proper industrialization of building products is developed, continued improvement in cost performance is possible.

THE ROLE OF THE DESIGNER TEAM IN DEVELOPING A SYSTEMS APPROACH TO BUILDING

ROGER T. WALTERS

INTRODUCTION

In any country which has a highly developed ma economy, such as Canada, the problem facing the building industry is essentially the same. The question, put in simplest form, is how to apply the lessons which have be learned in product manufacturing industry to the process building. The standards of productivity, by which we ju our own achievements, are mainly set by the firms who ma consumer durable products; automobiles, television sets, washing machines, ballpoint pens and so on. In practice find it difficult to adopt the methods of such firms. P who observe the building industry from the outside often der why we are so slow about it. We generally tell them the building industry is different, which is quite true. it is only when we ourselves have faced up to this compar between building and other forms of product manufacture, we can firmly establish the meaning of 'a systems approa building', and consequently the contribution which the de team can make to it.

PRODUCT MANUFACTURING INDUSTRY

Let us first ask how product manufacturing indu manage to achieve a high degree of efficiency and product First by creating a large market by means of advertising to the consumer. Second, by standardising the end produ far as the market will allow. Third, by designing a pro process which will provide the degree of variety require the end product without interrupting the continuous oper of the plant. Fourth, by controlling the quality of the duct during the process of manufacture instead of by rej after manufacture. Fifth, by planning the input of mat the process of manufacture and the distribution and sale the product as one continuous system.

The yardsticks of success in product manufactu industry are net profit and return on the capital employ The first responsibility of the company is to its shareh Control at board level is primarily financial. Manageme within the firm is concerned with the disposition and control of resources. As the amount of time and money needed to develop new products increases, the successful firms tend to become larger.

Product manufacturing companies are not expected to exercise a high degree of responsibility to society. If the ways in which they operate, or the products which they make, are considered to be in any way dangerous to society, suitable controls are imposed on the firm from outside, usually by Government. Seen in the context of the whole operation of the firm, the design of the product is important but not paramount. The designer team is to be found in the middle levels of the firm. It provides a service to the firm, bridging the gap between what the sales organization can sell and what the production plants can make.

DIFFERENCES BETWEEN PRODUCT MANUFACTURING INDUSTRY AND THE BUILDING INDUSTRY

Why does the building industry find it difficult to adopt these methods which have proved to be so successful in product manufacturing industry? There are two main reasons.

First, because buildings, unlike most other products, usually cannot be moved once they have been made. Collectively, they make up the built environment. Planning controls may be devised to prevent the worst effects of the building industry's activities. Our industry cannot, however, escape its responsibility to society to create a built environment in which it is tolerable to live and work.

Secondly, because most buildings are large and expensive, and once built they last a long time, they are not usually bought in the same way as other products. The typical purchaser is an organization which expects the industry to provide it with a building designed to suit its own particular needs. Most product manufacturing firms would be horrified if each of their customers demanded a specially designed product. But when such firms need a factory or an office building, that is what they expect from the building industry.

The exception, and a very important one, is private enterprise housing. Here the product is sold to an individual rather than to an organization. The purchaser of a house or an apartment can see the product, or one like it, before he decides to buy. He is a customer rather than a client. This means that the methods of product manufacturing industry can be applied to housing much more readily than they ca other types of building. This difference is so fundamen that the systems approach to building will probably deve in one way for private enterprise housing and in another way for other types of building.

PRESENT POSITION OF THE DESIGNER TEAM

Before we discuss the role of the designer in these two situations, we should look briefly at his pres position. When we speak of the 'designer team' we are ally thinking of a group which includes architects, stru engineers, mechanical and electrical engineers, technic of various skills and possibly specification writers an scape architects as well. We are thinking of the team is brought together to design a particular building, or a group of buildings, on a particular site; the team is up to deal with that scale of operations. But designer also involved in operations of quite a different scale. the upper end of the scale there are the design problem really large developments, the planning of new towns or major renewal schemes in existing cities. At the lower there is the design of building components. At this co we are concerned with the middle and lower ends of the While we are discussing a systems approach to building how it will affect the designer of buildings and the de of components, it is well to remember that the building fessions also face another set of problems concerning t future role in environmental design. That is a big que which might well be the subject of another conference.

Let us now draw these threads together and co the role of the designer in developing a systems approa building. We will do this first for private enterprise ing and secondly for other types of building.

PRIVATE ENTERPRISE HOUSING

The way ahead for private enterprise housing fairly clear. Single unit housing, where each house oc its own plot, is already designed, manufactured and sol much like any other product. The user requirements are blished through market research and sales reaction. Th duct is designed as a limited range of models from whic customer can choose. The components or sub-systems are standardized as far as possible. There is nothing in principle to prevent the whole process, from the purchase of raw materials to ultimate sale, being planned as a continuous system.

This should be an ideal situation for advances in technology. One would expect the traditional methods of building houses to be abandoned. One would expect metals and plastics to replace timber and bricks. One would expect a trend towards monocoque construction for the carcass of the house, combined with the use of highly industrialized subsystems for the interior divisions and equipment. One would also expect multi-storey apartment blocks to be built like layers of man-made land, as permanent structures with vertical circulation and services provided, with the apartments themselves being chosen by the customer, moved into position and replaced when they became obsolete.

Houses and apartments of this kind would certainly be made and marketed by integrated organizations in which the processes of design, manufacture, sales, transport and installation on the site would all be carried out by the same firm. The designer team would not be in control of the process. They would be operating in the middle levels of the firm, designing the ranges of models for the houses and the removable apartments. The technology of the product would be self-contained. That is to say, there would be no need for dimensional coordination except to make sure that the apartments would fit into the permanent structures. There is no doubt that by such methods the efficiency and productivity of the house building industry could be greatly increased.

But, if that is the aim of a systems approach to private enterprise housing, actual progress towards it is slow. This is mainly because the market is hardly ever established on a large enough scale. Those who finance speculative housing are reluctant to commit their resources beyond the immediate foreseeable sales. No doubt bitter experience has taught them to be cautious. They have not yet reached the point of being able to assume that a continuous market will exist, and that it can be maintained by advertising. A house is still regarded as a capital investment, related to the tenure of land, rather than as a consumer durable product. There are other constraints too. Building codes are often discouraging, and people are far more conservative about the design of their houses than they are about other products. The person who will accept a non-traditional design for a mobile home, will usually reject an equivalent design for a house which happens to have been put together on the site

It must be admitted that the quality of the env ronment created by this approach to private enterprise ho is a serious problem. The designer team working within t integrated building firm might sometimes be involved in t layout of housing estates or in the design of the perman structures for apartments. But more often the responsib would be placed on another team, working for the develop who bought the land. The quality of housing development the higher income groups might be good because the custo would expect it. But when building for sale to lower in groups, there would often be strong pressure to develop t site to its full potential at the expense of a satisfacto total environment.

OTHER TYPES OF BUILDING

Let us turn now to other types of building. He we are dealing with schools, hospitals, universities, off buildings, factories, farm buildings and so on; also with housing built by local authorities.

In western Europe, one usually finds that a hig proportion of the output of the building industry is comm sioned by the public sector. In Great Britain, for examp the central Government, the local authorities and the nat alized industries, taken together, are the clients for ab half of all construction work. This includes nearly all schools and hospitals and about half of all the housing. There is no doubt that progress in western Europe since t war, in building technology and in rationalizing the buil ing process, has taken place mainly in the public sector.

The reason is quite simple. Public authorities have found it possible to do what private clients cannot unaided; that is to organize their requirements into larg orders and to create a more continuous demand. The build systems for housing and for schools have been developed i this context. Some of the building systems are client co trolled, that is to say the designer team belongs to a pu authority. Others are proprietary, which means that the tem is designed and developed by a main contractor or a contractor. But in all cases the effective clients are p authorities and, if they stopped organizing the demand, of the building systems would no longer be viable.

In North America, the proportion of the industry's output directly commissioned by federal, state or city authorities, is much less. Consequently building systems have not been developed in the same way. The SCSD project which Ezra Ehrenkrantz has organized in California, is a brilliant adaptation of European experience to American conditions. Instead of having the client authority design the system, he has used performance specifications to encourage industry to undertake the development work. A similar project is now being planned for Toronto under Roderick Robbie. The essential feature of these projects lies in the organization of the demand, the bringing together of enough orders to secure the active cooperation of industry.

THE PROGRAM APPROACH

The big question is where do we go from here. One could assume that, in North America, agencies will develop, such as Ezra Ehrenkrantz's own firm, which are capable of organizing the requirements of any group of private clients which come to them. One could assume that some of the larger public authorities, such as the City of Toronto, would apply similar methods to their own programs. In other words, one could assume that a systems approach, for buildings other than private enterprise housing, is necessarily dependent on someone, somehow, organizing a large and preferably continuous demand. We could call this the 'program approach'.

This may be the pattern for the future. It may be that the building industry will rationalize its techniques and its processes only in response to the skillful organization of programs by its more enlightened clients. And this may prove to be enough. But if we think beyond the present situation, will it be reasonable, in the longer term, to expect those who want efficient building, always to organize themselves in special ways in order to get it? Should we not try to imagine a building industry which could take the demand however it came and nevertheless be highly efficient? What would a systems approach mean then? There are, in principle, two ways of solving this problem.

THE MODEL APPROACH

The first we may call the 'model approach'. This says that eventually all buildings will be sold in the way we have already described for private enterprise housing. It says that the economies which can be obtained from repetition, from integrated organizations, from being able to treat the building process as one continuous system, are so great that we must eventually come to regard all buildin as consumer durable products. The life of all buildings wi get shorter; they will no longer be regarded as permanent investments. All types of building will be manufactured an assembled by integrated organizations. Buildings will be designed in advance, to meet the anticipated needs of users Client organizations will choose the school, or the hospita or the factory, from a range of models, selecting the one which most nearly meets their needs. The extent to which t client can obtain variations in performance or appearance, will depend on the flexibility of the production system. Flexibility will be sought in the process rather than in th use of the building. Purpose designed buildings, as we kno them now, will be relatively so expensive that few clients will feel able to afford them. The components of buildings will become larger and will be assembled by heavier lifting equipment. Dimensional coordination, on a national scale, will not be needed. Each manufacturer will arrange his own degree of standardization with the firms who supply him wit bought-in components and sub-systems. The designer team wi occupy the same middle position in the firm as we have alre described for housing.

This concept of the future is based on two main assumptions. First, that the resulting environment would be acceptable to society. Towns and cities, apart from a f buildings of historic importance, would consist essentially of long term parking lots for buildings. Whatever planning legislation was introduced, the quality of the environment would mainly depend on the quality of the designs produced by the integrated building firms. Would they, could they, give enough weight to architectural considerations to produ a tolerable result? The second assumption is that the econ could afford it. There would have to be a turnover in buil ings large enough to support several national firms in comp tition for the same building types, otherwise the situation would not be acceptable to clients, certainly not to those spending public funds. The resulting economies would have compensate both for the shorter life of the buildings and f the additional cost of transporting large components from central plants, and still leave enough margin to convince everyone that this was the right way to build.

If we think that this is unlikely to happen, ther is an alternative which we may call the 'component approach This says that we can obtain most of the benefits of industrialized production, and be more certain of maintaining hi standards of architecture, if we agree to standardize the basic sizes and the perimeter conditions of building components.

THE COMPONENT APPROACH

In this concept, the building technology of the future will consist of industrially made components and sub-systems, efficiently produced in large numbers, which can be fitted together with the minimum of time and effort on the site, and many of which can be used in a wide range of different building types. The components and sub-systems will be dimensionally coordinated. In other words, there will be agreed ranges of preferred basic sizes for all the components which make up the carcass of the building and standardized fixing positions for the services and equipment. There will also be agreed conventions for compatible jointing. These will only operate where the components made by one manufacturer meet those made by another. There will be no need to have any national standards for the design of the components themselves. Each manufacturer will decide the degree of variety he will offer. Within the conventions of size and jointing he will be free to use new materials and to develop new designs and techniques of manufacture. The task of studying the user requirements of buildings and translating them into performance specifications for components will be shared between public authorities and industry. The results will be made available, probably as national standard specifications, and these will include methods of testing whether a particular component meets the performance requirements.

A technology of this kind would leave the structure of the building industry very much as it is now. It would not require any special organization of the demand for building. Designer teams would operate in two ways. Those designing building projects would remain closely associated with the client. They would choose most of their components and sub-systems from manufacturers' catalogues, knowing that these could be fitted together without modification, and knowing that, if they asked for special designs, the cost would be considerably more. Other designer teams would work with component manufacturers. They would be acting primarily as industrial designers. There would be a continual interchange of ideas between the two kinds of designers. Those working on components and sub-systems would certainly make an important contribution to both technical and aesthetic development. Those working on the buildings themselves would seek, as they do now, to achieve a high quality of architecture and t available ranges of components would allow them adequat dom to do this.

The standardization of component sizes and th introduction of compatible methods of jointing would gr simplify the process of assembly on the site. General tractors would become expert assembly fixers and, being familiar with the technology, they would be able to pla operations in advance with much greater precision than can now. Foundations and external works would continue be specially designed for every site but, above ground, would be an almost universal use of dry joints and prac no cutting and fitting of materials or components.

The 'component approach' is also based on two assumptions. First, that it would be possible to reach ment on the conventions for sizes and jointing. Dimens coordination is fairly well developed already. Work on patible jointing between components and sub-systems has just begun and no one knows, at this stage, whether it practicable or not. Second, that substantial economies be achieved through the industrialized production of co nents, combined with simpler methods of assembly, in sp the fact that the whole process would not be treated as integrated system.

POSSIBLE FUTURES FOR BUILDING

To sum up, for types of building other than p enterprise housing, there are three possible futures. first is the 'program approach' which assumes that the tions needed for a systems approach will always depend the demand for building being specially organized. The second is the 'model approach', which requires no speci organization of demand, and which assumes that all buil will eventually be regarded as consumer durable product The third is the 'component approach', which also requi no special organization of demand, and which assumes th conventions for sizing and jointing components will be developed and agreed so that a truly industrialized ver of building can develop within them.

It is on our attitude towards these three pos futures that our concept of a systems approach to build really rests. There is no doubt that, in North America advances in technology and management can be made simply by organizing the demand. Although the areas of building to which it can be applied are limited, the 'program approach' may give sufficient impetus to the building industry to improve its efficiency, at least for some time to come. But in Europe, where the limitations of the program approach are already being realized, thoughts are now turning towards a solution which does not depend on the organization of demand. Almost exactly a year ago, a conference of Government representatives from over twenty countries, from both western and eastern Europe, was held in Paris. This conference agreed that the 'component approach' was the long term policy most likely to lead to an efficient building industry as well as to high quality in architecture and in the design of the environment.

THE WAY AHEAD IN GREAT BRITAIN

In Great Britain, the 'component approach' has now been adopted as Government policy. We recognize that building systems have an important place in the future of building whenever the demand can be specially organized for them. We expect them to be most useful in local authority housing and school building. At the same time we want to move steadily towards an industrialized technology for building generally which does not depend on a specially organized demand.

There are five parts to this operation. The first is to take the opportunity of the change to the metric system in the construction industry to make a major advance in dimensional coordination. The change to the metric system will be substantially completed by 1972. The second is to develop conventions for compatible jointing between components and sub-systems which have a chance of being accepted nationally. The third is to intensify the work on user requirement studies for the principal types of public sector building, notably housing, schools, hospitals, factories and office buildings. The fourth is to write performance specifications for selected components and to invite industry to submit design and price tenders against very large potential orders, the resulting components being used in public sector programs. This is to create the essential dialogue between Government and industry in the course of which the conventions for dimensions and jointing can be tested and industry can get accustomed to working within them. The fifth part of the operation is to get the results of all this work, the preferred dimensions, the conventions for jointing and performance specifications related to functional requirements, all incorporated in British Standards. We are dealing here with the develo of building technology in the longer term. It may take between ten and twenty years to realize the benefits of we are now setting out to do.

THE WAY AHEAD IN CANADA

The way ahead for building in Canada will pro be somewhat different. You do not have the same degree Government participation, it is more difficult for you organize the demand and to go in for building systems o kind which have been developed in Europe since the war.

In private enterprise housing, one would expe you to follow the 'model approach' to its logical concl Canada and the United States may well be the first coun to demonstrate that houses really can be treated as con durable products, with all which that implies.

For other types of building, a systems approa described by Ezra Ehrenkrantz seems to be your best pol at least for some years to come. Eventually you may ex the possibilities of specially organizing the demand an may then try to find a way of doing without it. You wi probably find that what we have called the 'component a offers you the elements of a solution. One would expec components to be larger than those we are contemplating Great Britain at the present time, more sophisticated, in the nature of quite complex sub-systems. But you wi the same problem of compatibility between sub-systems p by different manufacturers. Eventually you will need t develop conventions for compatible jointing as well as dimensional coordination, and you will probably find, a have done, that some kind of Government action is neede help the process along.

But you will also find that the forces acting favour of the 'model approach' for all types of buildin very powerful. Wherever there are opportunities for se buildings ready made, someone will try to make a succes it. The fact that the 'model approach', applied to all ings, would virtually mean the end of the design profes as we know them, should not deter us from looking at it merits objectively. We cannot be sure that this will n the normal way of building in the twenty-first century.

Perhaps our greatest danger is to be confused in our thinking, as between the 'model' and 'component' approaches. They indicate quite different structures for the building industry, different relationships with our clients, different roles for the designer team. If we are not clear about our objectives at any given moment in time, there will be uncertainty about technical development, struggles for the leadership of the building team and something like despair in the minds of educationalists who have to prepare their students for the future. We have to remember that the building industry is largely protected from foreign competition. On the whole, people have to put up with the building industry which their country happens to have. So there lies on us a heavy responsibility. We have not only to think ahead and plan for a future when the building industry will be as highly efficient as any other industry. We must also ensure that it serves society by creating individual buildings which are beautiful in themselves, and a man-made environment which is a joy to live in. Who knows; perhaps it will be the building industry of Canada which will show the rest of the world how to do it.

THE MANUFACTURER/CONTRACTOR AND THE SYSTEMS APPROACH TO BUILDING

KENNETH M. WOOD

There are building systems which merely intro a systematic approach into the design and planning of b ing work while using traditional on-site methods of co tion. I am going to restrict my comments to systems wh there is a substantial degree of prefabrication so that manufacturer as well as a contractor is involved. Of c the contractor and manufacturer may be one and the same

A contractor embarks on the production of a b ing system with the intention of making a profit. A pr which is large enough when extended over the life of th not only to amortize his plant and pay interest on the employed, but also to make a profit reasonable in relat the efforts involved. To make this possible it is esse that the manufacturer/contractor shall be able to maint his plant output at a high average percentage of produc capacity for a long period. In very few countries it i commercially possible to amortize a plant over the peri of a single contract, and it is necessary to look upon plant manufacturing a building system as having a life to that of any other plant.

Table 2 gives some idea of the percentage of working capacity which must be attained to ensure adequ profitability. Although these figures are for a prefab cated concrete system, they are unlikely to be very dif whatever the material involved. A plant capable of pro a dwelling a day is assumed to have a full capacity of dwellings a year, so that 200 dwellings a year represen 80% capacity. The chart shows that there are two items the cost per dwelling is virtually independent of the u tion of the plant. These two, material and labour dire employed on production and erection, amount to approxim 50% of the selling price. The other items are, however the short term, independent of the rate of production a rise steeply as production falls. Thus, at 80% capacit would expect to show a return of 10% on turnover, and o of capital employed, at 60% there would be a loss of 3% turnover and 4.5% on capital employed, whilst at 100% t would be a profit of 18% on turnover and 45% on capital employed. I would emphasize two things, first that pro ability varies very rapidly with the throughput of work and second that labour directly employed on production and erection represents a comparatively small proportion of cost and that highly sophisticated manufacturing methods, which may reduce by a third the normal direct labour costs, will have less benefit than an increase in factory throughput. There is generally a conflict between saleability and the sort of standardization which permits a high degree of mechanization.

The same point is illustrated in Table 2 which shows the fixed sale proceeds per unit and the proportion of costs which are fixed per unit and the proportion which vary with the factory throughput. Here you see that making an allowance for interest on capital employed, break even is achieved at about 70% of full capacity. It is a fundamental principle for any manufacturer of a building system that he is unlikely to make an attractive profit unless he can maintain his factory at 80% of design capacity over a long period.

Except in cases where the system sponsor has under his direct control a regular flow of work over a long period, there is little hope of obtaining adequate continuity of orders unless - (Table 3)

a) The system is functionally effective and offers advantages in speed or cost (or both) over the conventional building methods.

b) The whole operation covering design, manufacture of components and site construction is consistently efficient not only during the formulation of the system but also on each individual contract.

c) The system itself and its operation are under continuous review both to improve the final building and to reduce its cost.

d) For a commercial system there must be a fully adequate sales organization.

e) For a client sponsored system there needs to be a carefully co-ordinated programme of building which will not be affected by changes in government or local policy.

To achieve the type of efficiency which is re
it is first necessary to examine carefully the relation
between the designer, the manufacturer and the building
contractor. It may be ideal that they should work for
and the same organization, but equally there are strong
arguments against this and in favour of cooperative wor
between independent firms. In this case, however, the
relationships between them must be on a continuation ba
and the partnership must not be changed at frequent int

It is, in my view, important that the manufac
of key system components shall be normally responsible
their site assembly. By key components I mean those fo
the structural framework and probably the external enve
In houses this will mean in practice all floors and loa
bearing walls. This is bound to affect the relationshi
between the contractor and manufacturer where they are
independent concerns. We have, however, found no diffi
in working with a large number of different firms of co
tors each operating in a restricted area, where, apart
the continuity over a long period, our relations have n
been very different from those normally found between a
contractor and an important sub-contractor.

There are a number of possible relationships
the designer and manufacturer/contractor. These can be
considered in three main types - (Table 4).

a) The partnership is dominated by the desig
This has been tried many times and has ce
ly been successful with the CLASP System.
is unpopular with manufacturers because a
it may be eventually successful, it is ex
ly difficult to control profitability and
continuous working in the early stages.
tically every system operated in this way
led to big losses for the manufacturer in
from the beginning, and in some cases the
manufacturer has been forced to withdraw
recouping his losses.

b) The next is manufacturer/contractor domin
This is the position of most successful
European housing systems, but there are s
that as requirements become more sophisti
some of these systems are becoming less s
ful. The domination of manufacturing con

tends to lead to an excessive degree of standardization, to a sameness in the appearance of the buildings, and a lack of flexibility in function. It is not certain that outside the Communist world contractor dominated systems will continue to enjoy the success they have had in the past.

c) Finally there is a combination of the first two, where the designer and manufacturer work in a partnership. Clearly one or other must lead and clearly I would prefer the leader to be the manufacturer, but the essence is that there is no dominance of one party over the other. I have experienced this in two ways - first, we have used a large range of professional architects working in private practice to assist not only in the design of building schemes but in the design of the system itself. This is the way in which the Wall Frame System is operated and something like one hundred different architectural offices have been involved to a greater or lesser extent. In the second way, we and our systems have been selected by firms of architects to work in partnership with them on major building schemes, such as universities or hospitals where construction is likely to continue for a period of up to ten years. This again has proved a satisfactory relationship although the system may well get slightly bent and there may well be teething troubles in the relationship in the early stages before mutual confidence is built up.

In most European countries the relationship between the system sponsor and clients and financiers has been simple since most clients have been Public Authorities or cooperatives. There have been, however, a number of cases where private estate developers have used a building system either operated directly by themselves or bought from specialist companies. The biggest practical difficulty may be the desire of some developers to match housing completions with their rate of sales. It is not simple to slow down completions when system building has to match a falling rate of sale. On the other hand the very high speed of building can simplify the problems of financing. While private financiers tend to be more conservative than public bodies in their approach to new building methods, in our experience this is not lik to be a serious cause of difficulty once the first few schemes have been completed.

If a partnership between designer and manufac of the type I have advocated is to work, it is necessar the essential disciplines of the system shall be clearl understood. The purposes of these disciplines are - (T

a) To limit the number of component types in single contract so that there is repetiti production without constant re-jigging or mould modification, and

b) Permit change from one contract to anothe without serious dislocation in productio

The minimum disciplines to meet these nee must cover -

a) Components of standard sizes or at least sizes which vary in a simple way.

b) Standard jointing methods between compon

i) Permit a component to be a standard r less of its position in a building.

ii) Provide joints between units which ar and watertight and where necessary a structurally strong.

c) Standard methods of accommodating heatin electrics and other services which cause minimum dislocation in production and ere

All these points are met most simply by what known as the Model Approach. This is most suitable for ing and means using a range of standard dwellings which designed to make the maximum use of common components. is the method used successfully in the Soviet Union and simple to operate and deserves to be used far more gene at least for housing.

It is the desire, however, of most buyers of ing systems, and therefore of many manufacturers, to ha system which is based on components rather than standar plans. Here there are two possible approaches -

a) The use of completely standard components which can be fitted together to give a large variety of plan types; and

b) The use of dimensionally coordinated components based on a reasonably coarse planning grid. Grids of 3 ft. x 3 ft., 2 ft. x 2 ft., 4 ft. x 1 ft. and 3 ft. x 1 ft. have all been successfully used.

We designed a system of multi-storey dwellings based upon the conception of standard components. This has been financially most successful and has provided a wide range of dwelling types. It is difficult, however, to adapt these components to a wider use and they are not really suitable for town houses or apartments from 2 to 6 storeys high. To meet this latter need, we designed a modular system which has been sufficiently successful for us to extend it from low-rise into the high-rise field so that we shall end with a single system based upon modular components.

It is probably difficult to understand exactly what is meant by modular component without describing an actual example of its use. Tables 6 and 7 will give you some idea of the way in which these components can be fitted together. This is the Wall Frame System which is based on a module of 3 ft. x 1 ft. In our case this is too fine to permit the use of individual one module components, and the 3 ft. variation is obtained by using a combination of floor panels 6 ft. and 9 ft. wide whose length varies in 1 ft. multiples. Load bearing walls are 9 ft., 12 ft., 15 ft. and 18 ft. wide, all coming from standard moulds.

This conception has been extended beyond building for housing. In a system designed primarily for schools, hospitals and offices, load bearing internal walls are replaced by beams and columns while on external walls there is an option between beams and columns and concrete load bearing panels. In the horizontal plane the modular discipline is very similar to that I have described for housing but in the vertical direction there is not the advantage of a single floor-to-floor height. In this case the floor-and-floor beams, and all services, are accommodated in a zone 2 ft. deep, while the floor-to-floor heights, and floor-to-ceiling heights are available in multiples of 1 ft. - the modular approach is extremely similar to that developed by the British Ministry of Education and used in the CLASP System.

I have probably over-emphasized the difficul
of system building. It is fair to do this because in
Britain certainly there have been plenty of failures t
the inability to recognize the facts I have mentioned.
the other hand in some cases system building has been
ly successful and certainly to us it has been most pro
What advantages does system building offer the client?
it offers speedy building and certainty of timing, and
should be far less affected by outside conditions than
building methods. A number of large American contract
have recently seen our operations in Great Britain, an
admitted that our contract times are roughly half what
would expect in similar size contracts in the U.S.A.
ularly when expensive land development costs are invol
the saving of time may mean an effective reduction of
Secondly, system building can be better fundamentally
traditional building and in particular it can offer lo
maintenance and heating cost. Thirdly, we are left wi
extremely difficult problem of comparative costs. Whe
tem building is sold competitively with traditional me
it is fairly certain that their selling prices will be
comparable and generally speaking this is the case in
Britain. On the other hand there are some fields whe
building has almost eliminated competition from tradi
methods. There are signs that this is happening in s
work and this certainly applies to the building of mu
storey flats of eight sotreys and above. We frequentl
we are able to undercut schemes designed traditionall
sent to tender by as much as 20% and our only serious
competitors are other systems. On the other hand, th
certainly not true of the great majority of building
systems have made comparatively small inroads, and on
trol a very small proportion of the total. Some refl
of the true cost of system building can be seen from
published accounts of Concrete Limited. This company
system building during their financial year 1964 and
five years from 1963 to 1968 their sales and profit i
has been almost entirely due to the production and er
of concrete components for system building. Their tu
has increased from £6 million (sterling) to about £15
(sterling) and profit £500,000 (sterling) to a predic
about £1,350,000 (sterling). Neither the increase of
nor the increase of profits were achieved by selling
which was not competitive in cost.

Finally, I would like to say that the syste
must always look to the future. It is historically t
traditional methods of building have been spurred on

tems to improve their own efficiency. In particular, a system sponsor must wage a continuous war against monotony of appearance. It is necessary continually to be producing new finishes and new shapes.

DIAGRAM 1

COSTS AS PERCENTAGE OF SALES VALUE

ITEM	PERCENTAGE PLANT UTILIZATION		
	60%	80%	100%
MATERIAL	35	35	35
DIRECT LABOUR	15	15	15
INDIRECT LABOUR-PLANT DEPRECIATION* & MAINTENANCE	40	30	24
OVERHEADS-DESIGN, SELLING ETC.	13	10	8
PROFIT OR LOSS	-3	+10	+18
SELLING PRICE	100	100	100
PROFIT EXPRESSED AS PERCENTAGE OF CAPITAL EMPLOYED	-4.5%	+20%	+45%

* BASED ON AVERAGE LIFE OVER BUILDING & PLANT OF 6 YEARS.

PROFIT RELATED TO PERCENTAGE UTILIZATION OF FACTORY CAPACITY

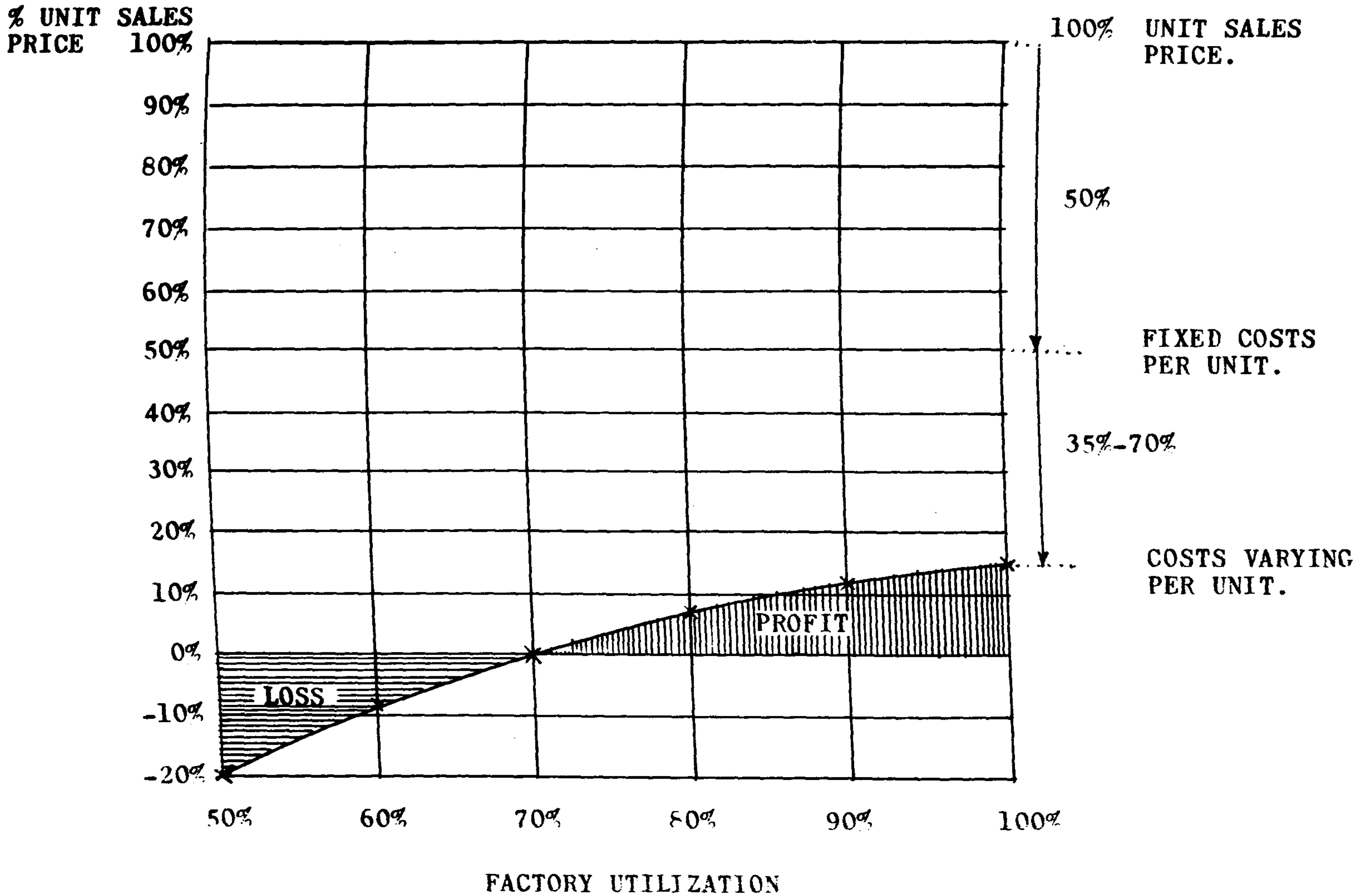


DIAGRAM 3

ESSENTIALS FOR A PROFITABLE SYSTEM

1. FAST AND LOW IN COST.

2. TOTAL OPERATION EFFICIENT IN PRACTICE.

3. SYSTEM UNDER CONTINUOUS REVIEW.

4. AN ADAQUATE ORGANISATION TO OBTAIN A CONTINUOUS FLOW OF WORK.

RELATION BETWEEN DESIGNER AND MANUFACTURE CONTRACTOR

1. DESIGNER DOMINATED.

2. CONTRACTOR DOMINATED.

3. EQUAL PARTNERSHIP.

SYSTEM DISCIPLINE.

PURPOSE.

a. LIMIT COMPONENT TYPES ON ANY ONE CONTRACT.

b. PERMIT EASY SWITCH FROM ONE CONTRACT TO ANOTHER.

MINIMUM NEEDS.

a. LIMITED SIZE VARIATION.

b. STANDARD JOINTS.

c. STANDARD ARRANGEMENT FOR SERVICES.

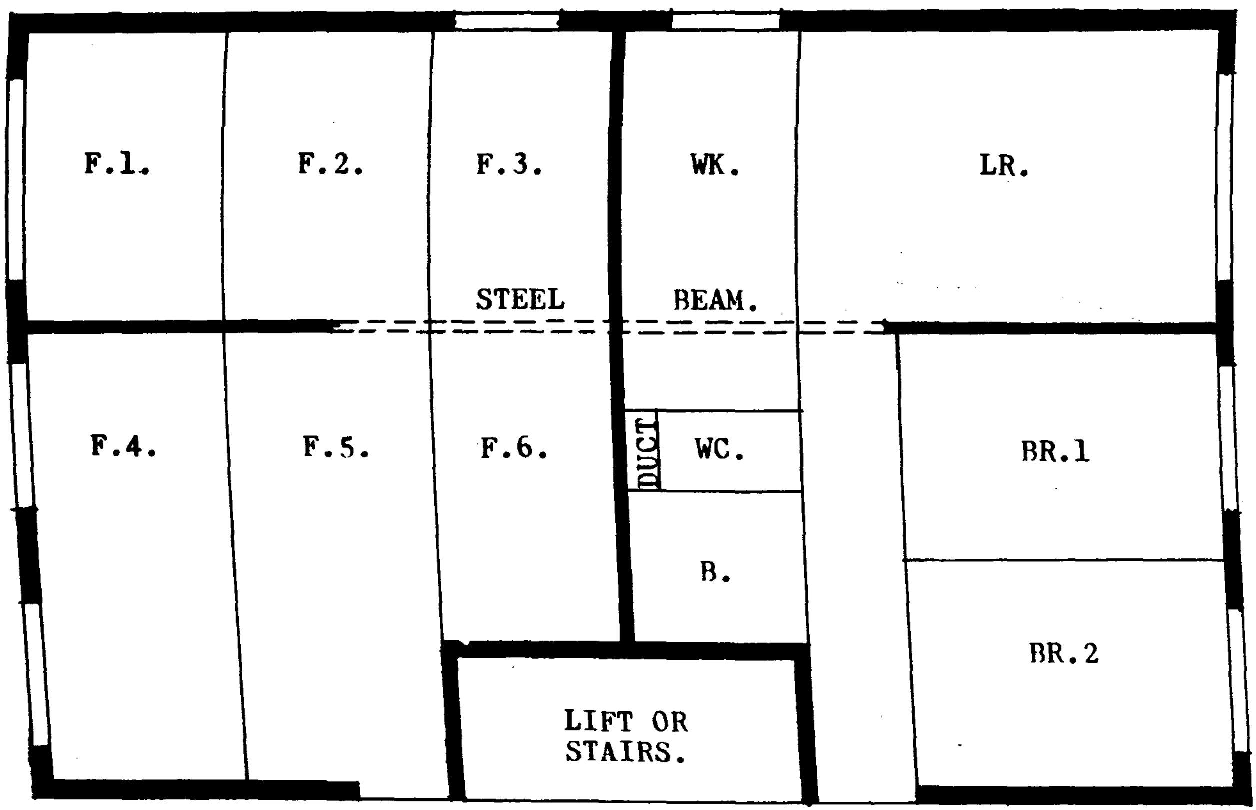
SOLUTION.

a. STANDARD PLANS.

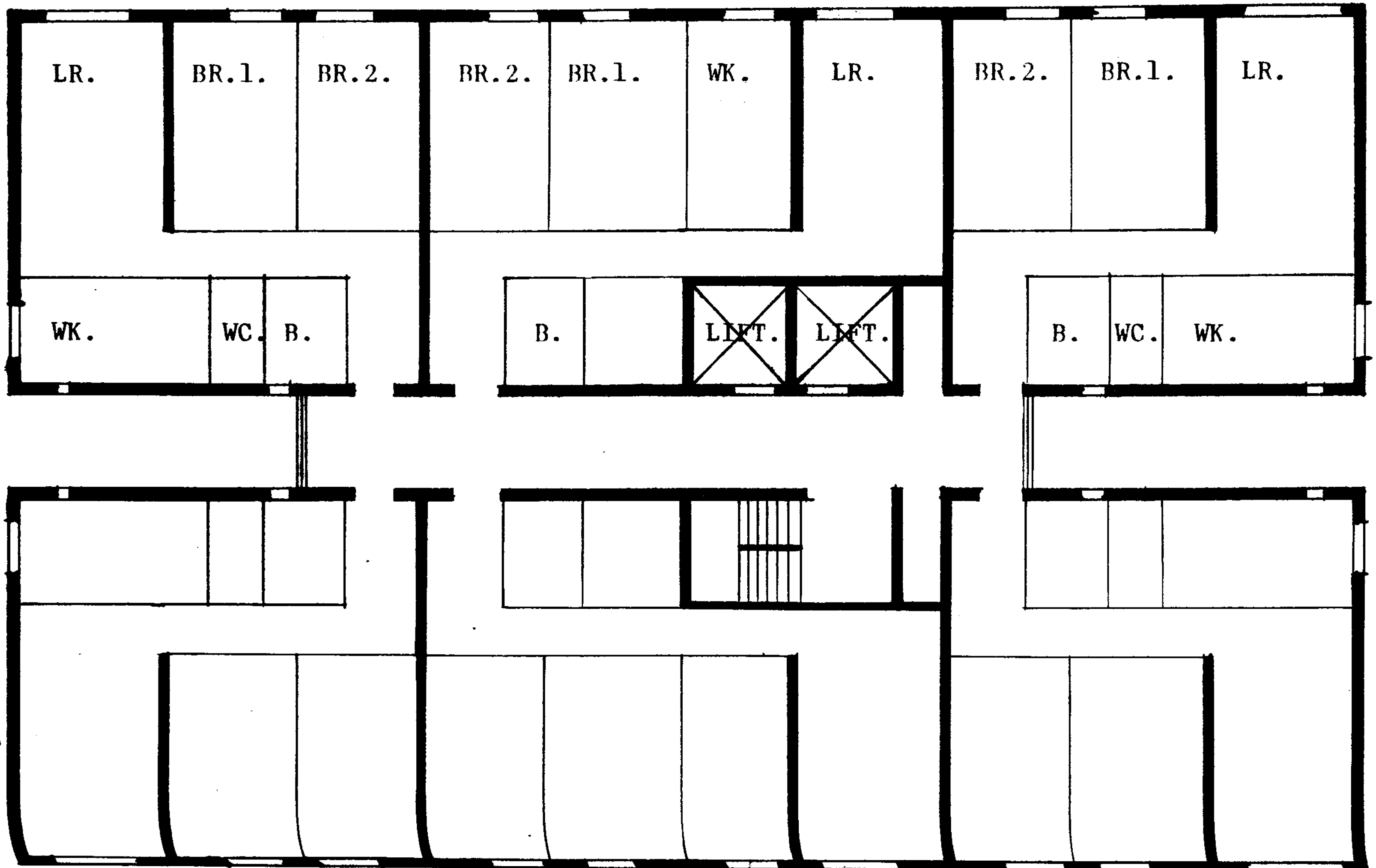
b. STANDARD COMPONENTS.

c. MODULAR COMPONENTS

HIGH WALL FRAME WING OF TWO FLATS



BISON WALL FRAME. 6 FLATS PER FLOOR.



LUNCHEON ADDRESS, Monday, April 29, 1968

WILLIAM LADYMAN

This morning's speakers gave some of the reasons behind this conference, and judging from the program, we hope to cover every facet of a Systems Approach to Building in the two days. I appear to be the first and possibly the only speaker for the labour side of the construction industry. One speaker is such a small proportion of the total number that I can only take it as a compliment to my powers of persuasion, and develop my remarks accordingly.

Some of you may be thinking - on the negative side - "What is the use of ambitious planning if unions run opposition - if jurisdictional troubles plague the job site or the factory - if unreasonable wage demands (and aren't all wage demands unreasonable to somebody?) are made, and slow-downs interrupt the factory flow?" Or else, you may be thinking on the more positive side - "How can unpleasant labour reactions be avoided?"

Let there be one strike in a Systems Approach factory-erection site, and someone will say "I told you so. It's those damned unions again....." And so we must tackle the second question - "How can good industrial relations be initiated and maintained?" and answer it in good faith.

Gentlemen: The problems of the Construction Industry are not new to us. Technological change is not new either. Nor is prefabrication. Nor, for that matter, is the Systems Approach. Nor are the Unions (and those who advise us) unprepared for a step forward in building techniques.

The suggested title for my remarks today is "There's Always a Way" - Not, you will note - "There's always a Union in the Way."

I have a message for you. It may not be entirely one of hope, but it certainly is one of quiet realism: that if we are to play on your team you can count on us as fully as you can count on the other players - and no more!

I propose to develop the following five points:

1. Canadian Construction Unions, not unnaturally, have had some difficulty working together in

the past. In a loosely-structured and fiercely competitive 'stop-and-go' industry like construction, this is understandable.

2. We are all aware of the need for inter-dependence and co-operation between management and labour. We hope that inter-dependence includes understanding and respect.
3. In our free enterprise economy, each person, each group seeks to maximize his own profit and gain. There is no particularly conscious desire to work for the common good. Such an ideal seems to be becoming more a function of government than of management, or labour, or capital.
4. There will be jurisdictional problems, but with good will they will either be solved or side-stepped.
5. The Building and Construction Unions have already researched the development of prefabrication, and its effects, and I will summarize the results. Such research doesn't do anything yet for the worker on the job at present, but it will, and we will be negotiating on his behalf.

In the Systems Approach to Building there are many problems to be solved before it becomes a 'fait accompli' in this country: Union attitudes are but one of the problems.

For a long time, the Unions have been blamed for impeding the wheels of progress, and for following what have been described as antiquated jurisdictional regulations. Some have said that our jurisdictional disputes hamper the development of prefabrication of building projects, and yet it seems to me that the facts are often quite different.

A thorough-going research project, undertaken by the Battelle Memorial Institute of Columbia, Ohio, recently made public, shows clearly that there are many, many factors apart from union attitudes, that act as brakes on the development of prefabrication.

These factors are: building codes, zoning, architects, tradition, the structure or lack of structure of the industry, transportation, and capital requirements. The report goes further into the way these various factors have acted as 'constraints' on prefabrication: -

Building Codes - and their lack of uniformity are cited as hindrances because they cause unnecessary costs. Some materials and products are rejected in one area, accepted in another.

Zoning - frequently results in the inefficient use of land, especially low-density zoned land, and "has a tendency to deter the rate of growth of prefabrication."

Tradition - In itself this is probably the biggest constraint to technological change. People usually want traditional homes that conform to traditional patterns. The Battelle study found that because of tradition, prefabrication can be accepted only in "small doses," and on an evolutionary rather than a revolutionary basis.

Architects - like to think in terms of aesthetics, art, and their own personalities, and I think they will agree that mass-produced prefabricated products stunt their individual styles. Another factor is the gearing of architects' fees to the cost of a structure. Any drastic cut in those costs is going to hurt the architect's monetary reward.

Unions - The Battelle report admits that "certain local unions have resisted specific advances with some success," but contends that up to the present, Unions, as a whole, "have generally accepted prefabrication and have tried to take advantage of its benefits, especially year-round employment and better working conditions." Battelle notes that the ultimate goals of each craft union are:

1. Full employment of its members,
2. A livable wage, and
3. The right to preserve and advance the traditional skills of the trade.

In the light of these factors, the report says, unions are now in the process of trying to determine "whether prefabrication represents a threat or a potential opportunity for its membership." This determination is still going on.

<u>Transportation</u> - of prefabricated materials is a major problem. Entire dwelling units can be factory-produced, the study found, but they can't be transported easily or economically by present methods.

<u>Capital requirements</u> - are a stumbling block because most home builders do not have the capital to set up costly manufacturing plants.

Finally, the study showed that the whole structure of the construction industry - fragmented, decentralized, made up of thousands of companies and widely differing components - "does not readily lend itself to innovation of any type."

The research report I have been quoting was made at the request of the AFL-CIO Building and Construction Trades Department at a cost of $66,000. It is designed to help the construction unions, which represent over 3.5 million workers in North America, to understand the nature of prefabrication and how it can help or hurt them.

What it shows, (and this should be of great value to other industries and the public) is that blaming the unions for hindering progress is a gross fallacy and that change in an industry does not hang on any single element in our highly complicated and individualistic economy. Blaming the unions is often a convenient way of covering up other deficiencies.

The principal constraints to the growth of prefabrication between now and 1975 will be building codes, zoning regulations, architects, unions, transportation, capital requirements, tradition, and the basic structure of the construction industry. In summation, it appears that the latter two constraints, "tradition" and the "industry" itself will be the most difficult to overcome.

Prefabrication will definitely grow during the next decade; but much of this growth will be based on the increased acceptance of existing methods and techniques of prefabrication by the construction industry rather than the development of new prefabrication methods. There will be more opportunities for advances than in any of the other segments of the industry.

As part of the Battelle study, the impact analysis technique was developed to determine the effects of the anticipated changes in technology and prefabrication on each of the affiliated unions. The basis for this analysis was 249 items or events that were expected to occur or change during the ten-year period.

Let me mention a few points to give you an idea of the depth of the analysis. Each Union was asked how they expected to be affected, both now and in 1975. Here are some of the 249 items that the Unions were questioned about:

Under the impact of "Bigger Builders" will you increase your membership? Your skills? Will you change your locations? With more building sub-systems and so on, through

Interior sub-systems,
Unit Prefabrication,
Larger Components,
Heart Units,
Sectional Homes,
"Tilt-up" construction.

and so on.....through 249 questions.

The answers to these questions from the AFL-CIO affiliated Unions reveal the following:

1. Prefabrication will offer the Operating Engineers and the Electricians the greatest opportunities for growth, whereas it will offer the Painters, Decorators, and Paper Hangers the least.

2. The Operating Engineers will have the greatest need for new skills because of the anticipated changes, and

3. the United Association (Plumbers) will be affected the most by re-location of work from the job site to the factory.

This detailed analysis was the most important part of the survey, and the tabulation of the pages of figures is the basis for the Unions' estimate of the trend of the future.

Let me give an example:

For the Electrical Workers, 22 items were fore as requiring an increase in manpower, eight items requir less manpower resulting in a plus gain of fourteen point Only one item showed a plus in additional skills, which indicates that our electrician members already have suff fundamental knowledge and skill to undertake the work. Location-wise, there was a significant minus-sign for ni items, indicating an apparent move from job-site to fac assembly plant.

Although one of the economy factors of new in- factory building techniques is supposed to be the requi for 'less' skill, and therefore, presumably lower wages such employees, one can forecast that insofar as the ele ricians are concerned, present skills are still require Construct your buildings as you will, the electrician is still needed to use his hands, tools and brain. And for that he must be paid the going rate and better.

At the other end of the scale, let us forecas the impact of the newer methods on the Painters and Decorators. Of 49 items of manpower, nine showed pluss and 44 showed losses, for a net loss of 35. Skills sta at zero or unchanged. Location showed a loss of four points which again meant the move from job-site to fact

Let us examine the bricklayers. They forecas an increase in manpower requirement in only four instan which were brick-bearing walls, tile wainscots, use of imported tile and cement, and urban renewal projects. foresee a loss from the following: larger building com ents, greater durability of paints, unit prefabrication as banks, schoolrooms, etc., unitized bathrooms, mobile homes, sectional homes, precast concrete components, ti up construction, slipforming, exposed aggregate panels, sandblasting for aesthetics, concrete forms, brick pane machines, glass wall and panels, and so on.

The analysis is complete, published, and revi What will the Unions do about it? I cannot answer that question at this time.

We could look at the organization of the cons tion trade workers in Europe and relate their organizat and pay-rates to the existing building systems over the but the facts of Union life in North America are differ

Something happens to European emigrants. They breathe freer air over here. Perhaps our loose federation of semi-autonomous states is working after all! Here we have to deal with Canadian and U.S. Construction Unions, and they are among the best organized and best paid in the world.

Obviously the Systems Approach will cause some unions to prosper and expand; others to contract and suffer. Such changes are - in the long run - inevitable. These changes would probably take place whether we take a systems approach or not. In the short run, however, there may be struggles to maintain present positions and jurisdictions.

The question of re-training and re-employing workers in the shrinking craft groups should be tackled now, and not left to follow changes in the factory or on the job-site.

More and more Unions demand that part of the expected profits to be derived from technological improvements must be spent on re-training workers for new crafts and careers. Remember the wise comments of the Hon. Mr. Justice Samuel Freedman on the Canadian National Railways run-through: and I quote -

> "The Commission is of the view that an obligation rests upon the company to take reasonable steps towards minimizing the adverse effects which a run-through may have upon its employees. That obligation has its root in <u>the principle that when a technological change is introduced the cost of reasonable proposals to protect employees from its adverse consequences is a proper charge against its benefits and savings</u>. Apart from the advantage of expediting traffic, the company's run-through program would yield monetary savings of nearly a million dollars a year. <u>It is proper that the cost of protective measures for employees hurt by the run-through should be charged against the savings resulting from it."</u>

The details of the C.N.R. case may bear little relevance here, but the principle does.

We can expect the large regional manufacturers or contractors who operate the building factory, to offer long-term employment at maximum output. The workers will appreciate fewer bad weather months exposed to the elements if they are in environment-controlled buildings. Accident rates could also show a decline. Some craft-workers, carrying their skills and know-how from the job-site to the factory, will expect the new-type management to accept the principle that as productivity increases, and as further improvements and further changes are made, the costs of re-training and re-employing workers displaced in the future are absorbed by the company. Even if tomorrow we could start twenty home-plants, each geared to produce, say, 1000 units per year, there would still be everchanging technological improvements. Some workers will leave through attrition, go on pension, etc.. but the younger ones will expect re-training and newer-type jobs.

In 1967 private construction in Canada amounted to about sixty percent of total construction of all kinds, and the Government (all three levels combined) was responsible for forty percent. Federal Government housing was included in that forty percent and it was, and still is, of negligible importance, except of course in the general area of providing financing to provinces and municipalities. However, we must not overlook the fact that systems approaches to building in Europe has been considerably helped by governments that were and are heavily committed to government housing programs. Such housing programs may yet come to North America. But I am assured that although this conference is sponsored by the Federal Government, the latter is not yet planning to build the Canadian Council House!

However, the demand curve for housing continues to shift higher and higher. And we all know that what private enterprise fails to provide, governments are finally forced into providing.

As regards the Building Craft Unions, we can forecast that each will keep its identity just as long as, and only as long as, they can maintain economically-viable organizations.

Jurisdiction-wise we have been conferring for many years. Decisions on record of national jurisdiction awards have been accumulating for half a century, and are in use daily. But what no-one has yet found means to control are the unilateral decisions of a firm, a contractor, a superintendent, made in an off-the-cuff manner, decisions that fly in the face of known trade practices and customs, and immediately precipitate a crisis on the job.

There is some talk of mergers of trade unions. True it is happening in Britain, but I know of no contemplated mergers here of any consequence.

In conclusion I would ask you not to forget the pride of a craftsman in his craft. Do not forget that he will guard his work and his knowledge with some degree of jealousy. But over and beyond the emotions of pride and jealousy, he prefers the economic realities of a skilled worker's wage. The economic realities of the wage packet are very important. Those realities constitute one of the main preoccupations of the working class.

Should, as seems likely, you plan to move some of the work from labour-intensive field sites to the capital-intensive factory site, take the skilled craftsman with you. Take the Union craftsman with you. You will do this, if you are wise.

And when you create the factory-site for a fuller use of a combination of craft skills, it would seem to me to be logical to have Union-negotiated wages and working conditions. The logical choice would be the craft unions whose skills are needed at both locations - construction unions that could be expected to grow with the growth of the systems approach to building.

There's always a way, Gentlemen. Instead of knocking our heads together, let's put them together!

THE BACKGROUND FOR INDUSTRIALIZED BUILDING IN DENMARK

MARIUS KJELDSEN

FACTS ABOUT AREA, POPULATION AND BUILDING ACTIVITY

Denmark proper, which consists of Jutland and the main islands, Funen, Zealand, Lolland-Falster, Bornholm and a lot of smaller islands, has a total area of 43,000 sq. km. (16,600 sq. mi.).

The greatest distances are:

East-west	300 km. (190 mi.)
North-south	340 km. (210 mi.)

Denmark has a population of 4.8 million or about 110 persons per sq. km. Of these, 1.4 million live in Copenhagen (the capital) while the second largest city, Arhus, has 180,000 inhabitants and the third largest, Odense, 130,000.

The number of dwellings built during the years 1958 and 1967 and the corresponding total volume of building in 1,000 sq. m. of gross floor area are shown in the following tabulation:

Number of dwellings built during 1958 & 1967:	1958	1967*
1. Total completed housing	21,000	44,300
2. One-storey housing (one-family houses, terrace houses, etc.)	10,300	27,200
3. Multi-storey housing	10,700	17,100
4. Dwellings built by unsubsidized private builders	4,700	30,000
5. Dwellings built by subsidized non-profit housing societies and private builders	16,300	14,300

* Estimated figures

Total volume of building during 1958 & 1967 in 1,000 sq. m. of gross floor area:	1958	1967*
6. Total new buildings completed during year	3,223	8,578
7. Housing	1,779	4,917
8. Factories and workshops and other private commercial bldgs.	947	2,869
9. Public buildings	497	792

* Estimated figures

The best way to characterize the development of the Danish building industry is through figures of the increasing production.

From 1958 to 1967 the increase in the total construction volume is 165% and for housing alone 110%.

The development during the last 15 years has followed two paths:

1. Rationalization of traditional building methods.
2. Industrialization

There is a fundamental difference between the effects of these two lines of development. As long as the traditional methods are the same and the basis for the entire process on the whole remains unaltered, it is only possible to rationalize up to a certain limit. But in order to meet the enormous growing demand for buildings of all kinds it is necessary to industrialize the production and therefore the basic principles of production will have to be changed.

THE GENERAL CONDITIONS OF INDUSTRIALIZATION

Industrialization does not begin with developing a new technique, but with creating the market conditions that will promote new developments. Some of these conditions are:

1. The building regulations must encourage

industrialization by establishing uniformity of requirements throughout the country.

2. The rules and regulations must, as far as possible, be in the form of functional requirements.

3. A high degree of national standardization as a basis for an industrial production of all components.

4. Dimensional co-ordination to make it possible to utilize components of different types in the same structure.

5. Long-range planning as a basis for continuity of production.

A comparison of technical development in different European countries will show that the industrialization of the building industry has indisputably progressed farthest in the countries where the government and/or the public authorities have provided the conditions mentioned above.

THE PRESENT CONDITIONS IN DENMARK

Referring to 1 — A new Building Act came into force in Denmark in 1961, applying to the whole country. Based on this Act the Ministry of Housing has drawn up building regulations likewise applying to the whole country. Local district authorities are not allowed to change the technical requirements.

Referring to 2 — To a large extent the rules in the National Building Code are expressed as performance requirements for individual building components, thus leaving it to the designer to decide what materials shall be used and how the functional requirements shall be met. In this way, the authorities seek to avoid confining technical development to present materials and constructions and to leave the door open for the application of new, rational building methods. General approvals of new constructions and materials are given by the Ministry of Housing.

Referring to 3

In order to provide the dimensional basis for the industrialized production of the various structural components the work on standardization has recently been concentrated on dimensional co-ordination.

The Danish Standard Specifications (DS) and Recommendations (DS/R) listed below specify dimensions which are in accordance with international modular principles:

DS	1010	Modular coordination in the building industry. Fundamental principles.
DS	1011	Modular rules for the building industry. (Basic module).
DS	1011	Modular rules for the building industry. (Planning module for house building).
DS	1011	Modular rules for the building industry. (Dimensioning of modular components).
DS	1000	Floor-to-floor height in buildings. 2. edit.
DS/R	1035	Marking of levels for installations and built-in components.
DS/R	1038	Precast concrete hollow-core floor units.
DS/R	1039	Precast concrete internal bearing-wall units.
DS/R	1040	Staircase for double-flight stair.
DS/R	1041	Modular dimensions of block-components.
DS/R	1042	Non-bearing partition wall units.
DS/R	1043	Kitchen storage units. Overall dimensions.
DS/R	1036	Dimensions of pipe installation, spacing and length of pipes.
DS/R	1037	Dimensions of pipe installation, equalizing of tolerances.
DS	1003	Wooden windows, modular dimensions.
DS	1004	Windows, designation of types.
DS	1005	Windows of wood, terminology and denominations of dimensions.
DS	1006-9	Normal windows of wood.

Referring to 4

Mass production is one of the prerequisites of industrialization, and mass production is dependent on standardization and modular coordination. The five Scandinavian countries have, in close collaboration with international efforts towards modular coordination, adopted uniform lines with regard to modular coordination: the basic module M = 10 cm. (4") and the planning module 3 M = 30 cm. (12")

In Denmark the significance of modular coordination has been further emphasized by the fact that the new Building Act of 1961, which applies to the whole of the country, provides that projects for all rented dwellings must be planned on the basis of the accepted principles of modular coordination.

Referring to 5

In 1960 the first steps were taken by the government to provide a basis for long-range planning within the building industry. At this time provision was made for the building of about 2,000 dwellings annually during a four-year period from 1960 to 1964 irrespective of the political and economic developments during this period. Two thousand dwellings correspond to about 13% of the annual production of apartments or to about 6% of the annual production of dwellings. The first long-range plan in Danish building history thus comprised about 7,500 dwellings - a modest figure when considered internationally; but from the Danish point of view this first long-range plan was of the greatest importance to further development. Today 9,000 dwellings per year (40% of the total annual production of dwellings) are covered by long-range planning, and the period has been extended to 5 years.

One of the most important objectives of the plan was to create the "climate" for the establishment of new production facilities. The Ministry of Housing therefore laid down special conditions for building schemes which could be included in this long-range program.

Both objectives and requirements were published in a circular issued by the Ministry of Housing at the beginning of 1960.

"The objective of the long-range program is to increase construction capacity and to attempt to reduce construction costs. It is endeavoured to achieve these results by planning buildings from the very start with the specific purpose of using prefabricated components to the greatest possible extent, in order thereby to obtain maximum efficiency of labor and materials and on the whole to obtain maximum productivity.

Production on these lines will allow greater use of machines to supplement and increase the effectiveness of the available labor force and will make it possible to continue construction throughout the year independent of the weather."

The conditions mentioned above played an important part in the very rapid development of industrialized systems building in Denmark. The foresight and efforts of the architects, engineers and firms, who together, and in close cooperation, created the various systems, also contributed materially to this progress.

The result is that today, in the country as a whole, about 60% of all multi-storey housing is constructed by industrialized methods, while this figure in the Copenhagen area alone is approaching 100%.

The system which is to be described by the following film and speakers, is one of the results obtained.

THE DESIGN

J. MUNCH-PETERSEN

INTRODUCTION

Mr. Kjeldsen's paper has provided an introduction to the means of solving our housing shortage, aggravated by the labor-shortage, especially the shortage of skilled labor.

Industrialization of the construction process has become a prime national objective for Denmark.

By special legislation larger projects in a continuous sequence were favored, on condition that drastic manhour reductions were demonstrated at prices and qualities at least equal to those on traditional projects. Another condition was that industries and factories established should be to the benefit of the country in the long run and not merely for the first projects, the Ballerup and Gladsaxe schemes, totalling 3,500 flats in four years.

Four non-profit building organizations joined in this project. They established a design team for analysing and formulating the design philosophy and for designing and coordinating the processes. They were soon joined by contractors like A. Jespersen & Son Ltd. and Velux Ltd., who were anxious to set up modern factories for producing concrete components and light façades. Enthusiasm and mutual confidence made public tendering unnecessary.

THE DESIGN TEAM (organization)

The design team comprised seven firms of architects, three consulting engineering firms, two landscape architects, advisors from several contractors. The owners formed a co-ordination committee with two architects representing the building organization and P. E. Malmstrom, consulting (structural) engineer.

This Design Co-ordination Committee was to ensure that layouts, components of all kinds, joints, tolerances, manufacturing and erection techniques and supply and erection (time) schedules fit together.

The basic idea was:

"Design geared to production for all bits of the jig-saw puzzle."

The set-up and the lines of communication are shown in the diagram: "The Design and the Building Process". The diagram also covers the next important step, the realization of the design, where the Site Manager had a similar central, co-ordinating position.

The diagram "Work Planning - Site Management" illustrates part of the design-building process. The planning staff works simultaneously with the design staff, but will function as assistants to the site manager later during the construction period when the design is definitely completed except in the rare cases where improvements are discussed with all parties involved.

The design-building process diagram illustrates only functions of the staffs involved. The design co-ordinator may by education be an architect, an engineer, a contractor or something else. However, he must not function in any other capacity than that of an unbiased co-ordinator between technical and economic factors, searching for the optimal solution as defined by the client. The site manager similarly has a co-ordinating and administrative position on behalf of the client - and he is the sole link between design staffs and site-contractors - in order to ensure complete co-ordination of qualities, supplies, time-schedules, specifications, etc. If one bit of the jig-saw puzzle is changed many other bits are influenced, and this applies to design as well as to construction.

Diagram I applies in its functions to almost any organizational pattern, except perhaps in the case of a package deal, where all functions are headed by one organization. In this case a link between the owner (the client) and the organization must be added - a technical (and perhaps economic) adviser to the client.

In the case of a general contractor the site manager may be on the contractor's payroll. The diagram should still apply, but it may be psychologically difficult to recognize the indicated position of the supervisors. The indicated lines of communication are necessary, with the exceptions indicated by the dotted lines (in the unusual case when the site manager refuses to consider complaints or the like). The design co-ordinator may be the same man as the site manager. They must in any case collaborate closely, and overlap each other in the later stages of design.

Usually the same man cannot fulfil more than one of the indicated functions. This is partly because of the work-load involved, partly because a universal genius covering aesthetics, economics, techniques and management is very rare indeed. Nevertheless, a single firm may have all the men needed.

In the case of the Ballerup-Gladsaxe projects the traditional Danish pattern was followed. Design by a group of independent architects and consulting engineers, construction and materials by independent sub-contractors and suppliers (a total of 35) each with his separate contract. Therefore, the client appointed a design co-ordinator and a site manager (coordinator), from P. E. Malmstrom's staff, working in collaboration with the client's representatives. The Ministry of Housing was directly attached to the organization described above, having an observer (advisory) at the committees.

THE DESIGN PHILOSOPHY

Traditionally, apartment blocks were constructed with brick walls and cast-in-situ floors. Steel structures were never competitive because steel was expensive to import and subject to strict fire-regulations requiring elaborate fire proofing. On the other hand Denmark has an extensive concrete industry, and precast structures were successfully introduced in 1950. Pioneers were firms like Hojgaard & Schultz (industry, offices), Larsen & Nielsen (apartments) and Malmstrom (structural design). In 1960 when the Jespersen design philosophy was formulated, a number of factories and contractors had proved the savings in manpower and money of precast structures. The aim was now to improve techniques. The conditions set by the Ministry were:

- a drastic reduction in total manpower, especially in skilled labor
- a reduction in manpower in the concrete-component factory to half of that in existing factories
- a 20 per cent reduction in costs of the precast components
- an overall cost similar to traditional, if the quality was better
- <u>or</u> a saving in money with the same quality - subject to the possibilities of various trades and components

- establishment of factories which in the long run could produce other similar schemes to the benefit of the country

The conditions were, by the way, fulfilled. Labor on site is reduced to a third (skilled labor to a sixth) of the labor for traditional apartments of the early 1950's. In money this labor-saving would amount to 40% savings in total costs. Two factors counteract these savings: 1) Depreciation of investments in factories and on site. 2) Traditional methods have also improved since 1950, by rationalization and use of some prefab components.

Today, industrialized housing in Denmark is approximately 15% cheaper than rationalized, traditional housing.

The design philosophy was then based upon:

a) the greatest possible freedom in planning layouts of flats (Ballerup-Gladsaxe had 3,500 apartments in 3, 4, 9 and 16 storeys and 35 layouts, and nobody could guess future needs).

b) the lowest possible labor requirement (mechanization, repetition of operations, continuity, coordination, optimal use of materials, no waste of materials or time, tight time-schedules for supply and erection, short construction time, freedom from the limitations of climatic conditions, especially in the winter, became the key words).

In order to make the factory investments feasible, and to make a continuous and repetitive mechanical production possible, dimensional coordination was a necessity in order to obtain flexibility in layouts (a - above), with the key-words of mechanization (b - above).

Danish legislation already called for extensive dimensional co-ordination:

Floor-to-floor height	280 cm.	(28M)	(9'4")
Module (for co-ordinating smaller components such as kitchen joinery, stoves and refrigerators)	10 cm.	(1M)	(4")
Structural grid (floors and walls)	30 x 30 cm.	(3M x 3M)	(12" x 12")

Ballerup-Gladsaxe gave rise to the present preferred grid (legally recommended, Danish Standard) of 30 x 120 cm. (12" x 48"), where the 30 cm. increments apply to the spans parallel with the façades (center-to-center of walls) and the 120 cm. increments apply to the depth across the building.

THE STRUCTURAL COMPONENTS

The design aims at separating the functions, i.e to separate the services and structure, whenever possible due to different tolerance requirements - but on the other hand making the components as ready-to-use as possible, except for finish and erection time. An ideal example is the vertical service cores for kitchens, which are standardized for all kitchens, giving geometrically identical recesses in all floors. Furthermore, recesses, inserts, etc. should not be spread all over the layout. As many floors as possible should be kept as simple standard components. The special requirements should preferably all be placed in a few components, i.e. the stair-end-wall is the longitudinal wind-bracing wall, comprising also T.V., electricity and telephone supply, meters and refuse chute. The bathrooms are similarly geometrically identical so that one special floor component can be used, with the same recesses and identical cast-in pipes and down-pipes. The span of this floor may, however, be varied according to the requirements of the layout.

The result is that the structure is built up of:

85% standard floors, mechanically produced, 120 cm. (48") wide, with spans from 180 to 600 cm. (6' to 20')
15% special floors, complex but comprising identical forming and operations (balconies, bathrooms, stairs)
80% standard walls, mechanically produced, 120 and 240 cm. (4' and 8') wide (3 ton system)
or 240 and 360 cm. (8' and 12') wide (4 ton system) with cast-in electric conduits
20% special walls (windbracing walls, gables, etc.)

Flexibility in layout is now based upon one requirement only, the 30 x 120 cm. (12" x 48") structural grid (plus the aim of simplicity in service arrangements which in any case is an economic requirement). This means that the widths of the rooms can be planned with increments of 30 cm. (or if two rooms share a span, the light partitions between them may be placed in any position unless the joinery requires a 10 cm. module to be followed).

The Danish Building Research Institute is convinced that this is not an important restriction on the layout, as dimensions derived from human and functional requirements are somewhat inexact in any case. The Institute is, in fact, at present recommending a further reduction in the number of available spans.

It should be made clear that the façade is not part of the structure. Any prefab façade can be hung on the structure.

The 120 cm. (48") increments across the building do not give rise to difficulties in the layout as so many wardrobes, bathrooms and access areas of a geometrically flexible nature can be arranged in a number of ways in the centre of the layout.

60 cm. (24") wide floor components may, however, be useful where local legislation has put up narrow limits for maximum size of flats in relation to number of rooms or beds.

Balconies may not necessarily follow the 120 cm. (48") module. A 120 cm. wide balcony is of little value, whereas 180 cm. (6') or 240 cm. (8') give adequate dimensions. Non-modular balconies may also be acceptable as these components are special ones and are arranged along a façade.

The system may, however, also be used with a center wall and load-bearing façades, requiring precast sandwich panels. A load-bearing façade places certain restrictions on the architecture, but a structure with floors spanning across the building (with one or even two longitudinal walls) may give additional layout possibilities.

In Denmark the System has so far been used primarily for apartment blocks in 3 - 16 storeys with load-bearing cross walls, but also for offices, terrace-houses, etc. The licensees in Great Britain, Sweden and Israel have constructed numerous kinds of structures. Corridor blocks (forbidden in Scandinavia) are examples from Great Britain.

THE OTHER COMPONENTS

The fast, dry and accurate structure, which is necessary for smooth erection, also affords a number of advantages for subsequent operations.

With regard to completion and finishing operations also, the basic design philosophy is to use labor in factories in the manufacture of components and to reduce site operations to simple assembly processes.

The structure goes up rapidly, continuously making room for repetitive installation of components, manufactured and supplied according to long-term schedules. Factories prefer this. The structure is dry and heated so that working conditions are optimal.

Tolerances of the structure are small so that mechanical installations and joinery can be shipped as standard components with no site-adjustments required. Wall-paper is applied directly.

These new possibilities for the finishing trades, have permitted important savings in cost (and labor). In fact, the savings in finishing operations are relatively higher than the savings in the structure. The good overall economy of system building results partly from savings in the structure and partly from the possibilities created for, and exploited by - other aspects of the building.

Diagram 18 illustrates the standardization in the kitchen joinery, stoves, refrigerators, service cores, structural recesses, etc. Diagram 17 illustrates the separation of components used around a door-opening, the door itself, the door frame, the architraves and the electrical switches, etc. This allows each manufacturer to supply only a limited number of different components, while still offering all door-switch combinations in the layout.

CONCLUSION

The Ballerup-Gladsaxe projects, followed by many others of ever-improving quality (in techniques, layouts and sociology) have proved the feasibility of prefabricated building systems. So far we cannot boast of real industrialization, but the objective has been reached - the savings in cost and in manpower so urgently needed in Denmark. The quality of finish has improved considerably, especially for that of prefinished joinery compared with the previous partly hand-made-on-site technique. Labor has learnt the tricks of making good money by working rapidly (always on a piece work basis for all building trades in Denmark) and precisely without adjustments and repairs.

Many improvements are still to come, for example in flooring, partitions and in the bathroom, where new requirements of higher standards will probably attract investments in the manufacture of complete bathroom units.

Co-ordination, repetition and continuity are absolute prerequisites. The political theory of using the building industry as a safety valve for fluctuations in the national economy is a hindrance. The problem is, however, primarily our own. Planning and co-ordination are the backbone of industrialized housing.

Diagram 1

P. E. MALMSTRØM RÅDGIVENDE CIVILINGENIØR M. ING. F. OG F. R. I.
JAGTVEJ 223 KØBENHAVN Ø TELEFON *29 11 44

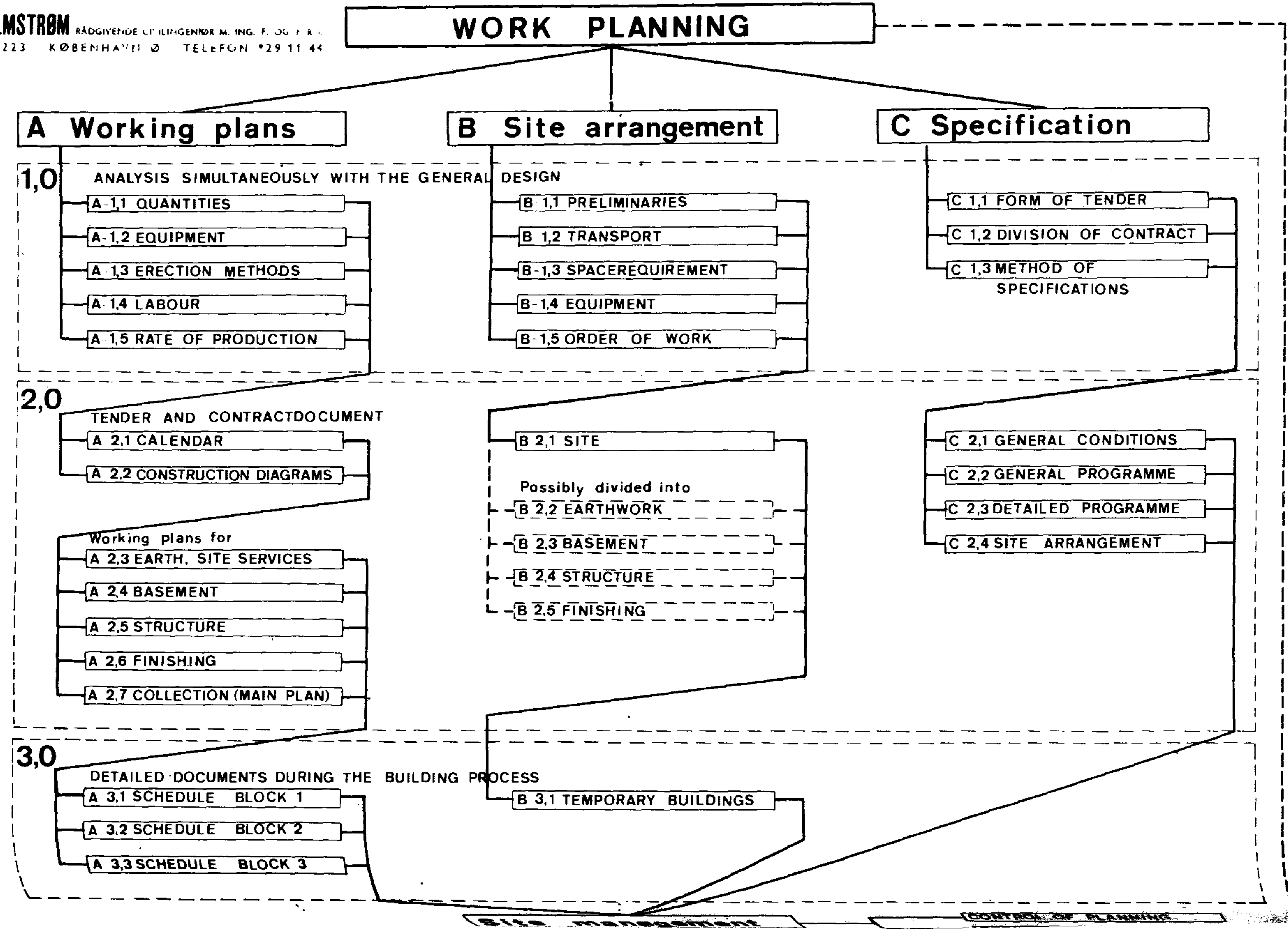


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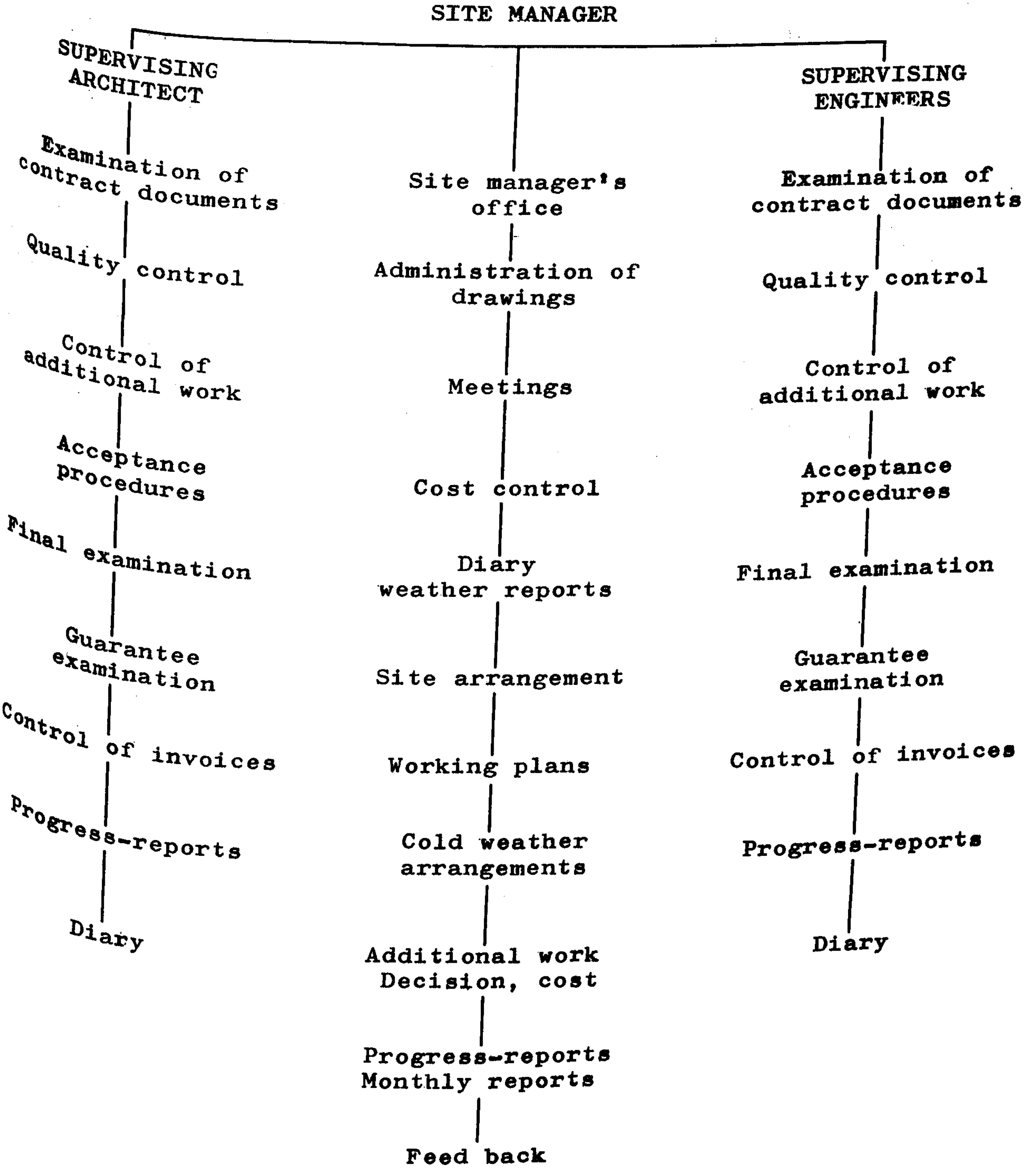
Diagram 2


SITE MANAGER
SUPERVISING ARCHITECT
Examination of contract documents
Quality control
Control of additional work
Acceptance procedures
Final examination
Guarantee examination
Control of invoices
Progress-reports
Diary
Site manager's office
Administration of drawings
Meetings
Cost control
Diary weather reports
Site arrangement
Working plans
Cold weather arrangements
Additional work Decision, cost
Progress-reports Monthly reports
Feed back
SUPERVISING ENGINEERS
Examination of contract documents
Quality control
Control of additional work
Acceptance procedures
Final examination
Guarantee examination
Control of invoices
Progress-reports
Diary

Man-hours per flat	GLADSAXE 1965	HEDEGÅRDEN I 1966
Erection, joints	122	119
Sanitary, plumbing	24	21
Electricity	15	19
Paint, joinery, cleaning	171	144
Total above basement	332	303
Foundation, basements, air-raid-shelters	54	89
Total	386	392

1.11.1967

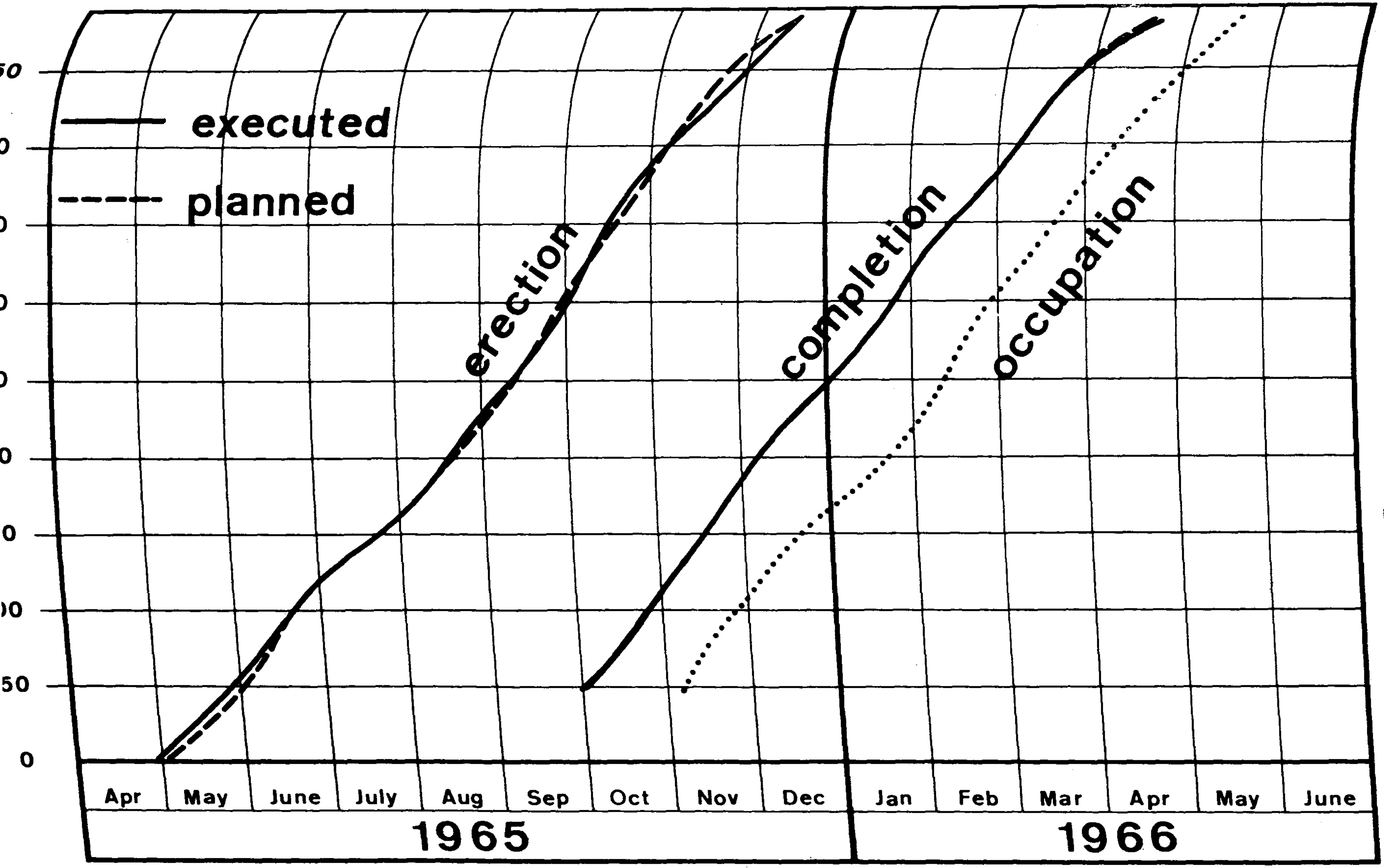
Diagram 3

Diagram 4

	Apartments	Storeys	Year
BALLERUP	1644	3, 4	1962 – 64
GLADSAXE	1435	4, 9, 16	1963 – 65
HEDEGÅRDEN I	1752	4	1965 – 67
HEDEGÅRDEN II	286	12	1967 – 68
GRANTOFTEN	836	8	1968
SYDJYLLAND	1800	(2) 3 (4)	1963 – 67
VOLLMOSE	~ 5000	2, 4, 8, 12	1967 – 76

Diagram 5

Year	Apartments per year
1955	20 000
1965	40 000
1980	70 000
2000	100 000



Gladsaxeplanen Lavhuse.

(4-storey blocks)

Diagram 6

The DESIGN and the BUILDING PROCESS

Diagram 7

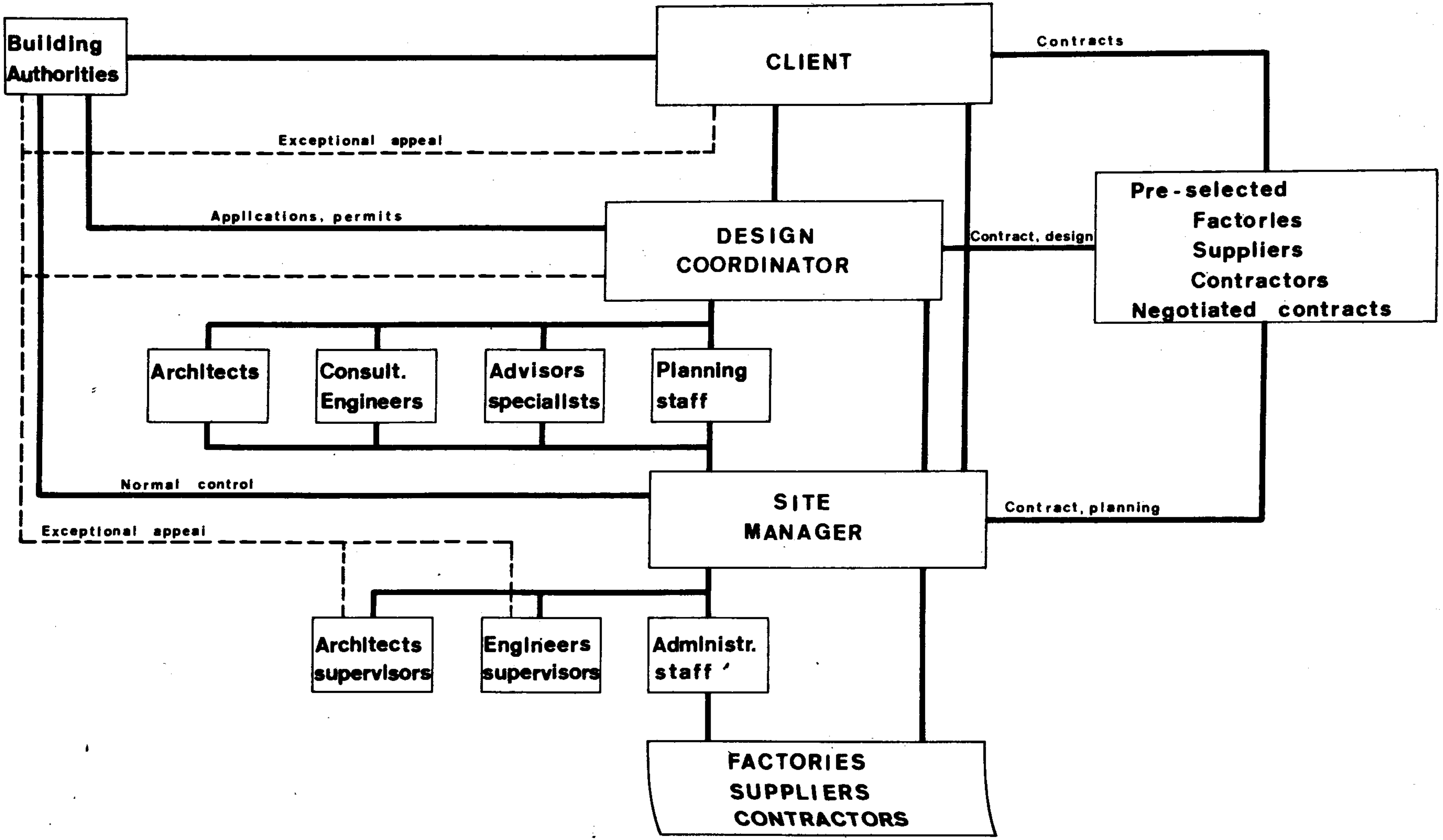


Diagram 8.

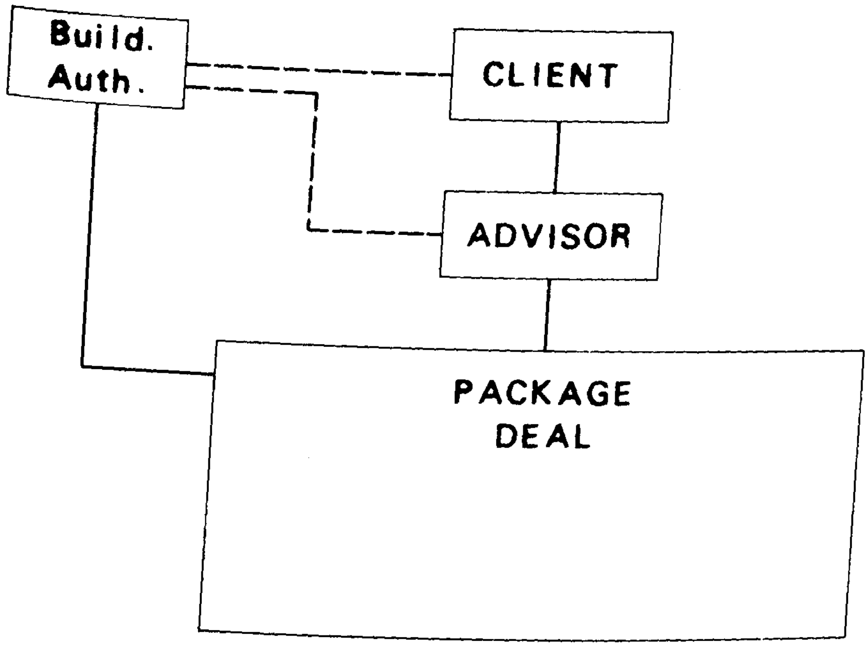
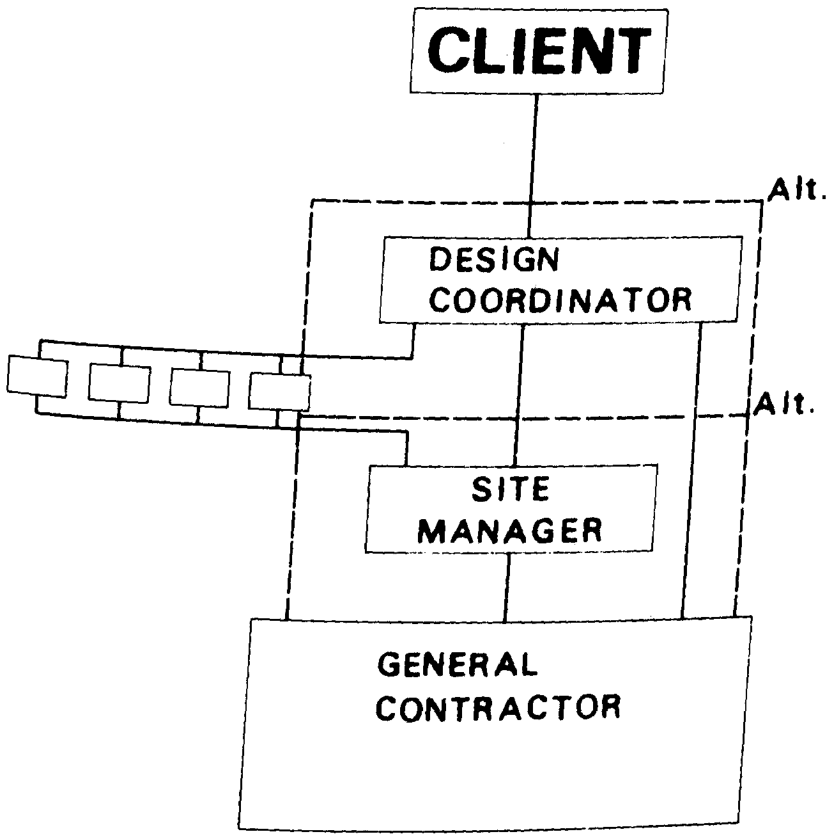


Diagram 9



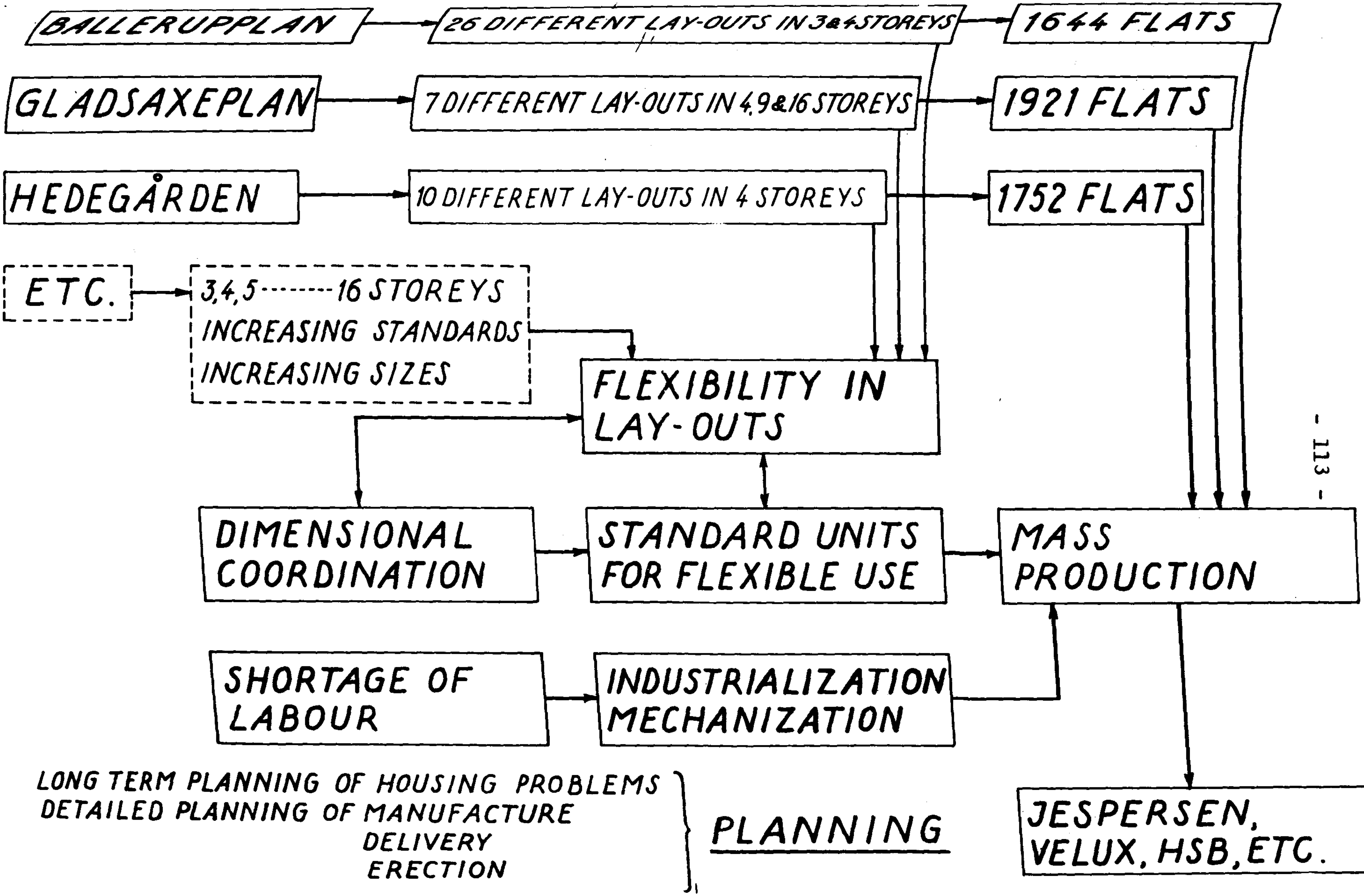
BALLERUP GLADSAXE Diagram 10

LEGISLATION
INDUSTRIALIZED BUILDING

Long term { building permits / state guarantees (loans) }

MIN. OF. HOUSING CONDITIONS

MAN-POWER	Drastic reduction (total) especially skilled labour
	Precasting factories 50% of existing factories
PRICES	20% reduction on precast components
	Lower prices better quality
INVESTMENT	Not for the present schemes, but as a long-term policy



BALLERUPPLAN
26 DIFFERENT LAY-OUTS IN 3&4 STOREYS
1644 FLATS
GLADSAXEPLAN
7 DIFFERENT LAY-OUTS IN 4,9&16 STOREYS
1921 FLATS
HEDEGÅRDEN
10 DIFFERENT LAY-OUTS IN 4 STOREYS
1752 FLATS
ETC.
3,4,5 -------- 16 STOREYS
INCREASING STANDARDS
INCREASING SIZES
FLEXIBILITY IN LAY-OUTS
DIMENSIONAL COORDINATION
STANDARD UNITS FOR FLEXIBLE USE
MASS PRODUCTION
SHORTAGE OF LABOUR
INDUSTRIALIZATION MECHANIZATION
LONG TERM PLANNING OF HOUSING PROBLEMS
DETAILED PLANNING OF MANUFACTURE
DELIVERY
ERECTION
PLANNING
JESPERSEN, VELUX, HSB, ETC.

Diagram 11

Diagram 12

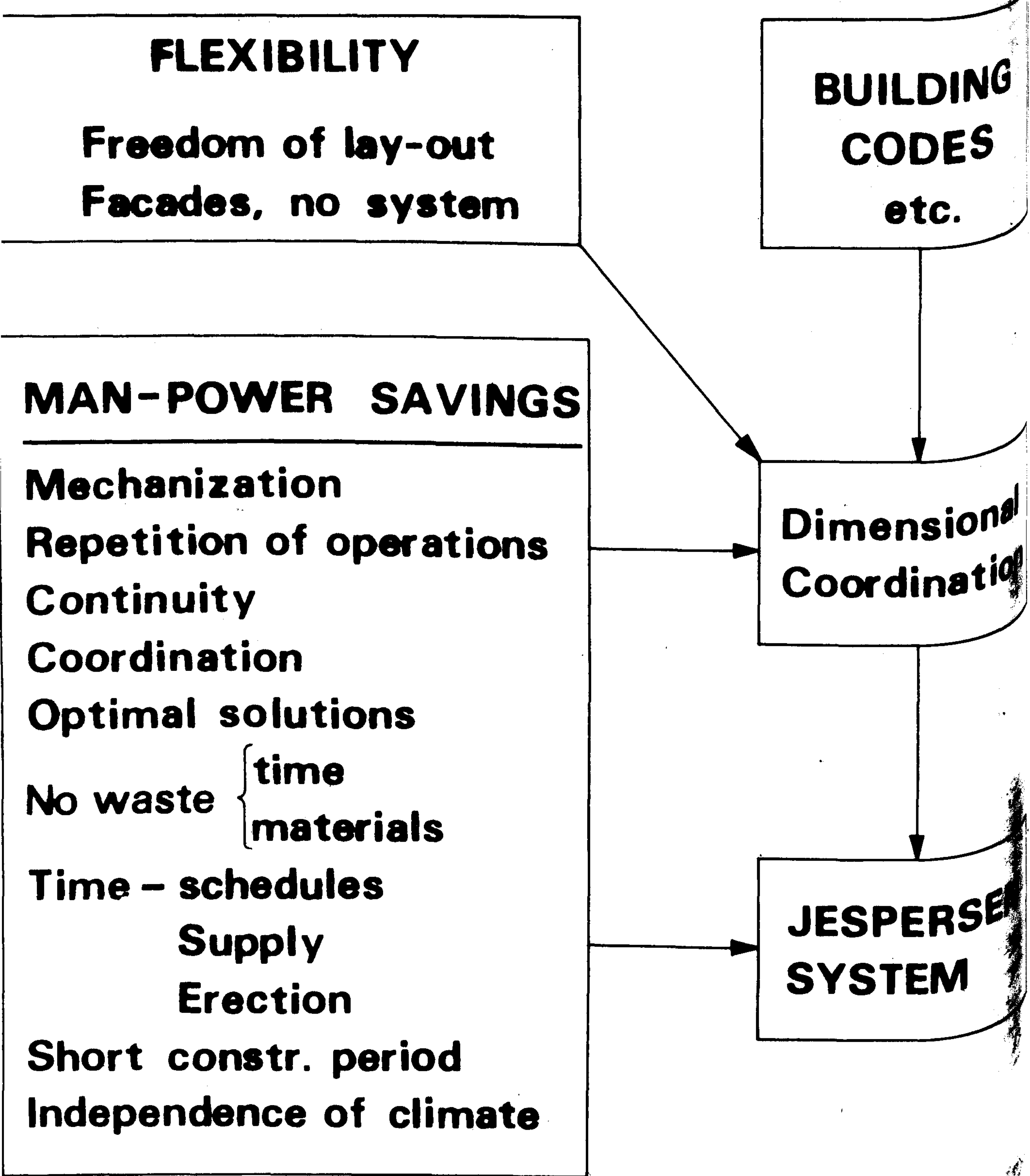

FLEXIBILITY
Freedom of lay-out
Facades, no system
BUILDING CODES etc.
MAN-POWER SAVINGS
Mechanization
Repetition of operations
Continuity
Coordination
Optimal solutions
No waste time
materials
Time - schedules
Supply
Erection
Short constr. period
Independence of climate
Dimensional
Coordinatio
JESPERSE
SYSTEM

Diagram 13

DIMENSIONAL COORDINATION

By legislation (incl. public standards)

Floor – to – floor height — 280 cm

General module — 10 cm
(smaller components, kitchen, cooker, refrigerator)

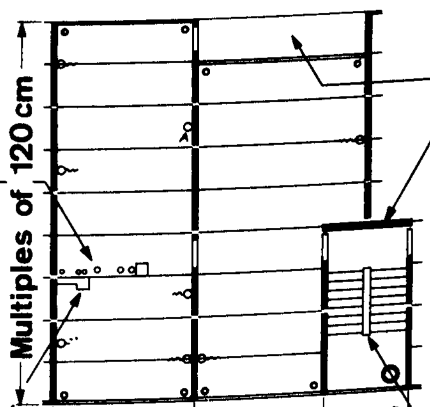
Structural grid — 30 × 30 cm

Recommended standard
Structural grid — 30 × 120 cm
load – bearing crosswalls
facade not loadbearing

JESPERSEN-SYSTEM in Denmark

Diagram 14

MODULAR SYSTEM 30x120 cm.
for 2,5 ton multi-lay-out-system.
Load-bearing crosswalls, facade independent of system
MAXIMUM OF SIMPLE COMPONENTS + STANDARDISED SPECIAL UNITS



Bathroom-standard and Kitchen-standard separated to allow maximum freedom in planning. Might have been combined in this example. If so a third standard would have been created, giving higher overall prices for all lay-outs.

Diagram 15

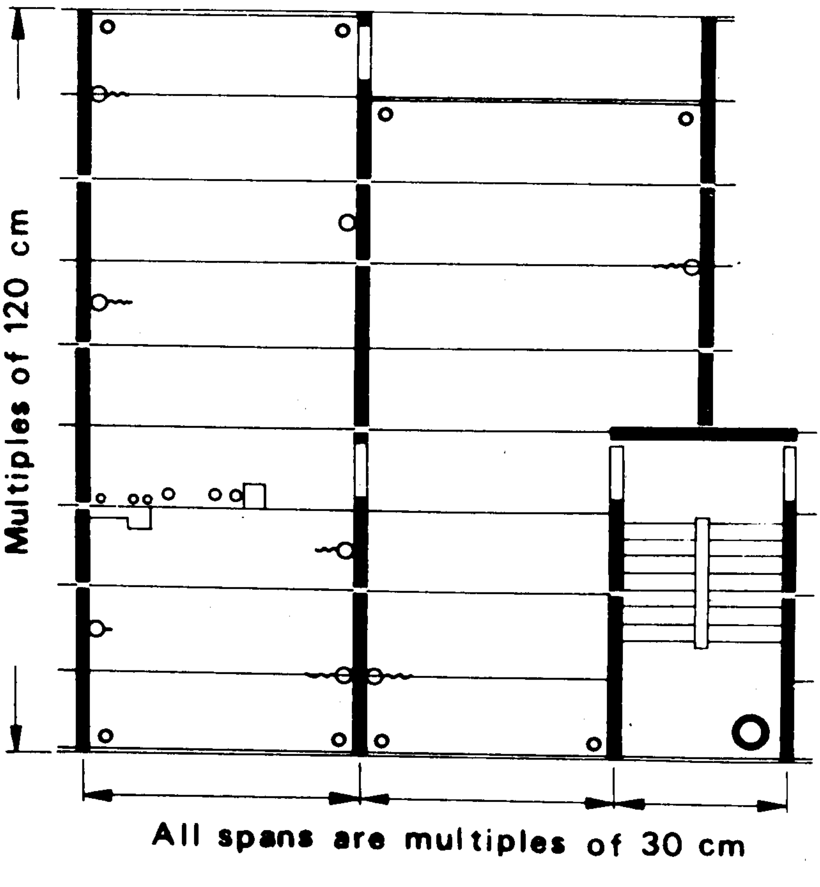
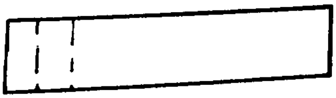


Diagram 16

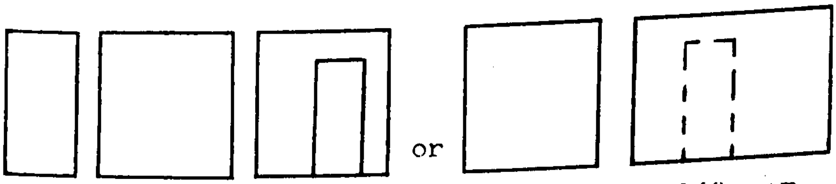
85% <u>Standard floors</u>



15% <u>Special floors</u>

Bath
Stair
Balcony

80% <u>Standard walls</u> (electric conduits)



20% <u>Special walls</u>

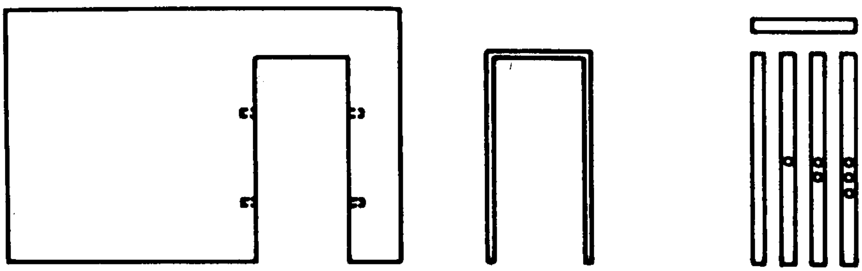
Windbracing walls
Gables etc.

<u>Façades</u> light or sandwich-panels

preferably room-sized so that the structure can be made watertight at once.

DOOR WALL

Diagram 17



Wall-component
1 variant

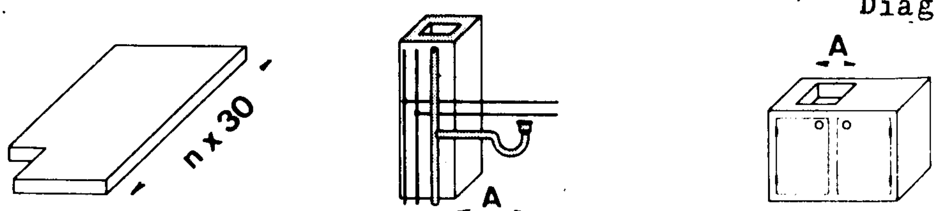
Door-frame
2 variants
(right or left)

Architraves
1 horisontal
4 vertical
(0-3 switches)

Multi-lay-out-system
Separation of supplies
200 possible
combinations

KITCHEN

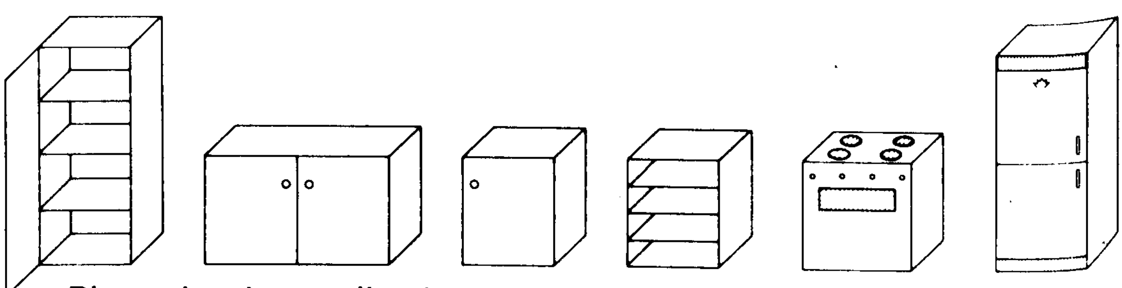
Diagram 18



Floor component
Standard recess,
1 variant (+ handed one)
for each span.

Ventilation-plumbing-unit
1 variant (+ handed one)
gives 4 alternate positions
of sink around each floor joint.

Kitchen-joinery-unit with sink.
1 variant (+ handed one)



Dimensional coordination and separation of supplies allow
unlimited kitchen-lay-outs

Diagram 19

SUPPLIED COMPONENTS

Floors	Walls	Gables
Stairs	Ducts	Facades
Light partitions		Service – units
Wardrobes	Doors	Door – frames
Architraves	Skirtings	Floors
Kitchen – joinery	Cookers	Refrigerators
Railings (Balcony & Stair)		
		etc.

Diagram 20

SEPERATION OF FUNCTIONS

STRUCTURE — Simple standard components

Complex specials, identical for many layouts

SERVICES — Preferably independent of structure (closer tolerances)

Service – units

OTHER COMPONENTS — Coordination
Separation
Pre-finished

MAN-HOURS PER APARTMENT – ON SITE

		Skilled	Specialized	Total
1960	Traditional (bricks, in-situ conrcrete)	1040	410	1450
1963	BALLERUP	262	258	520
1964	GLADSAXE			430
1965	GLADSAXE	188	198	386
1966	HEDEGÅRDEN	170	222	392

including idle time & basement, air-raid-shelter, structure, facade, services, completion, finish

excluding public roads, sewers, landscaping, boiler house, laundries

---

MAN-HOURS PER APARTMENT IN FACTORIES, WORKSHOPS (OFF SITE)

approx. 400 industrialized including precast components (100), service-units, joinery, other components

approx. 300 in case of traditional construction techniques

Diagram

THE PRECAST-CONCRETE PRODUCER

J. C. HOLM

HISTORICAL BACKGROUND

As elaborated by the two previous speakers, our associates P. E. Malmstrom, consulting engineers, in the late fifties had conceived a building system based on the repetitive use of a relatively small number of standard building elements. These were clearly defined by their functional requirements and by the discipline of the system for modular coordination adopted in Denmark.

With this concept of the "open system" fully developed and only requiring a relatively small number of sharply defined standard structural components which, with their variants, are used over and over again in the structure, the application of "mass-production" techniques to the manufacture of large building components was clearly practicable.

The real problem was to find an interested party, willing and able to finance this pioneering factory. It had to be designed from scratch, as no previous experience was available. Furthermore, even before the factory existed on paper, the developer had to quote firm competitive prices on the structural components for the initial 3,500 flats. This was the only economical basis for the investment, apart from the hope that the "open system" would be here to stay and in the future could compete successfully with existing systems.

Mr. Malmstrom found this man in the person of Mr. Paul Kerrn-Jespersen, head of Denmark's leading general contracting firm, which operated a conventional concrete prefabrication plant. Mr. Kerrn-Jespersen accepted the challenge. All sails were set for the design and construction of the factory as there was less than 2 years to have the factory designed, built and broken in for full production.

The first phase of the development work was centered in the laboratory in order to establish the parameters needed for optimizing the manufacturing process. It was found necessary to employ preheating of concrete and heating and steam curing of the components. This basic work was of paramount importance in order to balance the capital investment of the plant against the production cost and the designated strength requirements of the structural components.

With this fundamental data pilot tests followed to produce the design criteria for the fullscale processes and machinery.

The result was a plant consisting of:

Central Mixing Plant
Floor Element Department
Wall Element Department
Storage Yards for the various components
Plant Laboratory

CENTRAL MIXING PLANT

The central mixing plant is equipped with two 1 cu. yd. mixers with the concrete proportioning carried out by one operator. He also supervises the control panel of the fully automated transport system, delivering aggregates, water and cement to the mixers and the concrete to the two production departments. The aggregates are preheated. The water is heated to about 175°F. The resulting concrete is varied in temperature from about 100° to 140°F, depending upon its intended use.

FLOOR ELEMENT DEPARTMENT

The floor elements are cast in horizontal moulds circulating in a closed-loop conveyor system through the various stages of the process:

1. Mould cleaning, closing and oiling.
2. Placing of reinforcing steel, inserts and forms for the provision of openings, chases, etc.
3. Casting station with concrete placing machine, high intensity vibrating station and coretube extractors.
4. Stacking elevator for moulds and cross transfer to steam chamber.
5. Steam chamber with live steam at atmospheric pressure divided in three temperature zones.
6. Elevator for removal and cross transfer of moulds from steam chamber.

7. Removal of moulds and transfer of floor elements to trucks for transport to storage yard.

The entire process is controlled and timed by a transistorized control panel equipped with a memory unit for sequency control and a fault-indicating panel.

The curing time is 3 - 4 hours and every 4 - 5 minutes an element is leaving the casting station. The major part of the time cycle is determined by the length of the high-intensity vibrating cycle, which the operator cannot reduce, as it is exclusively under the control of the laboratory.

The operating crew of this department consists of 7 men per shift.

WALL ELEMENT DEPARTMENT

The wall panels are of mass concrete without reinforcing except for a 1/4" rod welded to the erection bolts and of course for elements with door openings, which are surrounded by reinforcing. The wall elements are cast, stored, transported and erected vertically. All lifting is carried out by the two erection bolts extending from the top edge of the element.

The wall elements are cast in vertical batteries each holding 10 elements per casting. The battery is built on a hollow steel base on which the hollow, removable form partitions are supported. Each side of the battery is formed by a hollow box section. This is moved inwards mechanically to close the ends of the 10 pockets. It carries the moulding strips forming the shear keys and other indentations on the vertical edges of the panels.

During the curing cycle a stream of hot air is passed through the hollow spaces in the battery, heating the concrete through the surrounding steel surfaces. Vibration of the concrete is carried out continuously during pouring by internal vibrators handled by an overhead crane.

In striking the forms, the battery sides are first withdrawn mechanically and thereafter steel partitions and concrete elements are alternately removed by the overhead crane. The partitions are placed in a rack on the floor for cleaning, oiling and refitting with electrical conduit and other inserts. The wall panels are placed on a dolly for transport through the curing tunnel to the yard.

By using warm concrete and heated battery walls the preliminary curing time is 2 - 4 hours depending on strength requirements. The after-curing period in the tunnel is 8 - 10 hours, during part of which the elements are sprayed with a mist of tepid water.

In the Danish factory there are 4 batteries: 1 for 1,200 mm. width (4 ft.), 1 for 1,800 mm. (6 ft.) and 2 for 2,400 mm. (8 ft.). The Swedish factories are equipped with: 1 battery for 8 ft., 1 for 12 ft. and 1 for specials following modular dimensions) for 12 - 13 ft. elements.

The operating crew of the wall department is 5 men per shift.

STORAGE YARD

The yard employs 4 overhead portal cranes each handled by an operator who unloads from the plant cars to storage and from storage onto the delivery trucks.

All cranes are equipped with vacuum lifts of our own design.

PLANT LABORATORY

The plant laboratory is equipped to carry out the daily quality control of incoming raw materials, of the concrete used, and of the precast elements. The laboratory also keeps a running control of temperature, humidity and other factors in the process and on a limited scale carries out research work.

The strength requirement of the concrete used is 3,750 - 4,000 lbs. per sq. in. compressive strength at 28 days, in accordance with standard testing procedures. The actual strengths obtained in the precast elements are 10 - 15% lower, which is the calculated penalty paid in balancing capital investment against production cost and strength requirements.

PLANT CAPACITY

The capacity of the plant has been rated at approximately 2,500 apartments (each of about 1,000 sq. ft.

floor area) per year operating with 2 shifts. This has been found to yield the highest efficiency.

Expressed in more exact quantities the plant can, operating with 2 shifts, produce per year:

Approximately 72,000 elements of average 4.5 m^2 area (49 sq. ft.) or 325,000 m^2 corresponding to 3,500,000 sq. ft.

The operating crew for 2 shifts totals:

60 operators and maintenance men
7 managers and supervisors

The average total use of manpower (including maintenance and supervision) is approximately 0.4 manhour/ m^2 or approximately 0.04 manhour per sq. ft.

TRANSPORTATION DEPARTMENT

In Denmark we have chosen to contract all transport from our factories to one contractor, who furnishes all rolling stock including the specially built rack-trucks (for wall elements). Payment is on firm contracts, on a ton/mileage basis, but rates are checked for each bid to avoid surprises from road detours, etc.

The rolling stock needed to handle the plant's full production within its shipping area (determined by the island's geographical boundries - or 30-40 kms.) (20 to 25 miles) has been

11 Power units
18 Rack-trailers
19 Flat-bed trailers

SPECIAL ELEMENTS

A complete modern prefabricated building requires a number of other concrete components, so-called "specials", such as stairs, garbage chutes, ventilating ducts, balcony and bathroom floors, gable and façade sandwich elements, etc. Our company in Denmark produces these parts in another factory. Many other components for industrial and institutional buildings are also manufactured there.

In Sweden and Israel a third department is added to the standard Jespersen factory for the highly mechanized production of sandwich elements and specials. In England our licensee operates his own separate plants for these items.

In Denmark we have recently, in the mechanized factory, started the production of standard panels for basement walls with double reinforcing and with inserts and holes for bolted connections, including bolted-on light shafts. These basement elements have so far been delivered to two-storey row houses and to single family houses.

They are produced efficiently in the standard wall batteries equipped with special auxiliary arrangements.

TOLERANCES

One of the secrets of successful prefabrication lies in holding the variations of the dimensions of all components within much closer tolerances than has ever been attempted in traditional building.

Due to the lack of official Danish code requirements for tolerances of dimensions of concrete elements, the consulting engineers and producers of concrete elements have imposed upon themselves the following maximum deviations:

Wall elements:	Height	± 2 mm (1/12")
	Width	± 3 mm (1/8")
	Thickness	± 2 mm (1/12")
Floor elements:	Width	± 3 mm (1/8")
	Length	± 5 mm (1/5")
	Thickness	± 2 mm (1/12")

SURFACES

By using the utmost care in the design and fabrication of the forms and machinery, by the application of the correct intensity and type of vibration, by the proper selection and grading of aggregates and concrete mixes, and by the correct formulation of form oil, the ceiling surface of the floor elements is so smooth that generally only one coat of spray paint is needed while wallpaper is applied directly to the concrete surfaces of the wall panels.

When all surfaces are to be painted, a light spackling* is used as on many other materials. In Israel, where all interior walls are painted, a coat of spackle is applied by spraying, after which they are rubbed down with a large rubber scraper, removing the surplus spackle.

In no case is plastering of walls and ceilings required.

STORAGE YARD

As Denmark, like most countries, has not yet adopted building codes specifying the minimum age of elements for delivery to site, a minimum age of fourteen days has been fixed. This was decided in discussion between the consulting engineers and the producers.

From this minimum age combined with our general experience in maintaining an uninterrupted flow of elements to the sites a minimum inventory of elements for about 350 apartments is carried continuously in the yard at full rate of production.

The minimum area required for the storage yard based on these premises is about 9,000 m^2 (100,000 sq. ft.) or about 2 1/4 acres.

The daily loading is controlled by the loading foreman, who is in constant touch with the construction sites and the hauling contractor, who can direct his trucks by radio. But the loading sequence of the elements, which are to be placed each in its correct place on each single truck, is obtained from the "loads-diagram" handed to the crane operator every day by the dispatcher. The preparation of the loads-diagrams is explained later.

* Spackle: A dry powder, which in the form of a paste is used for filling cracks, holes and other surface defects before painting and decorating: a trade name - v.t. -led, -ling. To apply Spackle to (a crack or surface defect).

It should be emphasized that there is no intermediate storage on the building sites as the elements are hoisted directly from the trucks to their place in the building. This makes the yard loading control a most important link in the entire erection operation.

PRODUCTION SCHEDULING

In order to ensure that elements of correct age are in stock when required, the factory activity is planned well ahead of time, Consideration is given to strength requirements, production efficiency (length of series-runs) and margin for variations in construction speed. Against these factors are weighed the desire to keep the stocks as low as possible in order to minimize loss of interest on inventories and to hold down working capital.

The basis for the production schedules is the "Construction Schedules" prepared by the consulting engineers and on which all bids are based. From these schedules and the structural drawings the concrete producer's technical department prepares: a) 'delivery schedules' specifying quantities and time tables (usually by blocks of apartments) and b) 'load diagrams' specifying the types, the numbers and the actual, relative locations of elements on each truck (with total weight), but without timetable. These documents are used by the plant for preparing: c) daily production schedules and d) daily inventory sheets. b) is also used by the yard crane operator for loading each truck and by the hauling contractor for scheduling and directing his rolling stock.

The dispatcher's continuous, daily contact with the erection manager pinpoints the final time schedule for the dispatch of the trucks in step with the erection progress. It also provides the feedback to the production planning office for changes in the production schedules if events on the sites (such as shortage of labour, high winds, high erection speed, etc.) necessitate changes.

CONTINUITY OF OPERATION

The financial success of the concrete component factory, with its relatively heavy investment, depends, to a large measure, on continuity of operation. It is true that the government must provide the economic climate in the country, allowing building activity as a whole to be carried out on a profitable basis. However, it is still the responsibility of management to find ways and means to sell the plant's output.

We are convinced that our "open system", based on the repetitious use of a relatively limited number of standard elements, offers the factory much better possibilities for achieving continuity of operation than the "closed system" with its room-sized elements tailored to a few layouts.

We support this opinion by pointing out the inherent advantages of the "open system":

a) greater flexibility from the architect's point of view.
b) the wide range of applications of the standard elements to many types of structures other than multi-storey dwellings.
c) the economic basis for a highly mechanized production process.

Although the system originally was conceived for the construction of 4 - 6 storey housing, the height was very soon extended to 16 storeys. Heights over 20 storeys are now under consideration. By the same token, the standard elements have been used successfully in a large number of 2 storey one-family row houses, and are presently being considered for a large development of one-storey, one-family homes north of Copenhagen.

The application of our system to low-rise dwellings has been accelerated by the development of the previously mentioned standard, reinforced basement-wall elements manufactured in our highly mechanized factory. The manufacture of these elements allows prices competitive with cast-in situ walls. The erection of the basement walls is, however, much faster, and the basement and first floor of a single family home have been completed in one day on previously prepared footings constructed together with the basement floor-slab.

The standard elements have been used in student housing projects, hotels, motels, hospitals and old people's homes. Preliminary studies have shown that an office building can be constructed at low cost using entirely standard elements.

In Israel, layouts have been prepared for army barracks and refugee camps constructed entirely from standard elements, including standard sandwich elements for façades.

It may be of interest to mention that, during a slack period for the floor department, a large number of heavily reinforced floor elements with larger cut-outs than normally considered feasible were manufactured on the automated production line with excellent results. They were used in a prefabricated factory building for light industry.

In my book, the answer to continuity of operation of the factory, and to its profitability, lies in diversification in the use of standard elements to an evergrowing list of structures, limited only by the ingenuity and imagination of the architect, the engineer and the producers of components.

THE SITE

ERIK ANDERSEN

My colleagues' papers have dealt with the background of industrialized housing in Denmark, with the design philosophy of the Jespersen System, the organization of the design team, and with the manufacture of the structural components.

The results of all these good and sincere efforts end up in the assembly plant, a term rather adequately describing a modern industrialized building site. I want to emphasize that the industrialization applies to all processes and components. The structural elements and the façade panels are of course prefabricated and dimensionally co-ordinated, but the designers have also tried to rationalize and possibly industrialize all other components and operations necessary for the completion of the building. Doors, door frames, architraves, wardrobes, kitchen joinery, stoves, refrigerators, floors and skirtings are also prefinished components. The advantages of this are illustrated below in diagram 3 on manhour consumption.

Many categories of components are delivered to the site, and these components are assembled by a number of different trades. All these supplies and operations must be co-ordinated, and the assembly plant has therefore a site manager. As shown in the "Design and the Building Process" diagram the site manager's function during the contract period is very similar to the design co-ordinator's function during the design period, and they may both be engineers, architects, or of a similar profession.

As shown on the diagram the site manager's job is partly based on the design staff's efforts and partly on the planning schedules for the construction process. (Diagrams 1 & 2)

I must emphasize that the most thorough, simultaneous planning of all phases of the industrialized building process is of paramount importance, from the very beginning of the design.

As an assembly plant the site depends on long-term contracts with a series of factories, and each factory must time its production to assure correct delivery of components of the specified quality at the right time.

The various stages of the work planning are shown in the diagram "Work Planning/Site Management". The basis for the planning process can be divided into three groups:

A. Working Plans
B. Site Arrangements
C. Specifications

The planning has three stages in the time schedules for the design and construction processes:

1.0 Analyses simultaneously with the design
2.0 Tenders and other documents
3.0 Detailing during the building process

The analyses within the three groups are subdivided as follows:

A. 1.1. Quantities, i.e. the number of floors, walls, kitchen units, etc.
A. 1.2. Equipment, i.e. types of cranes, number of cranes, etc.
A. 1.3. Erection method, an example of which is an analysis of the sequence of erection of floors, walls and façades, when to grout joints, etc. (the length of the block is decisive).
A. 1.4. Analysis of the necessary manpower.
A. 1.5. Rate of production, i.e. production per period (maybe 4 hour periods) is calculated from the information from A. 1.1. to A. 1.4.

B. 1.1. Analysis of the townplan for decision of the sequence of the blocks, the rate of production, the position of the cranes, etc.
B. 1.2. Transport analysis.
B. 1.3. Space requirements for top soil deposit, builders' sheds, parking areas, mixing plants, containers, etc.
B. 1.4. Auxiliaries like toilet, water, electricity, telephone, etc.
B. 1.5. Order of work, etc., also where to put garbage, fences, etc.

C. 1.1. Form of tender, main contracts, general contracts, sub-contracts, etc.
C. 1.2. Division of contracts, definition of

boundaries between the different operations.

C. 1.3. Method of specification, main specifications, planning specifications, contract specifications, bills of quantities.

The tender and contract documents can similarly be subdivided for the three groups as follows:

A. 2.1. "The Calendar". Relation between working periods and days, holidays, etc.

A. 2.2. Construction diagram, i.e. the sequence of small scale lay-outs indicating by symbols how the different operations and trades are working in relation to each other and the continuous sequence of operation.

A. 2.3. Working plans for earthwork, services, structures, finishes, etc.

B. 2.1. Drawings of the building site, possibly subdivided into drawings for earthwork, basement, etc.

C. 2.1. General conditions and information.

C. 2.2. The general basis for planning, coding of drawings, price basis, etc.

C. 2.3. Detailed program for each contract (subcontract or trade or operation).

C. 2.4. Site arrangements in general for all contracts.

The site manager's job is based upon the above information, the drawings, specifications, approval documents from the authorities, etc., and his functions are shown on the 2nd diagram.

The site manager co-ordinates all the operations. He is the sole link between the design staff and the design co-ordinator on one hand and the site on the other hand. The supervising architect and engineer collaborate with the site manager, and their jobs are co-ordinated with the contractor's work by the site manager on behalf of the client. The functions of the supervising architect and engineer are indicated on the diagram, and so are the functions of the site manager which are as follows:

The site manager decides on the routine of the site office and is responsible for his office staff.

The site manager is responsible for the contract registration, filing and keeping up to date of documents, drawings and specifications. All drawings are distributed through the site manager's office without a direct contact between the designers and the contractors. The site manager also co-ordinates all necessary alterations and is responsible for the cooperation of all parties involved.

The site manager usually has a weekly meeting with the supervising architect and engineer and the contractors. The purpose is to record deviations from the time schedules, prepare coming activities, but not to do any design. Such meetings are usually held separately for the different parts of the project, i.e. apartment blocks, boiler house, shopping centre, social buildings, etc. The site manager presides at these meetings and writes the minutes.

The site manager as well as the supervisors keep diaries of all incidents, observations and agreements of importance to the contract.

The site manager also keeps a diary of the weather, temperature, wind, etc. that may influence the time schedules.

It is the responsibility of the site manager that the progress of construction follows the prepared time schedules.

It is important that the site manager inform the contractor well in advance of forthcoming work so that the contractor is able to plan the operations (manufacture of components, materials, organization of labor, site arrangements, etc.) before the work is scheduled to start. This also includes the examination of any necessary special equipment for the entire process. If unforseen difficulties threaten to disrupt the time schedules the site manager shall take all necessary steps to ensure that the work is done in time.

The Jespersen System is a "12 months a year" System with the same rate of production summer and winter. Therefore cold weather arrangements are required, and the site manager is responsible for these necessary arrangements. Examples are light, heat, and frost precautions.

Possible additional work requested by the architect or consulting engineer must be approved by the site manager. He is responsible to the client for the cost and the time schedules of the project."

The site manager will make a progress report once a month to the client and work out moving-in schedules.

Finally, but very important indeed (and unfortunately quite often forgotten), the site manager is responsible for the feed-back to the design co-ordinator, to the architect, to the consulting engineer and to the planning staffs on all experience gained on the projects in connection with technical matters, labor problems, work studies, etc.

Most Jespersen System sites are managed in accordance with the organization pattern just described.

Having outlined the organization I would like to add some comments on the construction and the completion process you saw on the film.

The structural system of the apartment block is usually composed of load-bearing cross walls, some longitudinal wind bracing walls and simply-supported floor units.

The façades have no bearing function, they are for protection against the weather only.

Cross walls are 15 or 18 cm. thick for low-rise and high-rise respectively. Munch-Petersen gave you the standard height and the standard widths.

The edges of the wall panels have shear keys, so that the joints between elements can sustain shear loads after pouring.

The longitudinal walls are usually made from special components, reinforced or plain concrete depending on the number of storeys and the geometry of the lay-out.

The floor components are simply-supported on the load-bearing cross walls and are 18 cm. thick (max. span 480 cm.) or up to 22 cm. (spans up to 6 m.). The thickness is of course the same for all the floor elements of a single project, but may vary in accordance with local conditions (span, codes, aggregates, etc.).

Apart from the specials the floor elements are hollow core slabs with length and width as illustrated in Munch-Petersen's paper.

The longitudinal joints between floor elements are reinforced and have shear keys. The floor elements are supported on the cross walls by cams. These cams also act as shear keys of a sort.

The support using cams is designed for the purpose of minimizing the loss of active cross section area in the wall/floor joint. Thereby the reduction in load-bearing capacity of the wall at the joint is kept at a minimum.

The floor/wall joint is also reinforced in its entire length. This reinforcement may be post-tensioned in high rise buildings. The reinforcement in the longitudinal joints and the floor/wall joints ties the structure together so that the floors as well as the walls can act as diaphragms.

The façade has been designed in many different ways, utilizing different materials. Examples are light timber framed façades, concrete sandwich panels as well as combinations of steel and timber. As they are not a part of the load-bearing structure, the architect has a relatively free hand, but of course with the requirement that the façade elements come from the factory prefinished and glazed so that the handling of these units on the site is limited to erection, jointing and possibly window cleaning.

As soon as the structure proper has been completed, i.e. walls, floors and façades erected and the joints grouted, the completion and finishing begin with the installation of:

Light partitions
Central heating
Water supply

In the 4 storey blocks these installations are made as the building progresses. This means that when the roof is placed the services are ready for operation and the heating system may be connected to the mains.

In high-rise blocks temporary central heating connections are used, so that the subsequent work can begin simultaneously with the erection of the structure at the floors above.

When the block is heated the finishing follows.

Beech is the usual flooring material in Denmark. It comes in prefinished boards, which are nailed to joists, to form a floating, sound-insulating floor. Many other flooring systems have been used, especially by our licensees.

Next follow the installation of the prefinished joinery units, wallpapering and the installation of miscellaneous components like electric switches, water-faucets, stoves refrigerators, etc.

After a normal cleaning process the apartment is ready for occupancy.

The entire process from erection of the first wall components until the tenant moves in takes approximately 3 months for low-rise buildings and approximately 4 months for high-rise structures.

In order to ensure a smooth flow of components, erected by many different crews, we have found it necessary to plan not only where but also how the components are to be erected.

Therefore, in conjunction with the design process we have designed special tools for the erection work. Examples are two types of lifting equipment for floor units, for wall units and for special components; props for the walls to be used during the erection until the joints have been grouted.

The following diagram illustrates the results of co-ordinating among the three groups, design staff, suppliers and site contractors.

Ballerupplanen has 644 apartments erected in 1963 to 1964 at a rate of 3 apartments per day.

Hedegarden with 1752 apartments was erected 1965-1966 at a rate of 4 apartments per day.

The government's demand for fast erection was met by the Jespersen System.

Equally important to the country was the ensuing reduction in manpower. The rate can be seen from the Diagram 21 attached. The manpower on site was reduced to 30% of the manpower on traditionally-built apartment blocks. The skilled labor force was reduced to less than 20%.

The manpower has not just been moved from the site to the factory, as the factories supplying industrialized sites have a much higher productivity than the workshops furnishing semi-finished products to traditional building. The manpower used at the factories and workshops for the production of all the prefabricated components, elements and sub-assemblies is almost equal for both the traditional and the industrialized construction methods, namely 400-500 manhours per apartment.

Diagram 3 also illustrates the fact that approximately 50% of the manpower used on the industrialized site is consumed by the processes following the erection of the structure, i.e. for completion and finishing operations like plumbing, electrical connections, joinery, etc.

It is obvious that further attempts at reduction of manpower on site must be directed just as much to the completion and finishing operations as to the further developments of the erection of the structure.

PANEL DISCUSSION, Monday, April 29, p.m.

Question: ARE THE INTERIOR JOINTS IN THE WALLS BETWEEN ELEMENTS GOOD ENOUGH FOR DIRECT PAINT APPLICATION?

Mr. E. Andersen

The joints need to be made ready for painting because they are visible. There is a zone about one foot in width which has to be filled and trowelled flat. The normal Danish way of treating the wall afterwards is to apply wallpaper. The wallpaper completely and effectively conceals the joints.

On certain projects such as the Gladsaxe project, which you have seen illustrated, there is one wall in each of the kitchens which is painted, only to my knowledge, no joints remain visible in these walls and no cracks have appeared. In such buildings as the 16 storey apartments we post-tensioned the walls at the joints. This was illustrated in the film.

The question of cracks at joints depends upon stable foundation to a great extent. I do not think it is so much a question of creep and shrinkage in the concrete.

Question: HOW MUCH WAS THE COST OR FEE TO PREPARE THIS PROJECT (GLADSAXE) AND TO ORGANIZE IT FROM THE DESIGN POINT OF VIEW COMPARED WITH THE TOTAL COST?

Mr. J. Munch-Petersen

I have only a slight idea of how much it cost because we try not to think of it in that way. However, the fee in Denmark in relation to the cost of a scheme or project like Gladsaxe is the usual or normal fee. On the first scheme, we received a higher than usual fee to cover development costs. On later schemes, the design costs became less than for traditional blocks of apartments. This is because design man hours are saved as well. When our firm acts as site managers, then we receive an extra fee, but not for the planning-design side of it, that is within usual fee limits normally in effect at the time.

Mr. E. Andersen

On the Gladsaxe scheme, from a site management point of view, fees were based upon actual hours involved, not upon the normal fee structure. The total fee was only 75% of what we would have received had we used the normal rules.

Question: WE HAVE HEARD OF THE QUALITY OF INTERIOR JOINTS. COULD THE PANEL NOW COMMENT UPON THE DESIGN OF EXTERIOR JOINTS.

Mr. J. Munch-Petersen

Horizontal joints are of open over-lapping design so that they are automatically watertight. This open over-lapping design provides for ventilation of the insulation. The vertical façade joints are of the ventilated type. As you know, the NRC (DBR) of Canada, has made extensive laboratory tests on this type of joint, as well as the Norwegian building research station. We have used this kind of open ventilated joint for vertical façade joints in Denmark for 15 years, and I can absolutely recommend it. The principle is that, seen from the outside towards the inside, there is first a baffle which fits loosely into the grooves and will stop most of the water from entering the façade construction. The tendency of water to be driven through the joint is minimized because wind pressure is equalized across the joint. What little may seep through will drain out because of a set of grooves toward the inside of the joint. Wind proofing is on the inside. So we think of it as a two-stage weather tightness. If the joint is sealed on the outside, using any kind of mastic, or even the best artificial rubber, the full wind pressure differential will drive water through any small aperture left inadvertently by the labourer. For this reason, sealants are never used in façade joints of our design except perhaps at a special corner application.

Question: PLEASE OUTLINE FOR US THE BASIC DECISIONS MADE IN SELECTING THE SMALLER ELEMENT TYPE OF CONSTRUCTION RATHER THAN THE LARGER ELEMENT TYPE.

Mr. J. Munch-Petersen

The maximum width of elements is restriced to 8' because of transport regulations on public roads in Denmark. The decision then revolves around having 4' or 8' wide floor elements as the maximum width. If 8' wide floor elements are chosen, they usually will have to be combined with other widths of elements because an 8' module across the building has been created. Such a large module may inhibit flexibility of design in the system. If the system is based upon standard layouts, the layouts can be based upon the maximum transportable widths. Our decision was to create a very flexible system and not wishing to have a mixture of 4' and 8' elements we decided to make tham all 4'.

The use of 4' wide elements only compared with a mix of 4' and 8' wide units does not double the amount of hoisting but results in about 60% more lifts. Moreover, the lighter elements go up somewhat faster because they rotate less during lifting and are handled faster. I believe we achieved quite a high productivity by taking this decision. Of course, something may be saved by having larger floor elements but I am sure that trade-offs in flexibility would overcome the saving.

Question: WHAT MECHANICAL SERVICES ARE INSTALLED IN DANISH HOUSING AND WHAT ARRANGEMENTS ARE PROVIDED IN THE STRUCTURE FOR THEIR INSTALLATION?

Mr. J. Munch-Petersen

Danish low cost housing is not air-conditioned. Air-conditioning systems are not common in any type of housing in Denmark. We do require central heating in apartments and this is usually by hot water radiators placed below the window for proper circulation of air. The mechanical system includes hot and cold water supply piping and waste piping. The only ventilation systems included are for exhausting air and fumes from kitchens and bathrooms.

The elements forming the kitchens and bathrooms include service ducting for the exhausted air and also for vertical piping. Standard layouts facilitate such an arrangement and one such service duct can function for both the kitchen and the bathroom. In a highly flexible system, it may be advantageous to standardize the bathroom and the kitchen service units separately even if they sometimes are placed side by side.

Question: CAN YOU PLEASE DESCRIBE THE ROLE OF THE DANISH MINISTRY OF HOUSING IN THE OVERALL FIELD OF INDUSTRIALIZED APARTMENT CONSTRUCTION?

Mr. Kjeldsen

The Ministry of Housing offers the same conditions for industrialization of building as for conventional buildings. The only difference is that in industrialized apartment construction, the projects are built in accordance with a long-term plan. The long-term plan originally included about 2,000 dwellings annually for 4-year periods. Presently long-term programs now comprise 9,000 dwellings annually over 5-year periods. This provides the essential guarantee of markets.

Mr. Holm

Originally, the Jespersen company was guaranteed orders for 3,500 apartments from the Ministry of Housing to be delivered over 2 to 3 years at prices quoted before the first factory was built. There was no other subsidy or assistance of any kind.

Question: ARE SUCH CONTRACTS GIVEN AS A RESULT OF COMPETITIVE BIDDING, NEGOTIATED CONTRACT OR PRE-SELECTION?

Mr. Holm

You may refer to the method as pre-selection because the Jespersen company was the only firm willing to build a factory at that time and under the prevailing conditions.

Question: SCHEDULING OF THE ELEMENTS TO THE SITE APPEARS TO BE VERY IMPORTANT. IF A WALL UNIT DOES NOT ARRIVE ON TIME WILL THE ERECTION PROCESS BREAK DOWN?

Mr. Andersen

The process will not break down because there are always possibilities of doing other work, erecting other elements etc. Very few of the total number are key elements. It is, of course, better to deliver the elements to the site so that they can be erected directly from the trucks or the trailer; but if they do not arrive on time, erection of the other units will continue.

The film showed four trailers standing on the site and none of them were empty. All trucks are provided with radio. If something should happen to one accidentally it is possible to radio the factory for a replacement and to advise the site accordingly.

Mr. Holm

It is usual that when elements are delivered, the trailer is left at the site and the tractor takes an empty trailer back so there is always one or more trailers on the site. This means that a small stockpile of elements is there, ready to be hoisted. The system includes more trailer units than tractors.

Mr. Auerbach (Panel Moderator)

On that point, I think that good planning in this case leading to elimination of double handling is part of the savings that may accrue in the system. It is not very different from delivering steel on high-rise building contracts where the steel is so scheduled that as it arrives on the truck it is immediately placed in the structure, thus eliminating the more costly double handling.

Question: CAN YOU PLEASE COMMENT SPECIFICALLY ON ALLOWABLE TOLERANCES OF ELEMENTS?

Mr. Munch-Petersen

The overall dimensions of the components as they come from the factory will be within tolerance limits of plus or minus 1/8" (3 mm). This means that joints between two floors or two walls, should be designed as if they were 1/8" or 3 mm apart. The actual joint could then be between 0 and 6 mm wide. In inches this means between 0 and 1/4". Such narrow openings can be filled without the use of form work. The joint widths between elements always relate to the tolerances because the elements are placed by means of templates.

The next requirement is to erect the wall elements so they are plumb. This poses no problem because of the adjustable props, illustrated in the film. A problem of distance between two walls can arise. If it is necessary to have close tolerances, then usually, we work to plus or minus 1/2" between two walls. Two templates across the span are used to bring the spacing under dimensional control. Deviations tend to neutralize each other as the erection work progresses.

Question: CAN YOU PLEASE COMMENT UPON THE CEILING AND WALL SURFACES? ARE THESE SURFACES ACCEPTABLE FOR DECORATING?

Mr. Munch-Petersen

Ceilings will usually be sprayed directly with one coat. In some countries a ceiling spray resulting in a textured finish is used. In this case there are definitely no problems with pre-cast floors made in good moulds.

If the ceiling surfaces are required to be smooth enough for direct painting, problems may arise due to small bubble holes in the surface. These are usually covered by two spray coats of paint. In some cases some filling and trowelling may have to be done. With respect to walls, there are really no problems but as you know there must be some filling across the joint between two wall elements.

The tolerance on wall thickness is plus or minus 2 mm, so the walls cannot always be flush on both sides. Hence, there must be some filling and trowelling within a joint zone.

Walls are usually covered by wallpaper which means that bubble holes up to about 1/2" diameter are satisfactorily covered. If the walls have to be painted, more care during air vibration of the wet concrete is necessary. Even then, a wall will usually have to have a fair amount of filling before painting. To overcome this difficulty, a cheap wallpaper is sometimes applied before painting. This is probably the most economical way out of such difficulties.

Mr. Holm

May I elaborate a little on the question of tolerances between walls. In addition to the results of the measurements which I showed, the typical distribution curves or tolerances from Swedish Jespersen relating to measurement of wall-to-wall dimensions of buildings made from the same elements graphically indicate that, considering a large number of overall dimensions, 87% are within plus or minus 1/4" in the actual building.

Mr. Munch-Petersen

When I say tolerances, I mean tolerances, I do not refer to deviations. When I state the tolerances to be so and so it means that usually the deviation is 1/3 of that. Tolerance is a strict definition. If we consider a wall having a tolerance of plus or minus 2 mm this refers to absolutely straight walls. Any kind of twist, warp or other dimensional deformity is included. Thus, when I say that tolerances are plus or minus 2 mm on the wall thickness, I do not refer simply to measurements of different parts of the wall, I refer to a geometrically correct plan. That is how I arrive at deviation measurements.

Question: DO YOU UTILIZE CRITICAL PATH METHODS IN YOUR PROJECTS? PLEASE COMMENT ON THIS.

Mr. Munch-Petersen

Critical path analysis of a time schedule is extremely helpful for construction of large power plants, EXPO '67 or like projects. Projects involving repetitive operations of 2,000 more or less identical apartments, however, give in fact, more or less 2,000 identical sets of critical paths. Such operations with all their variables with reference to different trades, different layouts and relationships, lend themselves to C.P.M. but usually graphical methods are faster and more efficient to use.

If all layouts are identical or blocks are identical then we may efficiently use C.P.M., electronic data processing, etc. Usually, however, blocks are different in length, different in height, have different layouts in the different blocks and within the same block. Again, the structure is erected according to crane capacity, namely the 120 loads per crane per day. This means that sometimes six apartments, sometimes four apartments, are erected per day. Now, each apartment has a kitchen and the kitchens are almost identical. If six apartments are erected per day then the same number of kitchens have to be constructed per day. Sometimes a crane is held up for the placing of roof trusses before moving to the next block or project. This may result in a discontinuity in erection of the structure whereas painters, carpenters, plumbers and other trades are more or less working continuously.

The basic thing is, that there should not be any single critical path, or shall we put it another way, all paths should be equally critical because all labour must be continuously occupied on the site. There should be no excess waiting time for that means loss of money and the loss might be multiplied because of the repetitive nature of the apartments.

Question: I HAVE SEEN PROJECTS WHERE PEOPLE WERE LIVING ON THE LOWER FLOORS WHILE CONSTRUCTION WAS GOING ON. HOW DO YOU MANAGE TO AVOID ACCIDENTS? WHAT PRECAUTIONS ARE TAKEN TO PERMIT THIS KIND OF CONSTRUCTION?

Mr. Andersen

Jespersen's have never built blocks of apartments where the tenants had moved into the lower storeys while the top floors were still being finished. That situation would not be permitted.

It is true that, in the 16 storey high-rise blocks, we have all the following trades like painters, carpenters, joiners, electricians working in the lower storeys while erection of the upper floors is progressing. In such a situation water proofing of the floors above the workmen is required. It is necessary to ensure that the floor above the finishing crews is watertight. In this connection we have found that water does not penetrate through more than one floor. This comment is somewhat away from the point of your question, but the safety of workers occupying the lower floors is also involved.

Question: DO THE APARTMENTS ALL HAVE CROSS VENTILATION?

Mr. Munch-Petersen

In small or bachelor apartments there is no cross ventilating, but the family apartment is cross ventilated which, in the absence of air-conditioning, is a necessity. Generally living rooms face south and west; this it is felt is a necessity also. This arrangement does not cost appreciably more. On low-rise blocks, some savings can be made by locating more flats around the stairwell but this does not seem to be significant and ventilation would be impaired as a result.

Question: PLEASE DESCRIBE THE POST-TENSIONING METHODS USED IN THE JESPERSEN SYSTEM.

Mr. Andersen

The post-tensioning is done according to the PSC method which you probably know. In the horizontal joints, 4 cables are located and each cable is stretched with a 4 1/2 ton load; that is, 18 tons at each cross joint between wall and floor slabs is introduced. There are two active anchors in each end and two passive anchors so that stretching takes place from both ends, two cables from one end and two cables from the other end. The stressing forces should not only remain in the joint, but be transferred throughout the walls. Heavy stirrups from the wall units below the anchors ensure that the forces are distributed down through the walls.

Question: CAN YOU PLEASE COMMENT UPON THE STRUCTURE AND APPLICATION OF EXTERIOR FACADE ELEMENTS?

Mr. Munch-Petersen

In the light façade element (the timber framed type) there is no problem of continuity of the joint since these are separated. The component consists of, on the inside, painted gypsum board with aluminum foil to provide a vapour barrier at that stage and, four inches of rock wool insulation sheathed by a layer of asbestos fibre paper that will not support combustion, but that will hold the insulation in place. Between the asbestos paper and the exterior façade of asbestos cement sheet, plastic, wood, steel, etc. is a ventilated air space.

The concrete sandwich panels consist of two layers of concrete with insulation between them. The insulation is exposed at the edges so that care must be taken to produce a windproof joint at the exterior part of the sandwich. The cavities are ventilated from the outside in accordance with the rain screen principle so that there are no problems involving moisture penetration or condensation.

Question: WHAT IS A BUILDING SYSTEM?

Mr. Kjeldsen

A building system is not only a factory for concrete elements for floors, for walls, outer wall elements of asbestos cement, concrete, wood or something masonry. A system may consist of structural steel, wood, plastic, in fact any material; but the material does not make a system in itself. A building system is an industrialized continuous production of different components generally suited to one another and in modular dimensions so that they can be utilized for different layouts of dwellings and for other types of buildings.

But what about the architects? What are they asking for? They want a building system which permits them full freedom of expression in their design of layout and treatment of façades. But a successful result of using a "system" depends more on the ability of the architects than on the choice of materials, module and production forms. You have seen evidence of their design excellence in the slides of buildings constructed in Denmark. These buildings are all based upon industrialized building systems and all built using the same production principles.

I wish to underline the word principles, and at the same time underline the importance of the four main principles of the building process -- planning, programming, projecting and production -- with the emphasis on planning through all phases of the building process.

First and last, industrialization is not concrete, not steel, not wood, plastic or any material. Industrialization is planning, planning, planning from the very beginning of the whole building process until the last tenants have moved in. Industrialization is close team work between public authorities, building owners, contractors, architects, engineers and manufacturers. Industrialization is a new way of thinking for all parties concerned.

DINNER ADDRESS, Monday, April 29, 1968

WILLIAM M. ARMSTRONG

My field of technical interest is in the area of materials, plastics and ceramics. I am really the odd-ball of my family which has been in various aspects of the small construction business for about 100 years. Perhaps the reason I am not in construction is that my father believed that I should learn the business from the ground up, or actually down, using a hand shovel or an air-driven concrete breaker. I have also operated my own consulting firm engaged in the design of many types of industrial processes with their accompanying buildings.

When I first became involved in the construction industry, mechanical equipment was used for digging, earth moving, hoisting - but to a limited degree only and the frequency of mechanical breakdown was high. Most concrete was mixed on the job, usually by me, and plywood was not widely used in form work. The range of construction materials was limited and construction activity was much more seasonal than it is at present.

The changes in the degree of mechanization and the tremendous improvement in the mechanical equipment are obvious although the hand shovel is still the same. Some degree of prefabrication is now carried out but primarily on a job-to-job basis with little standardization of components - even the use of ready-mix concrete is a form of prefabrication and standardization.

It is important that we do not confuse technological advances with an improvement in the type of "systems" thinking that underlies the decision-making process that is inherent in all design and construction activities. The rate of change in technological advance is increasing almost exponentially and we believe that we are still near the bottom of the normal growth curve (or logistics curve) of technological knowledge. Unfortunately, our understanding of decision-making methods has not kept pace with technological advance. Over the years the methods used to reach design decisions have remained essentially unchanged while the decision problems have continually grown in size; the number of usable materials, the availability of alternative production processes, the requirements for variety in size, color, surface finish, the number of different user requirements - all of these have increased to the point where the number of strategic alternatives with which we have to cope is on the verge of expanding beyond the limits of the normal intuitive methods of making decisions.

Many of the concepts of "modular coordination" and "component standardization" are merely attempts to reduce the number of variants without interfering with the intuitive and inventive aspects of the design process. The decision-making process is difficult enough without adding the complications of the many and strange sizes of bricks and blocks and an incredible system of weights and measures based on such standards as the span of a hand and the length of a king's arm. Even the proposed 4" module causes me some alarm - about the time we adopt it widely we will change to the metric system and, although 4 inches is close to 10 cm. it is not quite close enough - 10.16 cm. to be exact. However, when the change comes we can take a lesson from the auto industry, where standardized structural components are approximations at best, and use lots of soft rubber moldings.

I think that by now there is general agreement that we want to develop standardized components for buildings rather than standardized buildings although the model approach is still feasible in the field of housing.

As pointed out by Mr. Walters this morning, it will still be possible to have a complete spectrum of buildings ranging from one with completely original design of all components to a range of standardized buildings made by assembling pre-designed components in different ways. Although this may appear to be a threat to the role of the architect as a designer of buildings, in many ways it will remove much of the drudgery of detailing from his work. After all, technology is a means to an end - certainly the purpose of the building is to keep people warm and dry but that alone is not enough. The main task of the architect is to create the desired environment both inside and outside the buildings and I believe that he can still fulfil this objective with standardized components. Of course I am an engineer and architects may not agree.

I believe that there are unquestionable economic advantages to both client and contractor in the use of component construction; shorter construction periods, lower overhead costs and increased productivity from available skilled construction tradesmen. Even if the total fee of architects and engineers from a given building is lower based on a percentage of total cost, the actual earnings may be greater due to a saving in detailed costs.

We have certainly not reached the stage of component building in Canada - in fact, we are still in a fairly early stage of "component development." Component building cannot be achieved until conventions regarding dimensions, joints, and tolerances are accepted by designers, manufacturers and contractors.

As you heard earlier, the specification of dimensions has progressed to the point of published recommendations in the U.K. and, in addition, the construction industry has taken the lead in planning for conversion to the metric system. Since the construction industry here still operates on an ad hoc basis - changing from one job to another - bidding competitively on the basis of architect's or engineer's designs and in general does not have a planned, continuous market - it is unlikely that the present system of operations will lead to an early introduction of component building.

Individual construction companies, even the large ones, are unlikely to experiment with off-site prefabrication of components if the next job is totally different and Canada doesn't have many large construction industries or many large industries of <u>any</u> kind. In fact, in the construction field we have about 55,000 different companies.

To demonstrate the feasibility of the component system of construction it is obvious that it must be applied in a field where buildings for similar end uses will continue to be erected for a long period of time - obviously schools, despite recent pharmaceutical developments which may eventually reduce the production of the raw material for the educational system. School buildings are ideal because they permit the use of the purchasing power of public funds and the application of component standardization in government specifications.

This method has been used in California in the Schools Construction System Development Project (SCSD) which will be discussed tomorrow morning, and pilot projects are under way in Ontario. The important aspect of SCSD is that 13 school districts were able to take part in the project and, since manufacturers were advised that standardized components were to be used in $25 million worth of school construction, they were prepared to bid competitively to supply and install their products and even to guarantee performance.

At the same time, the individual school districts employed their own architects for the design of their schools. However, the architects used the new SCSD components which accounted for about half of the cost of these schools. Local general contractors bid on each school and the component manufacturers became their subcontractors.

The schools, as constructed, vary widely in appearance although they were built with identical systems of steel structural components, ceiling and lighting components, cabinets, lockers, air-conditioning units, interior partitions and so on. Exterior walls were not part of the system and materials for them were selected at the discretion of the individual architects. The cost per square foot of these schools ranged from $15.50 to $21.50 for fully air-conditioned schools based on a state formula for area calculation.

Although some architects probably felt restricted by this system, in actual fact, they are subject to many restrictions in school construction anyway and in this case the cost of some components such as demountable partitions was brought within the cost limitations imposed by the California school system. However, the real proof of the effectiveness of this experiment will lie in the degree to which these ideas have been applied in subsequent projects.

It is worth noting, also, that Canada has some unique problems in design and construction. We now have about 200 single enterprise communities in fairly remote areas and we may expect many more as we continue to develop mineral resources in the North. These pose special problems in design, and prefabrication but, again, we must consider the complete system - the location, type of population, age range, recreational interest, communication, T.V. and radio capability, sources of energy and water, waste disposal and so on. A group at the University of Manitoba is currently studying the variables affecting the development of such communities but there is little doubt that they should be a ready market for industrialized building systems.

Although I appreciate the desire to build monuments to the originality of architects on every university campus in Canada, I believe that the paying public has just about reached the limit of what it will pay for higher education and that attempts must be made to erect university buildings for less than the $35 - $45 per gross square foot that is common at present. At these prices, the buildings requested by Canadian Universities over the next 5 years would cost about 2 billion dollars. Certainly university residences are a good starting point for a more sensible approach and in Ontario, some progress is being made by the Ontario Student Housing Commission. Universities are looking more closely at turn-key projects and negotiated contracts - terms which if used before this dinner would have upset the digestion of many of the architects present. However, I believe that these avenues would be less interesting if university planners, architects, and engineers and manufacturers were cooperating on a system of component construction.

As Past President of the Canadian Council of Professional Engineers, I hesitate to apply the word "irresponsible" to my fellow professionals but when I examine the buildings constructed recently on the campus of Canadian universities including my own, I must say that many of the architects and their engineering consultants are showing a serious lack of concern for the real needs of their clients. I am told, of course, that they are only following the requests of the users but the average academic user is only too happy to approve the installation of gold plated taps and wall-to-wall carpets in his laboratories if he is encouraged to do so.

This brings me to the subject of universities through the back door route of building construction and perhaps it is time to look at what we are doing in these buildings which might assist the construction industry. I suspect that we are doing so little that we probably deserve all the high costs and bad designs we get. However, I have said a little about the applications of systems in your business, now what about mine? I should say at this point, that the universities should be included in the national information system. When I asked two of my staff members about the BEAM program, they thought I was referring to computer programs for the design of beams.

Many of the developments which are needed in the construction industry will require a re-thinking of the present methods of operation in terms of what is often called "systems engineering." First, I should say that there is no universally accepted definition of "systems engineering." The term is used to refer to various aspects of the definition, the design, development, installation and management of complex man-made systems. In addition to traditional engineering and mathematical skills, it demands a knowledge of economics, operations research and behavioural sciences. It might be called, more simply, an all-at-once solution of a complicated problem.

Many people ask why the adoption of systems methods by the construction industry seems so slow in Canada. Certainly one answer is fairly obvious - the ideal systems engineer is not available today from our engineering schools and mixed teams of specialists and generalists are often used to replace him. The common approach at the present time is the use of a temporary mixed team composed of people from many different disciplines. Unfortunately, the limitation of this approach is simply that temporary teams are not able to build up the background of knowledge in the systems field. We might say that the ideal systems engineer is not concerned primarily with the devices that make up a system but with the concept of a system as a whole, its internal relations and its behaviour in a given environment. He must have a vigorous imagination because synthesis and creativity are vital parts of any systems engineering process. It is not generally considered that every systems engineer should have graduate degrees with a Ph.D. level, but it is generally agreed that formal training should extend beyond the Bachelor's degree. He needs to know, of course, the fundamental engineering disciplines, have a knowledge of probability and statistics, design experiments, traffic theory, decision theory and mathematical logic and the philosophy of science is valuable. Certainly, a knowledge of the mathematics of finance and market research, engineering economics is desirable and more recently, it has become important to be reasonably expert in simulation, gain theory, linear programming and dynamic programming.

However, it is interesting to note at this point that, in the course of recent visits to the United Kingdom on "Operation Retrieval" - the retrieval of graduates of Canadian Universities now studying in the U.K. - I find that the students who seem to have the greatest difficulty in finding jobs in Canadian industry are those who specialize in operations research and systems analysis - their names and addresses are available from the A.U.C.C. office here in Ottawa.

But to be more specific, I should say that, with a few exceptions, there is little research on construction methods or the application of systems approach to construction in Canadian schools of architecture or engineering. There has been virtually no research done by the construction industry and they do not support such activities in the Universities. Since the industry has a national organization they might follow the lead of the Pulp and Paper Industry and establish a Construction Industry Research Institute which might operate its own laboratories or contract out research to universities and provincial research establishments.

Until recently there was little support from the National Research Council for this type of research in Canadian Universities but, on the other hand, I am not sure that much was requested and, after all, NRC does have its own excellent facility for building research.

In our engineering schools we are training many good designers, - men who can analyze the stresses in a pressure vessel or use a computer to design a 20-storey building. We are not training men to devise and take responsibility for major innovations in industry. It is much easier to teach analysis than to teach synthesis and creative design.

Architects, on the other hand, have always considered design from a rather broad systems approach, although few of them would recognize it by that name and because of a limited technological background and lack of familiarity with decision theory and computer techniques their approach is usually relatively simple and subjective.

It is obvious that, if component construction is to be developed and the broader systems approach to design is to be used widely, the design training of architects and engineers must be altered drastically and be more clearly coordinated. In many ways the students at our universities today are wiser than the faculty - the architectural students in my own faculty have sensed these shortcomings in some nebulous and intuitive way and, in the current fashion of students, have had a teach-in and have refused to attend the present specialized and compartmented courses in technology and structural design. They have forced us to set up a committee of engineers and architects (both academic and practicing) which is meeting with the students in an attempt to resolve the problem.

Exactly what do I mean by systems design in engineering and architecture? As the scientific and technical capacities of man have expanded so have the complexities of the systems he is able to build. It has often been said that in projects of an earlier period such as the Egyptian pyramids or Roman aqueducts it was possible for a single man of genius and imagination like INHOTEP, the architect of the pyramids, to grasp all of the essential principles and guide the project alone. Today's projects, such as the Apollo space projects are compressed into a much shorter time and require such detailed knowledge that no single person can encompass it. Therefore today's system design is done by teams. Each member of such a team has a basic understanding of all areas of the problem and is expert in at least one specialized area. In an increasing number of projects technical advances are linked with economic and social problems and teams must include experts from these disciplines as well.

Systems engineering is usually divided into phases.

Conceptual Phase - Specifications are established

Project Definition Phase - Alternative approaches are identified and evaluated and the optimum chosen - usually includes detailed theoretical and simulator studies and cost and time analysis.

Acquisition (or delivery) Phase - detailed design and development completed and the system is built, delivered, installed and tested. (This corresponds to the construction phase.)

Operational Phase - operation, maintenance, modification and up-dating of the system.

The first two phases are most critical. By the time the third phase is underway, so much has been invested in the details of planning and production that any changes are very expensive.

The problem formulation and the system optimization are the most important and most challenging and are also the phases most readily treated in a university course. Also, in this country, they are the phases least likely to be carried out by the construction company but are done by consulting engineers and architects. In Europe and in some Canadian companies the whole job is often done by the construction organization and I am pleased to see representation of European total systems organizations at this meeting.

For this reason the system-oriented engineer is not likely to enter the Canadian construction industry in its present form. The students who enter the construction industry tend to be management-oriented and not design-oriented.

As many of you know, the construction industry has mounted a continent-wide campaign during the past year to apply pressure on the universities to produce more engineers for that industry and to modify curricula to include courses such as equipment selection and cost estimating. As an aside, I might say that, along with other Canadian Industry, when production eased off in recent months, they took the typically Canadian short-range point of view and seem to have lost interest in our current crop of graduates with the result that about 30% of some of our classes are going to the United States.

At my own university we have started on programs of Continuing Education courses for practicing engineers which will lead to diplomas in Construction Engineering and Engineering Administration. These programs provide some basic training in systems planning, decision processes and computer techniques. Even here the construction industries are slow to send their own people to us for re-training and up-grading and, in fact, have stated to me that the continuing education program should be designed to attract engineers from other fields into construction and that their own people do not need this training.

During the past year several government-sponsored conferences on modular coordination were held across Canada and since 1966 the Department of Industry has organized a number of technical missions to study advanced techniques of industrialized building in European countries. The results of these missions have been published.

These conferences and the present one are what are usually known as "motherhood conferences" - everyone agrees that modular coordination, component standardization, greater uniformity of building regulations, etc. are desirable. Manufacturers say they would like nothing better than a modular system for their products but no one will specify them. The architects say they would specify modular components if they were available.

We seem to have reached the stage where several large-scale experiments are required. Despite the fact that schools and education are a provincial responsibility, I believe that a project similar to the School Construction Systems Development in California should be organized across Canada. It is obvious that, as usual, the pump must be primed with federal funds - probably through contract assistance to manufacturers with sub-contracts to interested achools of engineering and architecture. Despite the provincial responsibility for schools, the Federal government can and does support research on a national basis.

Research on the much larger problem of the total systems approach to design and construction must be initiated in our educational institutions and somehow the stigma attached to the discovery of knowledge which is useful as well as new must be removed. In the U.S. the Office of Inventions and Innovation of the Department of Commerce has provided the initial impetus to stimulate universities into undertaking system studies on public sector problems such as urban planning, building systems design, urban transportation and others.

In closing, I must say that all the conferences and subsidized experimental projects in the world will not lead to improved decision making methods and a more efficient and profitable construction business unless we can both retrain our present designers and managers through continuing education and produce a new generation of young people trained in systems thinking, and perhaps most difficult of all, young people who are prepared to apply those talents to architectural and engineering design for the construction industry.

However, I wish to compliment the Department of Industry on their very successful systems approach to the BEAM program. With their sequence of technical missions, regional conferences, industry advisory committees, this present national meeting and the proposed training clinics they have carried us through the conceptual phase and the project definition phase in which they have identified and evaluated the alternative approaches and established the optimum system. We are now ready for the acquisition phase (or the construction phase) in which the system is built, delivered and tested. Hopefully this will carry on into the operational phase in which we place the system in full operation and, at the same time, add necessary modifications and improvements. However, these final stages must be carried out by the architects, the consulting engineers and by the construction industry itself.

A SYSTEMS APPROACH TO SCHOOL CONSTRUCTION

JONATHAN KING

At the Copenhagen meeting of the CIB, (Congrès Internationale du Bâtiment) in 1965, M. Blachére, one of the French delegates, commented that the most difficult element in the development of industrialized building systems is organizing the client or user. We have found this to be true.

The greatest problem in industrialized building systems is to get the user to organize his building program in a rational way. For industrialized building means more than using more factory-made parts in a building or even making a lot of identical pieces, large or small. It means this, but it also means reasonable long term use of a limited range of components to permit real industrial production rather than simply batch fabrication.

In my experience the user wants something extra - a significant extra - to compensate for the disciplines implicit in industrialized building. The extras may take a variety of forms, but the ones which have been important in the projects with which EFL has been associated in North America are economy, quality, and to a lesser extent, speed of construction. Only the prospect of getting quality not otherwise available at the same cost, or the prospect of lower cost without a decrease in quality, can generate the enthusiasm necessary to get such a project moving.

To inaugurate a building systems program, some agency, whether governmental, university-based, or a foundation, must take the initiative in drawing together the necessary volume. This cannot be done economically by any single manufacturer, due to the fragmentation of the building industry. Past efforts by individual firms to do so have been just short of catastrophic. There have been periodic rumblings of efforts by aerospace companies to take on the problem. However, the economic context in which these firms work, and the economic context of building are so far apart as to make this an unlikely prospect without substantial governmental subsidy.

Abstractly, the concept of industrialized building has substantial appeal to many of the professions and manufacturers in the building field. In fact, however, because it changes the normal methods of operation of all the industries, fabricators, trade unions and professions involved, there is substantial negative reaction which must be overcome if such projects are to succeed. Therein lies the crux of the matter.

Sufficient positive factors must be built in to counterweigh the negatives and at the same time to justify the considerable expenditures involved in the administration of industrialized building systems.

In California the School Construction Systems Development Program (SCSD) was established on an ad hoc administrative basis by EFL (Educational Facilities Laboratories of the Ford Foundation of America) and its western regional centre at Stanford University. It was a voluntary association of a group of 13 independent school districts. The project was funded entirely by EFL since it was the first attempt to develop an industrialized school building system on this continent north of the Rio Grande. While school districts were willing to participate, they considered the project risky and did not feel justified in committing public funds to its support.

The project's staff operated as a semi-autonomous design development group at Stanford University. Because of the significance EFL attached to the project, we, with Stanford University's School Planning Laboratory, appointed a national advisory commission of distinguished educators and architects to advise and assist the SCSD staff in its work. The legal basis of the project was the California law which permits school districts to join together to do anything they are permitted to do individually. This consortium of districts, the First California Commission on School Construction Systems was the legal entity which asked for bids on components.

Leaving these formalities aside, the underlying basis of the project was the desire on the part of school administrators in California to get better quality buildings within the basic cost context under which California schools are built. Two aspects of quality were uppermost in their minds and consequently in the minds of the SCSD staff.

First, they desired a far higher degree of flexibility than was ordinarily possible using conventional, uncoordinated components. The participating school districts, having had experience with the rapidly changing educational programs of the last decade, recognized that education needed a new kind of schoolhouse. They wanted buildings which could in effect be a participating tool in the educational process and which could accommodate change, within pre-determined limits, well into the future.

Second, and almost as important, was the districts' desire for schools with a higher level of environmental quality, with more and better air-conditioning, more satisfactory lighting and more educationally useful partitions. In short, more usable and more comfortable buildings capable of long range utility and economy of operation.

It was decided early on in the project to use performance specifications as a bidding vehicle, since we wanted to provide for maximum competition and for a maximum industrial research and development effort. The cost factors were determined by California state regulations which established a ceiling under which the schools had to stay in order to build at all.

Roughly $700,000 of EFL funds were spent in the project. These funds went largely for SCSD staff salaries and expenditures during the six years the project was in operation. The total project involved some $25 million of construction.

The use of performance specifications did indeed produce substantial industrial research and development, the cost of which, while usually exaggerated by the manufacturers who participated, nonetheless clearly exceeded by far the SCSD project costs.

The schools were all designed by private architectural firms. One of the secondary objectives in SCSD was to demonstrate that buildings employing industrialized components need not be, or look alike. The last thing we wanted was to produce a group of look-alike educational filling stations running up and down the coast of California. In this the project succeeded entirely - perhaps indeed, excessively.

The schools were paid for by the individual districts in the usual fashion.

The SCSD staff was a team effort involving architects, engineers and educators. The whole administrative structure was non-threatening to the various forces in the building industry and unburdened by the heavy hand of bureaucracy. By the same token it lacked the advantages of authority and administrative continuity characteristic of the major programs in which EFL is currently involved. It was, it seems to me in retrospect, an eminently successful way to do something for the first time. It would not be a reasonable way to do it again.

By contrast, the University Residential Building Systems (URBS) project of the University of California is administered by the university itself, employing outside professional services. I might add for those of you not familiar with it, the University of California now has some nine campuses which together enrol 90,000 students. The URBS project, while dealing with an entirely different building type - housing - had the same basic incentives for the owner-builder, the university. Their objectives in the program were:

First, long term economy. More and more, the increasing cost of housing was serving as a determinant of who could afford to attend the University of California. While tuition is free, students are expected to pay the complete cost of their room and board.

A second motive was the university's desire for an improvement in the quality of housing and collegiate living, to better satisfy students' needs and academic demands. These factors include a higher proportion of single rooms, better study conditions, and better environmental quality, particularly in regard to air-conditioning, more civilized toilets, and furnishings more amenable and adaptable to student needs.

Third, the university wanted flexibility to make the housing adaptable to the new kinds of student living arrangements which are beginning to replace the endless sea of two-student rooms interrupted only by gang toilets and massive but unused ceremonial lounges characteristic of most postwar student housing.

Components for some 4,000 to 8,000 student places will be bid this spring, again using performance specifications which have been drawn up for five types of components. Bids will be requested by the university itself. If successful the program can be continued indefinitely by the university. The housing will be varied in type and will be distributed among the several campuses.

The cost of the program will be roughly $600,000, one-third of which is from the university and two-thirds from Educational Facilities Laboratories.

Projects are also underway to bid individual schools on a state-based program in Florida using slightly modified SCSD specifications. The Florida program is interesting in that it is operating on a far more modest level than the other programs to which EFL has been contributing. Florida has accepted the SCSD specifications for the first of a long range group of projects and is bidding them, in comparatively unchanged form. By doing so they have been able to take advantage of components already developed and it has not been necessary to assemble the kind of volume which was characteristic of the California project.

Pittsburgh is another place where a systems project is currently underway. With comparatively modest help from EFL, they are developing five large high schools, each for 5,000 to 6,000 students. This is a total building program on the order of $150 million.

The Pittsburgh Program has taken a different route from any of the others. Performance specifications will not be developed for most components since there is not time to follow this line of attack. These five massive high schools will all be designed by the same architectural firm, and a professional team of architects, structural engineers, mechanical engineers, systems consultants and educational consultants working jointly in the development of plans and products. While local architectural firms will do the working drawings for the individual buildings, the essential design work will, in this case, be centralized in one firm. The buildings will all be built within a few years and the project will then be completed.

In addition, we are of course deeply involved in the two major Canadian projects to be described later in this program, for the development of schools in Toronto and in Montreal. Each of these is somewhat different in its organization, but the coordination of the performance specifications will give manufacturers an opportunity to bid twice without double development work. We hope and anticipate that the project will receive vigorous and more creative attention from Canadian industry because of this.

From the above recital you can gather that each of these projects has been characterized by somewhat different administrative and professional arrangements. But the reason for the establishment of each one of these projects has been the strong drive to get something otherwise unavailable within the cost context in which education operates.

From the standpoint of EFL, a foundation concerned with building research and development for education, the most important single factor which runs equally through these projects is that they offer a superb base from which to do a serious study of user requirements.

Indeed, SCSD's greatest contribution to school building in the United States was not the several schools built with the components but the fact that it provided us with a new way of looking at the North American High School. It is my expectation that URBS will do very much the same thing for collegiate housing, which is, after all, simply a sub-type of low cost housing generally.

These programs have each involved, as have the two Canadian School building programs, a concerted effort to dip into the process of education and to build buildings which come to grips with the needs born of that process in a way that conventional buildings do not. The extraordinarily fine study of elementary education published by the SEF Project in Toronto is certainly an indication of the kind of thing which can only be done as part of a massive systems program and cannot be done for individual buildings. Hence our interest in these programs and in developing new ways of satisfying educational building needs.

A SYSTEMS APPROACH TO SCHOOL CONSTRUCTION

EZRA D. EHRENKRANTZ

Yesterday, I spoke about the ideas and background that provide the basis for much of our work. This morning I shall talk about the work itself.

Starting with the student housing project, I shall describe the relationship between user requirements, costs, criteria established for technological development and the resulting performance specifications which are the basis upon which bids are taken.

The beginning of any process to determine user requirements of a given building type is the establishment of a basic methodology. It is possible to take any building type, to explore the requirements of that type and to develop comparative data. From this data, you begin to see where some of the problems lie, and what might be the basic criteria for the evolution of new forms to meet particular needs.

We began to discover, as we looked at student housing as a building type, that there were strange groupings of people. As many as 40 students might share bath facilities because it was assumed that this was the cheapest way. There were any number of other strange groupings and the students, when interviewed, asked for such things as privacy, acoustic separations and opportunities for individual expression in many ways. It is this kind of unsatisfactory performance of one's environment that drives people into the streets. They just can't stand the places in which they work.

When two students sharing a room have to study at the same time, in 80 per cent of cases one of them will work outside, in a library, lounge, or other public place. Today, the average student finds it very difficult to work in an environment with other people. Though perhaps most of our own generation entered college from a background of primary and secondary schooling during which we did our homework at the kitchen table with the radio playing in the background, today, when a student finds the family grouped around the television set when he wants to study, he retreats to the quiet of his bedroom. And so there are basically different patterns of student living, requiring different forms of housing.

These are only a few of the factors which have led to a set of requirements for the URBS project - very different requirements from those of traditional student housing. We are now calling for housing which will provide spaces of up to 2,000 sq. ft. for 10 students, in what may be called a flexible living area. Partitions within this area would be demountable, with complete freedom to reorganize space, so that the living areas themselves could change in configuration. We have taken modular disciplines and related them to the most complex of existing buildings. While we are not necessarily advocating the application of the system to this type of residence, we are saying that it could be done.

As we began to organize the criteria, certain disciplines began to emerge. For instance, we decided on small, shared bathrooms. What we found out was that, whereas a large "gang" bathroom cost an average of $300 per student at first cost, a small, shared bath would cost $450. However, 40 students would not keep the large facility clean, requiring maid service at $30 per year per student. At prevailing interest rates, this would increase the first cost of the large bathroom to $900 per student, as against $450 for the small facility which the students could take care of themselves. And so, the entire economic context has changed.

Related to bathroom facilities are plumbing, duct-work, chases and other spaces. Taking the vertical requirements for services, we begin to tie them into the horizontal circulation routes, which may also relate to the horizontal services. A flexible living area for 10 students, divided for dormitory living, could have single rooms in a variety of different types, which could later be converted, if necessary, into apartments for married students. At any point in time, the "mix" could change.

Once computer terminals are installed in residence halls, they will not necessarily be used for housing freshmen and women, per se. Many more Ph.D. students will be living in residence halls because, in addition to the educational and research assistance stipend, one of the advantages of coming to the university will the ability to use the computer from, say, 2:30 to 3 a. m. every other Monday.

We have taken five major categories of requirements. Within these categories, we must bid on a compatible basis, remembering that not only the structure, but the ceiling, air-conditioning and partitions are all part of the same system. We must take bids on a compatible basis, not minding increased structural costs if, as a result, air-conditioning costs are less. What we are concerned about is combined performance within the building. We don't care about the acoustic rating of a partition, or of a ceiling, but are concerned with room-to-room transmission characteristics, and these can only be measured by taking compatible bids on the performance of the total system.

We are concerned with the fact that we do not have all parts of the building within the system to develop weight factors; so that, in permitting the structural depths to vary, we can have an allowance of 2 cents per sq. ft. per inch in depth for the cost of the exterior perimeter wall. We are going up 13 storeys in this case, so that the depth of the structure becomes a very important factor within the building.

While the requirements for electrical distribution are not part of the basic system, provision is made to provide services and communications from any point of the building to any other point.

In developing our criteria, some interesting facts emerged. At Berkeley residence halls, for instance, it costs $2.25 per student per year to repair ceiling tile damage. It costs an average of a dollar per student per year to repair holes kicked in walls. These things are a part of life, and we are concerned with meeting annual operating costs. Student rentals are related to first cost operation and maintenance costs as well as alterations.

We begin to define the nature of the structural system. In telling how it may be done, we don't tell manufacturers that many different types of systems can be developed to bid against one another on a performance basis. Though the design of each system may be different, the end result, as far as the client is concerned, is the same.

In terms of air conditioning, efficiency depends on the correct relationship between the various parts of the system -- the source, the distribution system, the terminals and the method of control. What concerns us most is thermal control within the occupied zones, and this will sometimes conflict with acoustical privacy. Though partitions are made thicker and thicker, the mechanical engineer must undercut doors to allow the return of air from the conditioning system to the corridors -- resulting in more complaints about noise. We have found that, in addition to thermal controls, operable sash windows must be installed, for experience has shown that, if you do not provide windows which may be opened, students are creative enough to find a way to open them anyway.

Each student must be able to control his space individually. Because of such varied requirements as the physicist with his oscilloscope, and girls with their electric hair dryers and irons, the heat loads in different rooms are so varied that individual control is becoming increasingly important.

We have a maximum of 12 control zones in each 2,000 square feet, and we provide information to assist in the location of mechanical equipment. To provide different finishes for the partitions, students will be able to "snap-in" their own veneers, fabric, paper, etc. If a girl wants to decorate her room in red velvet, she can do so and at the end of the year take it home and make a dress out of it.

As part of the scheme for compatibility of the components, we developed a basic tolerance system to which the manufacturers must work. In terms of bathroom units, we require a one-piece pan that drains very much like a shower pan, into which everything flushes. We discovered some rather interesting things about student bathing habits; a student will usually take a shower if he wants to get clean, but will bathe in a tub when he has some hard reading to do. So we called for sit-back reading rests and work shelves. Since a shower has a natural requirement wider than that for a tub, we have room to do this. Once you make a start, many other things become possible. For instance, one of the reasons people do not take baths in facilities used by others is their objection to the debris left by previous users. This is partly caused by the fact that the water comes in and goes out at the same end -- anyone who has cleaned a tub knows how the debris just floats upstream and then comes back to where it started from. The drain cannot be put at the other end, because that's where you sit. However, now that we have a shelf, we can locate the drain underneath the shelf.

There are any number of other improvements, such as a wing wall for shower controls, so that you don't have to put your hand under the hot water to turn it down. The sink is designed according to the Cornell Bathroom Study requirements, so that water dripping off the elbows (as it does when girls are washing their hair) runs back into the sink rather than on to the floor. There are many other features of individual design criteria which become part of user requirements, to be translated into performance in order to come up with new products responsive to particular needs.

The provision of storage space is also important. For example, at the University of California, at the present time, men and women students are given exactly the same storage facilities, though their requirements are very different.

We develop basic cost criteria on a performance basis by evaluating components, developing target costs and comparing bids. This is done on an "apples to apples" basis -- not in terms of trade content, but in terms of function. We are concerned with performance, and we must therefore evaluate past performance and project our findings into the future. In the same way, we evaluate operation and maintenance costs, and so they become part of the context.

We are now out to bid on this project, and I will give you an idea of what will be done when the bids come in. Initially, we had in SCSD a group of districts working together to take bids on performance specifications, with manufacturers developing structural, lighting, ceiling, air conditioning products, etc. Once developed, these products were fed into the mix, and individual architects designed the schools. We had similar criteria for flexibility in terms of design. After the bids were in, the different components had to be co-ordinated to work together. They had to fit, and work with each other, the chief requirement always being flexibility. We developed the first flexible one-hour rated ducts, methods of controlling separate zones, and demountable as well as, in some cases, folding or operable partitions. The entire system was tied together to do a job, but the trades were separated. No two trades occupied the same space on the building site, and this is one of the ways to get efficiency.

Before bidding, manufacturers made structural tests to ascertain whether they could, in fact, meet the requirements; after bidding, testing began in earnest. First, handling and erection tolerances were tested through mock-ups, then direct load testing for both horizontal and vertical loads was carried out. Fire tests followed, of up to 70 minutes duration, and then tests to ascertain whether the air conditioning system met requirements, with a tolerance of plus or minus two degrees, summer and winter, at any position, from breathing level to six inches from the floor.

Most teachers, like all people leading a mainly sedentary life, have poor circulation, and tend to have cold feet. As a result, they turn up the temperature, and so put the students to sleep. Good mixing of air, then, would provide a good environment. An aid to "mock-up" testing is the fact that a 100-watt light bulb gives off the same heat energy as the average student.

Field tests of services in various schools were performed in order to verify the earlier testing.

Altogether, there are now 800 schools using one or more SCSD components, and our own 13th - and final - school was occupied this month.

A SYSTEMS APPROACH TO SCHOOL CONSTRUCTION

RODERICK C. ROBBIE

As a preamble to my talk today, I propose to outline the terms of reference of the Toronto program. Rather than talk about the details of the program, I intend to review the structure and then speak of those factors which will have an influence on all of us concerned with "A Systems Approach to School Construction".

The terms of reference given at the outset of the Toronto program were as follows:

1) The development of systems and components specifically for school use;

2) More effective application of the principles of modular construction in the achievement of greater flexibility of interior design;

3) Reduction of the cost per sq. ft. of school building construction, so as to provide better value for expenditures in terms of function, initial cost, environment and maintenance;

4) Analysis of the problem of short-term accommodation, including an evaluation of the present use of portable classrooms and the consideration of alternate methods of meeting short-term needs.

Of these four requirements, the first three relate to the regular school system in terms of permanent buildings while item four concerns a local situation in Toronto, where, at the present time, owing to demographic changes, we have just under 1300 portable classrooms.

The SEF* program evolved from the SCSD program. It had its origin in the recommendations of Dr. Kenneth Prudor of the Institute of Educational Studies, Province of Ontario and Frank Nichol, architect in private practice who at the time was Regional Architect for the provincial government of Ontario. Through the efforts of these two gentlemen, the provincial government and the Toronto School Board worked together, to obtain funds from the EFL** and then formed an advisory committee. The committee of 23 members is multi-

* Study of Educational Facilities, Metropolitan Toronto
** Educational Facilities Laboratory

disciplinary, consisting of architects, engineers, educators, builders as well as the Assistant Director of the Building Research Branch of NRC.

Guided by the aforementioned terms of reference, the Advisory Committee arrived at the following conclusions:

That in Toronto, the educational system now tends toward the development of the individual student rather than the group. This in itself has a basic effect on the design of schools. The traditional concept of a classroom with a teacher in front and pupils sitting in rows, in an enclosed box is obviously unsuitable to this new trend.

That the changing trends in education and the new emphasis on the individual student also influence the permanence factor in school buildings. If the educational process is ever-changing and unpredictable, then the ideal would be to provide buildings that are perfectly flexible internally. This factor of flexibility has been a great part of our past and present financial problems in Toronto. We have been spending substantial amounts of money each year on quite massive alterations to existing buildings and it is still questionable as to whether the long-range flexibility requirement demanded by the educator is satisfied.

These conclusions became a basis for our objectives: To develop a building system which would suit the new educational trends and provide for the continuous development of the student, by taking into consideration the building needs for specialized teaching, private instruction etc.

Turning to the S.E.F. we felt that the overall systems approach was the solution. The advisory committee set up a project office under a dual directorate, with Mr. Hugh Vallery as Academic Director and me as Technical Director. We divided our program into two parts. A major study of both sides of this program has been done. It describes the combining of the new educational philosophies with user requirements and has resulted in three publications. The first deals with elementary schools which includes kindergarden to grade six. The second, now 50 per cent complete, will deal with middle schools -- grades 7 and 8 and in certain instances grades 7 through 9. A third study is to be done which will deal with high schools. This study will extend through the three years' duration of the project.

The question was raised as to how we could develop the technical side of the project -- that of a building system to accommodate the educational needs of high schools, when in fact these needs would not be known until 1969. We solved this problem with a quick study to determine the serious points of conflict between school construction and user requirements and proceeded to satisfy these issues. This left the team concerned with education free to do an in-depth study and we on the technical side could continue with our plans.

To complete the picture we have now set up a number of other studies. One is a study called "Portables and Relocatables" which involves the whole question of portable schools or portable classrooms with an ultimate view to developing a plug-in building system to be attached to a permanent building system when there are serious demographic changes. In Toronto, there are areas where population fluctuates so violently that an entire school population can disappear over a period of ten years. A second study is concerned with building sites, land use and mix use. It will determine how school sites can be utilized to the maximum by mixing apartments with schools, etc. It is based upon the Garison Law idea in New York City.

A further study is being done on "The School in the Urban Environment". This particular study will provide the Advisory Committee with a picture of user requirements as viewed from the "outside".

We are also doing a management study to determine the means of applying efficiently all the information we have collected. By examining the progress of a school from its inception to its completion, we hope to establish new requirements for building codes and to question certain situations which are in existence now. Subsequently, we will set up the best method of school building possible within the official context.

The above,with the exception of some other minor studies, is the S.E.F. program.

Coming back to the building system, as in California, the first task was to establish a market of a size and continuity satisfactory to the development of the system. A survey was carried out which determined that this market should not be less than one million sq. ft. gross of construction. We then went to the six boards that constituted Metropolitan Toronto and asked them to assign the requisite schools to our program. We requested that they restrict these schools to the elementary and middle classifications so that we could ensure that their design and ultimate construction would adhere to the recommendations of our completed study. Up to this time the Toronto boards have assigned 26 schools to the program. Architects have been appointed for 23 of them; the rest are being handled by the school authorities themselves. These schools will amount to about 1½ million sq. ft. in their final configurations. Twenty-two of the schools are to be finished by 1970. Four are to be finished in 1971 which would indicate that there will probably be more added to the program in 1971.

From our discussions with industry people over the past months we gather that they would like to see a bigger order. As a consequence, we have canvassed 33 school districts or school boards across Canada from Newfoundland to the west coast and the 10 provincial departments of education, asking them if they would review our performance specifications. We requested that they tell us what changes they would require, in order to fit our specifications to their districts and particular regional situations. We have also asked them to give us their five-year prospective construction program. We would like to publish this information when we go to tender on July 9 in order to indicate to bidders the extent of the total market. Of course, these other school districts are not obliged to accept the results of the bidding program. We felt that this would be a useful service to the industry to let them know at least where interested people are located and what the real market could be.

We now move on to the development of the actual program. This has resulted in the preparation of two documents. T1 describes the method of obtaining information and T2, the method of program development which is the same as SCSD, using the program specification approach on an interface compatibility basis with regard to adjoining sub-systems. We are proposing the use of 10 sub-systems which amount to about 75% on the finished cost of the building. Unlike SCSD, this includes the exterior walls, plumbing, electrical and electronics systems and interior finishes. The interior finishes would probably be a number of sub-sub-systems, painting and some other items and the performance specifications covering gymnasium floors. As of now our performance specifications are completed except for three. These documents have been sent out to industry for criticism. We hope to receive your feedback by May 8. We will spend the May, June period editing and finalizing these documents and by July 9, when we call for tenders we should have on paper a comprehensive expression of the views of both industry and the various school boards. The period of tender will close January 7, 1969, a test of interface compatibility of the systems developed will follow, and the program will then be applied.

Our most serious problems to date have been:

a) The need for a uniform building code. We can certainly use the help of the federal government in this area.

b) The need for a central agency to represent the interests of the entire building industry.

c) The need for financial assistance from the federal government to aid in the development of products and;

d) The need for a co-ordinating service for industry on the professional level.

That, I would say, sums up our program.

A SYSTEMS APPROACH TO SCHOOL CONSTRUCTION

GERARD A. CORRIVEAU

The structures in the socio-economic and industrial organization of a country are the result of historical development, therefore belong to a tradition and, on that account, form a factor of resistance to any change, irrespective of the value of the change. However, for several decades, all economic and political theories of government, whatever its orientation, have granted a primary importance to the establishment of normalization, that is, of a body of technical rules with the purpose of simplifying, unifying, specifying various areas of human endeavour. To normalize is to define collectively, between producer and consumer, series of appropriate products or processes to satisfy categories of requirements determined in advance, by eliminating the superfluous complications and varieties, in order to increase productivity and improve internal and external exchanges of products, services, or information.

Before illustrating this by the example of industrialization of school construction, I would like to show that normalization can be situated on the national level only temporarily.

Even if normalization on the national scale demands a coordinated sustained national effort, it can only be considered as a phase, intermediate but indispensable, leading towards an international normalization, since there can be no doubt that the multiplication of international exchanges, the abolition of tariff barriers and the development of technology will in the near future demand a definition of products, processes and requirements on a world-wide scale.

THE RAS* PROJECT

Viewed from a distance, the RAS Program of normalization and of integrated component system perfection already appears as an enormous, powerful machinery for producing schools faster and at lower costs.

However, the starting up of this program has consumed a lot of pedagogical, economic, sociological and technical studies, in Quebec, as well as in the United States

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*RAS - Recherche des aménagements scolaire and even in Western Europe and in Scandinavia. These studies have enabled us to know the pedagogical data in effect, the pedagogical trends, the present equipment of the M.C.S.C., the construction costs and processes, and school maintenance costs and problems. Research into pedagogical data has been carried out with the Parent report and Quebec Regulation No. 1 as a starting point. Technical studies have dealt with 17 schools in which costs, architectural solutions, heating, ventilation, and electrical systems, and calculation criteria have been studied and compared.

In order to determine the present and future educational activities and requirements, we have set up 32 pedagogical committees, consisting of a group of 250 teachers. These committees have brought to light, in detail, all the activities and their interdependence. They have also enabled us to draw conclusions as to the resulting requirements, from the point of view of space, environment and circulation. Knowing even the pedagogical requirements, professional people will be in a better position to study the architectural, mechanical and other factors. All this information has been compiled in the code of requirements and functions.

The RAS Project program has been divided into 5 stages spread over a period of 4 years. In order to visualize and co-ordinate its overall development, management based on the critical path method has been established for the purpose of enabling certain due dates to be met, in terms of various activities and their relationships.

These activities, 256 in number, deal with various fields and are concluded by reports. In addition to the studies quoted above, I will mention studies on the use of carpets, minimum fenestration, flexibility in spaces, physical environments including quality of air, heating, cooling, ventilation, humidity, lighting (intensity, distribution, brilliance), acoustics (transmission, absorption), color, adult education, recreation, transportation, operational costs, capital and amortization, primary energy sources, bulk purchases, techniques, modulation, basic criteria from the architectural, structural, mechanical, and electrical viewpoints.

PHASES

All these activities are synthesized at the normalization stage by the elaboration of performance specifications and a code of construction standards.

The publication of these codes enters into the framework of the first phase.

The second phase consists in perfecting a system of integrated components. The third phase consists of the construction of a pilot school planned for 1969. The fourth, of revision of the calculation criteria and of the standards, using all available feedback, and finally the fifth phase which is the construction of the RAS schools projects.

This formidable task and all these studies have been tackled by the IRNES researchers. Taking into consideration the diversity of activity, IRNES formed a working team consisting of architects, engineers in various specialties, educationalists, administrative experts, economists and technicians. This research team has been assisted by a group of 10 university professors and several consultants on structure, fire protection, acoustics, etc... As you are aware, this research program is financed by the M.C.S.C. and Educational Facilities Laboratories, of New York, whose Vice-President, Mr. Jonathan King is with us today.

Mr. Jonathan King, who is primarily responsible for the success of SCSD Project is bringing his active support to all similar projects throughout the world.

I do not hesitate to add that without his support the RAS Project might have never come to light.

Also I wish to mention that Mr. Andre Gagnon of the Cadre Professionnel and President of the M.C.S.C. has been in the province of Quebec the first man to believe in system approach, as a means to solve the problems inherent in school construction. This decision of voting $1,000,000 in research a year ago was a much harder one than a similar one would be today considering that the trail is now open.

The solution to the M.C.S.C. problems which I have previously set forth, becomes obvious to the extent in which it was finally possible to resort to industrialization of construction in the current context.

The building world has in fact shown a decisive trend towards a thorough industrialization of construction by assimilating the techniques of mass production.

We may say that the decisive factor introduced into the industrial building sector has been research, to determine in advance the specific requirements of the user - this is a sine qua non - for mass production.

On the one hand, the civic awareness which engendered new policies in education and progress in applied pedagogy and, on the other, the application of scientific research to construction methods, together with the desire to industrialize the latter, have succeeded in creating an exceptional climate favorable to the implementation of far-reaching programs.

THE THREE GENERATIONS

The phenomenon of industrialization of construction which we are now living through is a direct result of the work of normalization undertaken for at least the past two decades in most highly-developed industrialized countries.

We can henceforth discern three clearly distinguished phases or generations.

The first generation witnessed the development of many independent systems of prefabrication, which it is usual to call "closed" prefabrication. This name clearly reveals the weak point in this type of prefabrication. This quasi impasse was almost inevitable for one main reason:

The industry was not sufficiently well organized for lack of appropriate channels of communication. The industrial promoter was therefore obliged to design and manufacture himself, all or almost all the prefabricated elements, whence an inevitable tendency to achieve a set solution offering almost no flexibility in use, except to adopt the solution in entirety.

The second generation, by forming an infrastructure of adequate means of communication witnessed the birth of open systems of industrialized construction since it opens an infinitely richer field of possibilities than closed prefabrication.

Manufacturers originating in various sectors have thus, as a result of joint efforts, produced catalogues of integrated, coordinated components offering great flexibility in use. This generation is already taking rapid strides, as you know, and the RAS Project enters, as we shall see later, within this second generation, which will hasten the advance into the third generation.

The third generation, of which we can already discern certain preliminary signs, would represent the final solution, i.e. the inter-system coordination and integration, through inter-changeability.

Mr. Raynaud, Director of School, University and Sports Equipment of the French Government recently wrote, and I quote, "The industrialization of school and residence is a natural event in the modern world, transformation activities can no longer be conceived of without industry."

And, at about the same period, Mr. Christian Fouchet, Minister of Education in France, had also written, and I quote, "Industrialization is not simply the result of a mutation or reconversion of enterprise, it is a genuine transformation in methods, and also in thinking".

THE SOLUTION SOUGHT

In taking into account the technological development, it seemed to us that in the present situation, the most convincing and economical response to the problem of construction in general, and likewise, in school, hospital, and housing, is the industrialization of construction.

On one hand, construction costs follow a rising curve, and on the other, the revolution in the pedagogical sphere and new trends require such flexibility in spaces that the use of traditional methods could not reconcile these contradictory demands if it is hoped to remain within set budget limits.

We have sought the common denominator both in normalization of environment and in perfecting an integrated component system; these are the primary objectives of the RAS Project.

IRNES has therefore undertaken research for a system capable of meeting both the requirements of the M.C.S.C. and the current possibilities of Canadian industry.

It was in short necessary to define a system of "open" construction, and I did say "open", lending itself to the techniques of mass production and able to offer a catalogue of integrated components.

Only such a procedure could bring the degree of flexibility in use which the M.C.S.C. requires. It would have been pointless to ignore the present context in not wishing to take into consideration the fact that our construction industry is based on specialization.

Therefore, it was also necessary for the construction system to be adapted to this situation. As a result, the method to be adopted had to allow the various sectors of the industry, which could be involved in school construction, to become coordinated.

The construction system being sought rests on a basic principle:

The division of the main functions essential to construction and operation of the school building into compatible elements called components - <u>appropriate to mass production</u>.

Furthermore, in order to be likely to make up a homogeneous whole, these components must have the peculiarity of being capable of mutual integration, that is a system of construction by <u>integrated components</u>.

On the economic level, the IRNES studies have established that:

1. The systems of construction by integrated components would offer a potential of direct and indirect savings at every level of the budget.

2. These systems would, moreover, offer incalculable advantages. We are thinking, in particular, of the imperatives, long and short term, of education.

In short,

- considering the extent of the M.C.S.C. construction program.
- considering the increases in requirements imposed by:

1. The educational system adopted (among other things comprehensiveness and subject promotion).
2. The methods in contemporary education.
3. The characteristics of the physical environment necessary for the learning process.

- considering that the sources of financing are and will remain relatively limited and that

they cannot on that account follow the same pace.
- we have been able to presuppose that the objectives set could only be attained by resorting to:

1. Elaborate normalization of school construction.
2. Technology currently available; i.e. the replacement of the traditional method of construction by a more appropriate method: That is, systems of construction by integrated components.

It would, however, be necessary to add that the need for using such a system to a certain extent goes beyond the economic point of view.

In fact, this necessity is mainly a product of new requirements in education which, on the level we are more specifically concerned with, may be summarized in two points:

First necessity:

Flexibility in use of space

This requirement radically changes the architectural solution which the school building should receive.

1. Introduction of large spans, in order to free the maximum of space from every obstacle: the object of this is to make every regrouping possible.

2. In order to meet the type and degree of flexibility required, many elements, fixed until then, must become mobile. (partitions - lighting equipment - air distribution - electric-electronic services distribution).

3. It has become necessary to control the required physical environment; without this, any effort tending to improve pedagogical methods would be in vain.

Second necessity:

Readaptability in the long range view of the school building, in terms of changing requirements in education

The economic necessity of using the school building for a period of between 25 and 40 years (amortization) must not put the brakes on the educational process.

On the other hand, resorting to a construction system, as opposed to traditional solutions, seems to be the most plausible solution for the complex problems of the school.

I would like to quote the Educational Facilities Laboratories Inc. report, "The Cost of a Schoolhouse", published in 1960.

"On parts and wholes -

> Designing a building is more than collecting materials and spaces. Good design is more a system than a collection. Discussing the elements of the building tends to make one think in terms of the pieces. But always remember that a well designed school is a system, the whole is greater than the parts, and the parts are basically interconnected. In short, it is what is called in psychology a gestalt".

THE SYSTEM SOUGHT

In response to the type of flexibility and the quality of the physical environment required in schools, the construction system which the bidders are going to be called upon to realize and for which they will be invited to undertake research, must be:

- economical
- simple
- fast erecting
- easy to operate and maintain

Any industrialized construction system of the "open" type, that is the type being sought in the context of the RAS Project, must obey a certain number of rules, essential for anyone wishing to achieve such a system with the hope for success.

These rules cover the following three basic principles:

a) modular coordination
b) integration
c) normalization of criteria in connection with design and quality.

MODULAR COORDINATION

We had to have a convenient means to permit the integration, not only of the various components among themselves, but also of the components with other elements in the school building. To coordinate this diversity, it was important for dimensions to refer to a common unit of measurement, and this means was the use of a module.

As a result of technical research on modulation undertaken from the outset of the project, it was decided that dimensional coordination would be based on the normal module of 4", an international system known as modular coordination (which moreover was part of the first stage of the BEAM Program of the Department of Industry). This coherent system would then be used for all the schools of the RAS Project, for we are convinced that it is the most fully adequate means of solving dimensional coordination. In our opinion, the modular grid by which the modular coordination is expressed is small enough to permit great freedom of design, but also large enough to locate elements and define assembly details with respect to this grid.

However, it was also obvious that the normal module of 4", perfect on the level of materials, was too small for the component level and therefore a multiple of this basic module was necessary for the building scale. The choice, for numerous reasons, fell to a module of 20", called the horizontal module of integration and vertically to 8" which provided the necessary heights for the project.

The adoption of modular coordination also enabled a common language to be set up; this was particularly important for the definition of the whole system of tolerance and application in the manufacturing and implementing of the elements.

We are certain that modular coordination will be an invaluable tool which will be used by manufacturers, contractors, architects, and engineers and that the result will benefit school construction - if this coordination is correctly understood, not as a restriction, but as an excellent means of organizing space and the elements composing it.

In another connection, to show you how far we wish to make integration understood, we have defined the aesthetic criteria which take into account the requirements for truth and simplicity which must be apparent in a school building. There must be a particular environment in the school and integration does not mean that everything must be hidden, as in an office building; the building elements must be evident, their function must be understood (that they could be apparent), their form must be compatible and integrated with the module and the adjacent elements, their appearance must be authentic and not spoilt by imitations. Aesthetic then does not mean beautiful - (a very subjective concept) - but is used in a positive manner, i.e. simple and logical in relationships of the elements among themselves, - truth of these elements, therefore evidence of a system and its components.

INTEGRATION

The integration of the components forming the RAS system, i.e. the 2nd basic principle, will therefore be considerably simplified by the use of modular coordination.

This integration, so greatly sought after, is in fact the determining factor in the success of a system; a system in which all the components must be intimately integrated; a system in which components must co-exist on good terms; a system in which components must be designed in mutual sympathy; a system, finally, whose coherence will be determined by the mutual integration of all its components.

We assert that a group of components which are only compatible cannot be qualified as a system. As we have just seen, a system requires total integration planned from the initial stage of the research.

This integration will necessitate a close cooperation among the various sectors of the industry interested in devising a construction system so that they may effectively integrate their respective components, from the preliminary study of design of the system.

We shall see later the criteria we have determined so that this integration may be possible to achieve, both within the RAS system and with the elements of the school building left outside the system.

The third basic principle, i.e. the <u>normalization of criteria in connection with design</u> should permit us to ensure quality control of components and therefore of the system.

These norms of design will cover:

- dimensional criteria.
- technical calculation criteria.
- performance criteria.
- aesthetic criteria.
- flexibility criteria, i.e. of displacement and reorganization.
- criteria covering admissible deviations, dealing with joints between elements of the same component or between elements from one component to another.
- criteria in connection with codes and by-laws in effect.
- and finally qualitative criteria strictly speaking expressed in the form of tests to which the component parts must be subjected.

IRNES has chosen to express the specific requirements of the M.C.S.C. by performance specifications, in order to communicate these requirements to the industry at a preliminary stage of design.

This basic document, which will be published next month when the call for tenders is ussed, expresses the specific requirements of the school buildings of the M.C.S.C., by setting forth the problems to be solved and the criteria to be observed.

This document is therefore diametrically opposed to the traditional descriptive specifications.

The industry will therefore have the chance of selecting in complete freedom the technical solutions which in its judgment should be in the position to be able to meet effectively the requirements of the M.C.S.C., since it is not in the spirit of these performance specifications to impose particular materials or solutions.

The system as developed and perfected will then be used by architects and engineers entrusted by the M.C.S.C. with carrying into effect the projected schools implied in the construction program devoted to the RAS Project, taking into consideration all the peculiarities of the said system.

So that the space inside the school may be remodelled as desired, a certain number of elements, until then fixed, must of necessity become moveable; they are:

- partitions.
- lighting fixtures.
- acoustic treatment of ceilings.
- air distribution system.
- electric-electronic services.

I will briefly recall that we have established 2 modules of integration:

i.e. a horizontal module of 20"
and a vertical module of 8".

The horizontal module will serve to establish the functional grid of each of the components and the vertical module to determine the space contained in the depth of floors, i.e. the dimension included between the under surface of the ceiling and the finished surface of the floor of storey above, which we call a "sandwich" floor.

The below ceiling heights have been set at 9'-4", 13'-4", 17'-4" and 22'-0", i.e. at multiples of the 8" module.

The school buildings to be created will be designed from 20 foot bays, with in certain cases, transitional 10 foot bays.

These dimensions are established on a grid formed by the horizontal module of 20".

The depth of the sandwich floor, corresponding to the spans of 20, 30, 40 or 60' may be selected among the modular dimensions of 24, 32, 40 or 48", just as for the span of 80' a choice could be made of the modular depth of 48, 56 or 64".

The most complicated problems of integration will have to be settled in regard to the depth of the sandwich floor.

In fact, we will find here the structural framework, the air distribution ducts with eventually mixing boxes, we will also find all the primary and secondary electric-electronic distribution, lighting between, various pipe-work and finally the devices which are to ensure the stability of the moveable partitions.

All these elements must be integrated here either by superposition or interpenetration or with the assistance of polyvalent constituent parts.

The component construction system which industry must realize for us consists of five totally integrated components and one semi-integrated component

The five components must each meet specific functions and, by mutual integration, form a coherent system meeting the required degree of flexibility.

The five components are:

- structure component.
- heating, ventilation, cooling component.
- ceiling, lighting component.
- partition component.

and finally the electric-electronic services component.

Let us first look at the <u>structure component</u>.

A component designed mainly to create large spaces free of any obstacle and able to permit the corridors to be relocated easily. Whence also the necessity of distributing loads uniformly. The primary necessity is to integrate intimately the structure with the four other components, a requirement implied in the limits to flexibility inherent in any structure.

Parts of this component are:

The whole of the framework; i.e. columns, beams, joists; as well as all floors and roof slabs.

Since this component has been freed from the servitude due to the peculiarities of each site where it will be implemented, foundations and ground slabs have been left out of the system.

The structural elements must also be planned to be capable of supporting three types of exterior walls: i.e. a traditional masonry wall, or panels of prefabricated concrete or a curtain wall.

Next we come to the heating - ventilation - cooling component.

This component is designed to create a physical environment favoring the educational process; this component, furthermore, must permit rezoning the spaces to be served and on that account, offer great adaptability in use.

Designed in harmony with the structure and ceiling-lighting components, this component will present a compact solution, result of a total integration.

Parts of this component are: air distribution ducts, diffusers and return grilles, mixing units, control units, filters and ventilators or fans, as well as heating or cooling coils.

Boilers, compressors and cooling towers have been left outside the system.

Next we will approach the ceiling-lighting component. This component should permit rezoning the areas to be served and should on that account offer great adaptability in use.

The component should offer moveable lighting fixtures meeting the performance specifications required as well as finishing elements of an acoustic nature.

Two types of performance criteria have been used for this component.

First: the VPI (visual performance index, utilized mainly for space or quality).

The functional grid of this component will be the result of efforts of integration carried out by the manufacturers.

Now we come to the partition component. This component must ensure, by the mobility of its elements, flexibility in use of spaces necessary to the educational process.

It must fill a primary function: visual and acoustic separation, and a secondary one: support the vertical working plans.

Since the component is freed from the servitude due to electric and electronic services, these have been ensured by a separate component.

The functional grid of this component consists of an orthogonal grid of 20P. (i.e. the partitions may be moved every 20" in either direction).

Finally we look at the fifth integrated component of the system, i.e. the electric-electronic services.

In this component are to be found the grouping of all feeders and distribution of the electric and electronic systems.

Distribution in areas will be by "columnettes", offering the same degree of flexibility as the partitions.

A component in which the problems inherent in its nature must be treated by integration with the other components.

The services covered by this component are:

- intercommunication services
- television services
- synchronized clocks
- electric outlets and lighting controls as well as controls for the heating - ventilation - cooling components.

A functional distribution grid has been perfected for this component; a grid offering primary and secondary branching roles and as a result great autonomy in use.

The "columnette" should be able to be placed in two different positions.

- First: placed against or incorporated in a partition.
- Second: self-supporting, in a free standing position, this being the case in all the large teaching areas, the small pillar thus giving great autonomy to the different working groups sharing the large areas.

To conclude this brief description of our components I would like to give you a glimpse of the multi-purpose component which, because of its particular nature and its semi-integration will be the object of a separate call for tenders.

According to the particular requirements of a specific activity, the interior divisions of the school building should unite one or several functions essential for this activity to take place.

If we set out from the assumption that the material now used by the exhibition techniques (our Expo 67 offered us an incomparable series of systems) we can catch a glimpse of the limitless uses this material may offer us while adapting to pedagogical requirements.

By considering, just as an example, either a system of the "tubular scoffolding" type or a system of the "Meccano" type, we can see from here the multiple uses of such a component:

- movable and demountable screens
- carrels (audio-visual or others)
- exhibitions, etc...

1. Temporary separation among several activities going on in the same area, each of the spaces delimited by screens, laying out the equipment and working surfaces necessary to it, thanks to accessories set in the framework.

2. Equipment of audio-visual laboratories. A three-dimensional cage set up in any regular area enabling individual work areas or carrels to be formed.

3. exhibitions

4. Individual work areas
   For - Pupils
   Monitors
   Or - Teachers

The recourse to industrialization of school construction necessarily implied a sufficient volume of construction, on the one hand, to stimulate the research which must be undertaken by the manufacturers and on the other, that the construction elements could be manufactured in mass quantities.

Therefore, the M.C.S.C. has decided to allocate a volume of 3,000,000 Sq. Ft. valued at $45,000,000 to be built throughout 1970, 71 & 72. This volume covers the construction of 13 elementary schools and 9 comprehensive high schools.

TENDERING AND IMPLEMENTATION

The realization of an industrialized system of construction by integrated components implies certain particular techniques, i.e. a call for tenders of a special type based on the performance specifications, unusual bidding and contract awarding procedures, a series of conditions which we have had to perfect.

On the basis of these principles IRNES has perfected a method which will enable the M.C.S.C. to acquire a construction system in which the components will be really integrated. This method, as we shall see, will keep the industry from deviating from the objectives which have been set. This method will finally enable the bidders to be judged in complete equity.

The period included between the call for tenders and the construction of the projected schools within the framework of the guaranteed construction program may be subdivided into 5 main stages.

The period covering:

1. The call for tenders and the bids.
2. The evaluation of these bids, followed by the awarding of contracts.
3. The development phase.
4. The perfecting phase.
5. The construction phase, strictly speaking.

The period covered by the tender call is subdivided into 5 sequences and is spread over 5 months.

<u>1st Sequence</u>: An information meeting during which the documents for the call for tenders will be given to the interested persons.

<u>2nd Sequence</u>: Prequalification of the bidders, established according to information they provide in the form of a letter expressing their intention to tender.

<u>3rd Sequence</u>: The bidders hand in a confidential preliminary design proposal. No price tender will be required at this stage.

The bidders will have complete freedom to become integrated within as many systems as they wish; however, for every different construction system they will participate in, a separate preliminary design proposal must be presented.

The documents presented must describe clearly the solution suggested by the interested person and contain enough information for a valid assessment to be made by the M.C.S.C. and IRNES.

<u>4th Sequence</u>: An evaluation report drawn up by IRNES will then be transmitted to each bidder.

<u>5th Sequence</u>: The interested persons submit their tenders. For each of the 5 categories of components, the bidders must present:

1. a final design proposal.
2. a unit price test.
3. an application of their component to four sample projects; prototype plans which must serve as a basis for these projects will be inserted in our performance specifications.

   These sample projects have the purpose of enabling an effective assessment of the tenders presented to be made.

The second phase will devolve upon the process of final evaluation and selection.

We shall proceed by a primary verification to determine whether the bidders are qualified, that is to say if they have become integrated in at least one complete system.

The second verification will be for the purpose of ensuring that all the norms of design and integration have been respected.

A third verification will deal with the application of the components to the sample projects.

Any combination of the five categories of components in which the integration is considered effective will be designated by the name of integrated system.

For each of the tenders, we will apply the unit prices, presented by the bidder to the total number of elements corresponding to the series of the four sample projects.

The amounts obtained in accordance with the terms of the preceding clause will be adjusted with the assistance of readjustment factors corresponding to each of the categories of components.

The "grand total" of an integrated system will be equal to the sum of the adjusted values of the five integrated tenders forming this system.

The selection of tenders will be made on the basis of a comparison among the adjusted grand totals corresponding to each of the integrated systems presented.

The M.C.S.C. therefore does not commit itself in any way to accept necessarily the lowest tender.

I will add that all the tenders must be guaranteed by a surety-bond.

A contract shall then be drawn up directly between the M.C.S.C. and each of the bidders who have formed the construction system as retained.

This contract shall cover the work projected for the development, perfecting and construction periods.

Each of the bidders retained shall be known as a component contractor, responsible directly to the architect for each of the construction projects and paid directly by the M.C.S.C. for processing and implementing his component. There will, strictly speaking, be no general contractor, but a contractor to assume the coordination of the construction site.

The development stage which will be spread over 4 months will have the purpose, as indicated by its name, of developing the components, of carrying out trials on the prototype and of manufacturing the components which are to be implemented on the construction site of the pilot-school.

This pilot-school, a two-level elementary school, including 50,000 square feet of construction, will enable us to carry out complementary trials during and after construction as well as the definitive perfecting of the system in its entirety. This school is to be completed for September 1969.

A final evaluation report shall then be prepared and the components of this system can then be mass produced.

CONCLUSION

Without wanting to raise a too-hasty generalization, we can, however, try to draw conclusions for industrialization, using the experiments which have been made in the field of school construction as one starting point.

In fact, whatever has been proved valid in this particular field could be adapted for a variety of programs, each equally specific. Thus we may consider public utility buildings, such as hospitals or government buildings, offices, such as post offices, or civic centers, or again a far broader area such as residential construction, whether single family or apartment blocks. In all these spheres, requirements exist and solutions could be found.

There is no miraculous solution, or universal applicability. In every field, the problem is first to be able to formulate existing requirements, which demands thorough methodical research. And in particular these requirements must be located in time - for example in school construction, taking into consideration the population developments, in which for a specific period, that is, so many elementary schools, and so many secondary schools must be built.

This definition of requirements is the responsibility of the client and from it a dialogue will be established with procedures, leading to normalization and industrialization.

From this point of view, government authorities have a bast responsibility to promote this scientific approach to problems, which responsibility is presently being undertaken by the BEAM Program.

I shall close by adding that:

Efficiency is a determining factor in productivity, which is a dimension of the standard of living in a community. Normalization of construction processes by integrated components is by definition an expression of efficiency.

<u>LUNCHEON ADDRESS</u>, Tuesday, April 30, 1968

MR. LUCIEN LALONDE

To most of us, this conference has shown that a systems approach to building has indeed many elements. One of these is modular co-ordination, and it is with this aspect that the Department of Public Works is particularly concerned at this time.

I therefore propose to confine my remarks to this element of the systems approach.

As you are no doubt aware, the Minister of Public Works announced late in February that DPW will be going modular within a year. The announcement had considerable impact, judging by the amount of editorial comment, both in the popular press and in the trade journals. I am happy to say that comments have been favorable.

Our adoption of modular co-ordination has generally been hailed as a desirable step in the direction of a more productive building industry. Several editorials have since advocated that all federal departments involved in construction should follow suit, making modular co-ordination universal at the federal level.

There has been encouragement across the board, with exhortations that provincial governments also join the modular club, as a necessary step towards the development of systems building on a Canada-wide scale. The architects have fallen in behind us - the Ontario Architectural Association recently came out in favor of a recommendation that the provincial government adopt modular co-ordination. Central Mortgage and Housing Corporation also recently announced their support of our decision.

It is nice to have the assurance that in moving to modular co-ordination, we are not treading on anybody's toes. But when you consider the preliminary studies that led to our decision, the response is not too surprising. There has been, after all, a great deal of discussion of modular systems in recent months.

When the votes were counted, after what amounted to a survey of the industry through the BEAM program, it looked as though everybody was in favor of modular co-ordination, and waiting for someone to start the ball rolling. Knowing this, we were in a position to implement a modular program without having to resort to the arm-twisting methods of the hard sell.

Neither did we pluck modular co-ordination out of a hat. It did not suddenly occur to one of our more promising young executives that it would be a good idea if the Department of Public Works went modular. Our architects have been generally familiar with modular co-ordination for years, and our manuals have laid down standards for working with modules for some time.

But we could not unilaterally dictate to you, the construction industry, where and when modular should be adopted. First, because we do not have the desire to dictate. As a department which perhaps more than any other relies on a smooth working relationship between government and industry, we like to be assured that our policies have popular support with the builders. Secondly, it should be patently clear that modular co-ordination simply will not pay the dividends we hope from it without that support.

The BEAM Program gave us the assurance we wanted, and we have gone ahead with our program. In case there are some who have not been reading the papers, our modular program can be outlined as follows: first, the methods and standards for working with modular have to be made familiar to all employees of the department who will work on it, inclusing architects, engineers and draftsmen. For this purpose, a team from our Design Directorate has been conducting seminars in DPW shops across the country. I am told that they have met with enthusiasm at every stop.

By the time the seminars are completed, about mid-May, all our personnel at headquarters, in each region, and at the district level, should have a sufficient working knowledge of modular. As the regions become sufficiently familiar with the system, each will begin to use it in all work designed exclusively by DPW personnel.

A pleasing indication of the kind of support we are getting was the invitation extended by the Halifax chapter of the Nova Scotia Architects Association to our design team to speak to their members on modular co-ordination while they were in the area. This sudden upsurge of interest may stem from a desire not to be left out of any fat government contracts, but I prefer to think that having read the book, people now want to see the movie

Following the familiarization of our own personnel, and until the end of February 1969, we will encourage private consultants in any way we can to use modular in designs carried out for DPW. After a date which will be announced, and which we hope will be around the end of February, modular will become a requirement for all consultants working on DPW jobs.

The one-year period between the Minister's original announcement and full implementation of the system has been provided in order to allow all consultants who will in future be doing jobs for the department to become familiar with it and to prepare for its widespread use.

That is our program. There are, of course, a few questions that cannot be answered at the moment. There will undoubtedly be a few procedures that will have to be worked out as we progress. We will have to write modular into our specifications, and while indications are that modular components are and will be available in sufficient quantities, the development of a full-blown modular catalogue would be of great assistance both to us and to the bidders on future jobs.

But our problems should be minor ones, and we have little doubt that modular co-ordination will be a successful step towards more efficient construction; a benefit to both the industry and the taxpayer.

Our Canadian economy is a healthy one, as is amply demonstrated by our general standard of living. I am not troubled by visions of a foundering construction industry in Canada, and neither are you, I am sure. The efforts of this industry have generally been adequate to the most demanding tasks, and its productivity rates with the best in the country.

But demands increase day by day - indeed, they mushroom. The Economic Council has shown some concern about our abilities to meet the construction demands of the coming decades. While we do not want to be doom-criers, we must prepare for what the best expertise available forecasts will be a revolutionary increase in demands on the industry.

So we are dealing with more than the cost of providing accommodation for the public service. For any innovation of the sort we are making, a sufficient market has to be available to make the change economically feasible. Our construction industry is a very splintered one, and very few of the myriad units that comprise it are large enough by themselves to effectively influence the whole. It is reasonable then, to look to some source such as the federal Department of Public Works, with a real property inventory that includes more than 35,000,000 square feet of accommodation, to take the lead.

This is what we hope we are achieving in adopting modular co-ordination. If our construction program is <u>all</u> carried out on a modular basis, it provides a sufficient market to render the change to modular in a large segment of the industry economically feasible. Once it is apparent that a portion of the industry is geared to modular, with the anticipated advances in terms of efficiency, it then becomes possible, in fact desirable, that other major users of the industry's products begin to buy modular. Soon, all segments of the industry should switch to modular co-ordination in order to remain competitive.

And although we in Public Works anticipate short-run savings by switching to modular co-ordination, we realize that it is not until the system is used more or less universally that its true economies can be realized. That goal is still, I think, somewhat distant. But judging by the reaction of the industry to our announcement, I am encouraged to forecast that the goal will be reached far sooner than we had hoped when the decision was being considered.

I note with gratification that systems designs are being applied to the building of schools in a couple of metropolitan areas in Canada. School provision is another area of snowballing construction demands, and this is also a reasonable field in which to make a start.

And there certainly is room for improvement in the field of less costly construction of individual buildings. We can increase productivity significantly by tackling the cost problem 'from the ground up' as we recently demonstrated in the Department of Public Works. Long before our decision to adopt modular co-ordination was taken, we were working on methods of reducing the cost of office accommodation to the taxpayer.

After a concerted and imaginative design effort, our architects and consultants came up with a prototype design for a high-rise office building, the first of which is being built at Tunney's Pasture here in Ottawa. The design was a significant success, with the result that we are going to be able to put up a building which will provide well over 300,000 square feet of usable space at less than $18 per square foot. The price is low enough that other governments have expressed more than casual interest in the design. With a net-to-gross space ratio approaching 90 percent, we should indeed have an efficient building design and yet we haven't sacrificed anything in the way of pleasant working environment.

But we as a society still have a long way to go in reducing costs, in increasing productivity of construction. We all know that anything that serves to reduce the cost of housing is highly profitable. Anybody who pays school taxes knows that it would be desirable to get more space for less money. And all of us, taxpayers, home seekers, builders or civil servants would benefit from an increase in the speed with which construction demands are satisfied. What I'm saying is we would all benefit from the widespread use of systems building.

Now, the Department of Public Works cannot by itself bring about this transformation. We cannot, for example, coerce provincial and municipal governments into doing our bidding. We can encourage. We can take a few steps in the desired direction. Other agencies, federal or provincial, can do the same. With the co-operation of all concerned we can clear the way, at least, for the growth of systems building.

At the outset, we need an elaborate, detailed, efficient information system, where communication and co-ordination of data keeps us all, from the manufacturer to the customer, aware of the latest industrial developments.

The BEAM Program is committed to the development of an information system. This gives me cause for optimism, since one of the chief virtues of the BEAM Program is that it depends for its impetus not so much on the recommendations of government experts, but rather on what you in the construction industry, in its various fields of activity, recommend.

The idea of the industry advisory committee - made up of senior representatives of the teaching profession, the designers, the builders - is a highly commendable method of approaching the building problem, particularly in a country where the industry is highly diversified and government takes place on several levels.

An editorial in Heavy Construction News, which most of you probably read, recently stated: "Surely co-ordination of building systems - be it for design of schools, post offices or warehouses - can lead to more economical use of standard components through the nation."

But, and here is the rub: "Unless DPW's proposed modular co-ordination system can be integrated with the other programs, it will only add to the coming chaos."

That last comment is perhaps pessimistic, but it is nonetheless pertinent. In order to be effective, the steps we take must be concerted rather than divergent. Not only must each of us know what the other is doing, we must ensure that the systems we develop are in effect elements of the same basic system.

It is too much to expect that the thousands of interests that make up the construction industry see eye-to-eye in their everyday activities. Yet we all have at least one long-run goal in common. We all stand to benefit from the development of the ability to produce more buildings faster, and for less money.

To bring about this desirable end, we need first of all to recognize that while individually we will achieve little, we can through communication, co-operation and co-ordination produce by the turn of the century as much housing of various kinds as Canada has so far produced in all its previous history.

We are moving in the right direction. If there was no serious consideration being given to a systems approach by the industry, we would not be here. You are attending a conference, after all, which has been arranged through the co-operation of the Royal Architectural Institute of Canada, the Association of Consulting Engineers of Canada, and the Canadian Construction Association. You could hardly launch a discussion of construction topics with more auspicious backing.

This is an ideal forum for the discussion of both the problems and the prospects facing the construction industry. I don't think many of us will go away feeling that we have wasted our time. I hope, in fact, that we will all go away with increased enthusiasm for innovations that will lead to more industrialized building techniques.

If we do not, and if there is not an enthusiastic follow-up to the public works adoption of modular co-ordination, the DPW decision will, a year or so from now, look somewhat like the Cheshire Cat in Alice in Wonderland - it will all have faded away except the grin.

The author of Alice in Wonderland, Lewis Carroll, used to cut some pretty fancy logical capers. One of them has a moral for this gathering. I am sure most of you will recall the passage in which it is explained that you must run as fast as possible in order to stand still, and if you want to actually get somewhere, you must run twice as fast as that.

Well, construction demands are like that. I am sure that we here today will maintain, to the last man, that we are running as fast as we can. But looking a decade or less into the future, I have to conlude along with Lewis Carroll, gentlemen, that we are going to have to learn to run twice as fast as that.

PANEL DISCUSSION, Tuesday, April 30, a.m.

Question: I WOULD LIKE TO HEAR ABOUT THE ARRANGEMENTS WHICH GOVERN THE BIDDING PROCEDURE AND AWARD OF CONTRACTS RELATING TO THE SUB-SYSTEM CONTRACTORS IN SEF. WILL THE GENERAL CONTRACTOR AND THE ARCHITECT EXERCISE AUTHORITY ON THE SUB-SYSTEM CONTRACTORS?

Mr. Roderick Robbie

There will be ten successful bidders for the sub-system contracts, one in each category. Each will have a contract in the first instance with the Metropolitan Toronto School Board assigned according to the legislation which governs the Board and the six Metropolitan Borough Boards for actual execution in the field. The Borough Boards will pay these sub-system contractors direct on the certificate of the architect and of the general contractor for the specific project. Therefore, the general contractor will exercise restraint to the extent that the work is being completed, and similarly, the architect may also exercise restraint. The answer to your question is therefore 'yes'.

Mr. Gérard Corriveau

In our project, all the component contractors will be considered, as far as the Montreal Commission is concerned, as prime contractors. In other words, for building a school, there will be six main contractors, one for each component system and one acting as a general contractor.

The first tender call will be for the system only. After the successful bidder is known, he will be part of the actual contract from the Commission to build a particular school in the program encompassing 22 schools. For the next four to five months there will be much to do in searching contractual or technical solutions, but, this time will be regained later since part of the work of the consulting engineers will have been completed. The time we lose now will be recuperated during the period of the total construction program.

Mr. Ezra Ehrenkrantz

I really do not know whether the Florida schools project saved time on the program; I have not been involved in that project directly. In terms of systems application for other school districts, however, the time both for design and for construction, has been shortened so that the market necessary to provide for the development of system components results in longer lead times for forward planning with regard to the timing of the school program. Thereafter, a vehicle, to combat package building and other approaches, is provided. The normal construction design time, with respect to the Florida Program, is shorter but I do not know by how much.

Mr. Roderick Robbie

As far as the Toronto program is concerned, the schools included in the first SEF building system are part of the 1970 and 1971 construction program. These are not schools that have been delayed; they are schools that would not have been built in any event until 1970 and 1971. The subsequent systems following the first one will similarly be phased. Therefore, as Mr. Ehrenkrantz remarked, we are dealing with long lead time and attempting a great deal of work in this lead time.

The program will develop in a somewhat different pattern from the conventional. We hope, through the management study, to subject the owners to certain disciplines in meeting the time schedule of the program.

Mr. Gérard Corriveau

There are many ways that we could solve the problems which confrontus but I do not think we can offer a solution in the form of a set of drawings showing instructions. First of all, we could act as advisors to a group of manufacturers. Five manufacturers have to group themselves together in order to be able to supply integrated systems as solutions because we will not consider a component or system by itself. Each system requires to be integrated with the four others. Therefore, the consulting engineers, as well as the architects, can advise the manufacturers in supplying the best and the cheapest solution. In another way, we of IRNES could act as co-ordinators among the manufacturers because if the manufacturers already have technical staff to study the requirements and provide solutions, there would be no need for outside consultants. It seems advisable, however, that most of the manufacturers call in a consultant, either an architect or an engineer in each discipline to help ensure that the solutions meet specifications and also, that solutions are totally integrated with each other.

Mr. Roderick Robbie

Our view of this situation is that an engineer or an architect can offer himself as a consultant to a specific sub-system contractor or contractors to advise on the development of their particular sub-system and also the interrelationship of that sub-system with the others. This, as Mr. Corriveau pointed out, is a feature of both the SEF and IRNES developments. The consultants may also be part of a consortium that is actually bidding for the sub-system. Then the consortium might be multi-disciplinary, composed of professionals and manufacturer/contractors. This aspect remains the prerogative of the participants and we of SEF are not prepared to specify the exact means of provision of the contracted work.

Another way is by the provision of a co-ordination service by multi-disciplinary professional teams. Such teams would offer a service to groups of manufacturers, who wish to bid these two programs, to assist in the co-ordination between the various sub-systems. Now, this means that certainly, in the case of SEF, and, as I understand, of RAS, paper solutions or designs only, will not be entertained. The design, the testing, the development, the manufacture, the supply and the installation of a given sub-system are all required. In addition, a particular sub-system must be integrated on an interface basis with the remaining sub-systems of the particular building system in question.

Question: IN THE PROVINCE OF QUEBEC SLIGHTLY DIFFERENT LAWS FROM THOSE OF OTHER PARTS OF CANADA GOVERN THE DESIGN PROFESSIONS. DIFFICULTIES ARISE IN THE FORMATION OF PARTNERSHIPS OF ARCHITECTS AND ENGINEERS, ESPECIALLY WITH RELATION TO ULTIMATE RESPONSIBLITY FOR FAILURE OF A SYSTEM OR SUB-SYSTEM. IN THE CASE OF A CONSORTIUM OF DESIGN PROFESSIONALS, WHO WILL ASSUME THE RESPONSIBILITY FOR THE PERFORMANCE OF THE PRODUCT?

Mr. R. Halsall

I can not answer for Quebec, but in the SEF program, the fabrication drawings must all bear the stamp of an architect or an engineer. Presumably the engineer who does the design for the sub-component contractor would be responsible for its integrity. The building engineer - the final project engineer - will be responsible for the integration of all the components and sub-systems. But as far as the responsibility of the professionals and limited companies is concerned, I believe, speaking as a professional, we have to face the fact, as Mr. Ladyman remarked yesterday with respect to unions, that if there is a better way of building by systems we cannot, as professionals, maintain the old ways of practice as a matter of personal preference. Our ways of operation must be adapted to the requirements of a rapidly changing industry.

Mr. Roderick Robbie

We of SEF have specifically asked for stamping by professionals of the technical drawings in regard to materials from the manufacturer because under Ontario law the act of placing a stamp on the drawing determines responsibility. Being registered as an architect in both Ontario and Quebec, I do not think the situations differ appreciably. Things are a little more onerous in Quebec because of the longevity of responsibility, but in terms of the fact of responsibility, they are the same. The owner - in SEF the six school boards are the owners - on all occasions hire architects and engineers to design their schools. This is done for two reasons: one is obviously to provide the designs for the buildings, and, to consider your point, to have someone take the public responsibility for the safety of those buildings. In order to ensure that this responsibility is not impaired, it is mandatory to call for stamping of drawings and documents as Mr. Halsall pointed out. We are asking that the professions change their ways of operation to accept a flow of responsibility within the professional context. This means that the project architect and the project engineer accept the responsibility for the finished building on the premise that their professional colleague, who is captive to the manufacturer/contractor, or, who is acting directly for industry, has taken the responsibility for developmental stages of the project from a professional standpoint so that they can, with impunity, take responsibility from the co-ordination standpoint. I suggest that if architects and engineers who put the buildings together finally, are not compatible with the architects and engineers responsible for the work in the plant, then the matter revolves around internal professional discipline. This implies a carving up of the capabilities. I think the point is that unless the professions take black and white responsibility and the manufacturers and contractors and everybody else involved follow suit, then they really have no role to play. We feel that there is a role to play. Provincial legislation recognized this role very properly and precisely and we must find a mechanism to make it fit this new concept.

Question: CAN YOU PLEASE OUTLINE WHAT PLANS ARE MADE IN EACH OF THE THREE SPECIFIC SYSTEMS OF PERFORMING THE WORK DESCRIBED EARLIER FOR ORGANIZING ALTERNATE MANUFACTURER/CONTRACTORS?
THE MONTREAL SCHEME APPEARS TO CALL FOR PRELIMINARY SUBMISSIONS OF IDEAS OR CONCEPTS. THESE, I PRESUME, MAY PROVIDE PATTERNS FOR THE ORGANIZATION OF THE MANUFACTURER/CONTRACTOR GROUPS. IF THIS IS SO, IS THE SAME ARRANGEMENT BEING EMPLOYED IN SEF AND WAS IT EMPLOYED IN SCSD?

<u>Mr. R. Halsall</u>

Do you mean that the SEF and IRNES agencies actively encourage or act as mediators to the formation of such groups?

<u>Mr. Gérard Corriveau</u>

As far as our project is concerned, we do not suggest any group to be formed, in other words, we do not suggest to Firm A to unite with Firm B or C. Our role is to supply all the necessary technical information so that firms can take their decisions to form consortia or groups as they see fit.

<u>Mr. Ezra Ehrenkrantz</u>

Formerly in SCSD and now in the student housing project, we had and have a policy of trying to solicit the interest of industry through involvement in review of performance specifications during their evolution. When the performance specifications were completed, we began with a pre-bid conference for industry which was advertised widely. At the same time we sent particular letters of invitation to those companies who had expressed interest during the development of performance specifications. We then set up review procedure enabling each manufacturer working in a particular area to commence work on his designs. At a particular point in the bidding process, we have also worked with evaluation submissions wherein the designs were submitted for technical review. At this time we played a very strong role as marriage broker, checking mutual compatibility of the various submitting manufacturers. In this respect our policy is not to disclose the design concepts of any single manufacturer to another, but to indicate, on a mutually agreeable basis, the areas in which we thought compatibility could exist. We also have had additional pre-bid conferences at each of the various design phases to up-date the initial discussions and also to provide an opportunity for different companies to become acquainted.

It might, therefore, be said that we have played a very strong role in trying to get companies to work together by doing the first screening and evaluation. This gets over the difficulty of companies' reluctance to disclose their ideas to other companies without previously having some degree of assurance that their products might be mutually compatible.

Mr. Roderick Robbie

We are attempting, essentially, the same procedure in SEF. This is with relation to what we call the Series One contracts; the sub-system contracts from which the actual building system will be chosen. When we progress to the Series Two contracts, the application of the chosen building system to the 26 schools, the 6 Borough Boards of Education will exercise their responsibility to decide whether they will let one school to one contractor or let all the schools in a borough's program to one contractor. We are suggesting the use of management contractors to the boroughs. These management contractors would be appointed on a competitive basis, on pre-qualification on a fee, and would come onto a project at the time when the architects are commencing work on the final design of the building and beginning to prepare working drawings. At this point in time, the architects have already completed preliminary designs for the 26 schools which are going to be incorporated in our Tender Documents. The contractor will then work with the designers and integrate the building system into each specific project performing any lead work that has to be done. In the case of one board having 9 schools in the project, all 9 schools may be given to one management contractor. Another board having only one school in its program may mean that the contractor may be given only one school. We may then have somewhere between 6 and 8 general contractors working in a management configuration on the 26 schools.

Question: WOULD THE PANEL PLEASE COMMENT UPON THE STRUCTURAL SYSTEMS FOR FLOORS, WALLS AND ROOFS IN SCSD, SEF AND IRNES IN THE CONTEXT OF APPLICATIONS TO SINGLE, TWO-STOREY OR MULTI-STOREY APPLICATIONS?

Mr. Ezra Ehrenkrantz

In SCSD there were a number of two-storey buildings and one that went to three storeys. The structural system, however, was designed essentially for one and two-storey construction.

Mr. Gérard Corriveau

In the IRNES development there will be schools of one, two, three and four storeys, depending upon the requirements of the school in question.

Question: I WOULD LIKE TO ASK MR. CORRIVEAU TO COMMENT ON THAT QUESTION WITH RELATION TO THE FIRE RATING REQUIRED SINCE THIS OBVIOUSLY AFFECTS THE STRUCTURAL SYSTEM GREATLY, ESPECIALLY IN MULTI-STOREY SCHOOLS.

Mr. Gérard Corriveau

Unfortunately, I cannot provide precise information because this matter is currently under discussion with the City of Montreal. We have requested a deviation from the building code of Montreal allowing a reduction of fire rating, but I would prefer not to discuss the matter since it is under consideration by the city.

Mr. Roderick Robbie

In SEF we are calling for a structural system that will be applicable to five storeys. This is the break point between one and two hour fire rating requirements under the National Building Code. Our maximum height decision was based on this limit. We have a requirement in Toronto for some multi-storey schools of considerable height in the down town area, but in the program involving the 26 schools there will be one one-storey school and the rest two and three-storey with one probably of four storeys. This will be indicated on the bidding sheet so that bidders can frame their price to meet our specific requirements. However, we have a design requirement for a structural system capability of five floors.

Mr. Halsall

Perhaps Mr. Ehrenkrantz would like to comment on the role of the professional in the context of this last question.

Mr. Ezra Ehrenkrantz

The most exciting thing, as far as I am concerned, as an architect working in systems construction, is that it opens a whole new group of roles. The basic role of the person who is involved in planning, I believe, has historically been the matching of resources and needs to design facilities which meet the needs in the best aesthetic manner. In this regard, some of the traditional roles of the designer (of the professional design team) which has had control in past days over the pallet with which we design the keyboard has begun to escape us and products have been designed by people in industry who have frequently relatively little knowledge of how they are going to be used in buildings. They are put on the shelf as so much hardware almost challenging the architect and the engineer to use them effectively within a building. So that a concept that results in a systems approach makes it not only possible, but almost necessary for technical consultants to be involved, both in the use of products, and in terms of the development of the keyboard with which they themselves and other consultants will work to design buildings. This, I believe, is a great opportunity.

The aspect that may be changing is the development of greater efficiencies in the way in which professional services are used. In the same way that we may be talking of reducing man hours at the building site, to some extent, through the use of system building, we may be talking of procedures which will enable us to reduce, somewhat, the man hours involved within the design process. But this should essentially be in terms of the mechanical aspects of the design process, not the areas of creative thought. I, therefore, believe a number of things will happen. First of all, we will have professionals involved in working for clients to set criteria. We will have professionals involved working with industry to develop products to meet criteria. And thirdly, the more traditional role as we know it, the professionals involved, to use the products, the hardware created within the keyboard, to design the individual buildings and, in this respect, I think that we are talking of a significant expansion of the influence of professionals within the building industry.

In our work in California, to give an example, we as architects and engineers with engineering consultants, when we do not have capabilities within our own firm, are working for clients to define the needs and performance requirements. Architects and engineers are associated with most of the people who are developing products to bid to the clients criteria and each project is being designed using separate architects and engineers working for the particular client.

Question: THE TYPE OF EXTERIOR CLADDING ON A BUILDING CAN HAVE A VERY SIGNIFICANT EFFECT UPON THE DESIGN OF, AND UPON THE PERFORMANCE OF THE BUILDING. CAN YOU EXPLAIN WHY THE MONTREAL SCHEME EXCLUDES THE SKIN FROM ITS PROGRAM WHILE THE TORONTO SCHEME INCLUDES IT? WHAT WAS THE EXPERIENCE IN CALIFORNIA WITH REGARD TO EXTERIOR CLADDING?

Mr. Bezman (answering for RAS)

In IRNES we had very serious problems to face, in terms of shortness of time, in order to complete the program by 1972. By examining the existing market we found out that there are lots of ready made acceptable solutions as far as exterior walls are concerned. Because of this we decided that the structure should be capable of carrying the three main types of walls; block and brick, prefabricated concrete, and curtain walls. We are, therefore, asking the structural manufacturer to demonstrate three different cladding solutions which will be used according to the type of exterior skin chosen by the architect.

Mr. Roderick Robbie

This question is a winner; it is essentially addressed to architects and their attitude towards the exterior of the building with respect to the rest of the building. We take the view that architecture is the manipulation of space and not just the design of an enclosure around that space. It is proper to put considerable effort into the development of the internal systems such as air-conditioning and heating. The exterior wall is a significant part of the atmosphere control system since it provides the division between the natural climatic elements and the man-made climate inside the building. Thus it seems proper to include the exterior walls as an integral part of the systems approach.

We also wish to have buildings which can be easily expanded. Because of this we require that the structural system manufacturers and the firms producing the exterior of the buildings design these in such a way that the walls can be taken off easily if it becomes necessary to relocate them; at least to be able to remove them to facilitate extensions of buildings in a satisfactory and simple manner.

A third point is that in Metropolitan Toronto, the concept of variety in school exterior design was really a little specious because within the metro area just about every school is built of brick. We therefore felt that already, aesthetically, we are looking at one particular material and that perhaps as a purchaser we might get greater variety by considering the cladding as part of the system.

We are attempting to take a strictly functional viewpoint. We believe that the exterior of the building has a role to play with respect to climatic conditions vis-a-vis weather proofing, air-conditioning, heating and exterior cladding obviously affects the structure by its weight, method of fastening, etc. Therefore, in requiring a truly integrated system rather than a hybrid, it seemed proper to include the skinning as part of the system.

Mr. Ezra Ehrenkrantz

In California, the school districts concerned in SCSD do not have great extremes of climate. Moreover, in SCSD we dealt predominantly with one-storey suburban schools. Because of these factors, the performance of exterior walls was not considered crucial to the development of the total system.

The exterior wall of the average California school amounts to 6% of the cost of the total school. As we began to review the variety of designs commonly used within the SCSD districts which might legitimately be called upon to provide a reasonable keyboard, the division of the 6% of the construction for $25 million worth of schools into costs of doors, opaque and transparent cladding materials of all varieties did not leave sufficient volume for the development of an acceptable system for the exterior on a total concept basis. As it has worked out, we have mixtures of precast concrete, brick, concrete block, asbestos cement, plastics, redwood siding and a number of other materials being used for the wall cladding.

In the URBS project, to the extent that the shear walls for the multi-storey buildings are on the exterior, the exterior walls are part of the system. Therefore, as in any systems approach, one must evaluate the provision of walls etc. within the context of the project.

Mr. Roderick Robbie

The SEF project relates to a comparatively small urban area with a very concentrated market. Because of this we felt that there was an opportunity for the development of wall systems seeing that in SEF most of the schools will be more than one storey high. Another point is that unlike the SCSD program which was admittedly a prototype or seeding program, we in SEF are probably involved in a whole series of programs that may follow this first one, assuming the first one proves successful. It seems that we are not looking at a one-shot operation, where one specific exterior system is going to gain the market and hold it against all others. Also in Metropolitan Toronto the SEF program only represents 1/3 of the school construction that will be built in the two year period of 1970-71. The value of construction for those years will probably amount to $100 million. SEF will probably account for $33 million of this, so that there is still a very large section of the school building market generated by Metropolitan Toronto remaining to traditional methods. We would, therefore, suggest that the non-successful bidders on the vertical skin sub-systems will find a 2/3 greater market in the traditional sector than the one that is exclusive to SEF. It is a little difficult to justify in our context the application of a systems approach to the structure, the atmospheric system, the finishes, etc. and to leave out the outside walls for some almost mystical reason. To my mind, architecture is not only about exterior decoration, it is a great deal more than that.

Mr. Jonathan King

May I address myself to that mystical aesthetic question? One of the reasons which Mr. Ehrenkrantz did not mention regarding the exclusion of exterior walls in SCSD was simply that to include them was not acceptable to a large number of the architects involved. In addition, their inclusion was unacceptable to the school districts involved. For example, there is one district that insists upon cladding its buildings with locally produced Fullerton bricks rather than other makes of brick.

A question arises, however, in this kind of project as to just how far development can proceed at any one time. A rather good case could be made for the premise that SCSD buildings would be, aesthetically, entirely more satisfactory if a cladding system had been developed as an integral part of the building system. The cladding and the plumbing did not seem to be areas which could be included in the systemization and they did not seem to be sufficiently important to insist upon, perhaps at the expense of the rest of the project.

Mr. R. Halsall

Perhaps as systems become accepted, a cladding system could be applied to a project which was not originally designed to have a systematized cladding.

Mr. Ezra Ehrenkrantz

Obviously, an exterior cladding system could always be added, but certain school districts participating in SCSD were committed to specific exterior materials by regulations. The regulations refer not only to houses built in those areas, but to public buildings as well. This meant that a very much larger volume of construction would have been necessary for the development of viable exterior systems. It was just not feasible to develop a system to meet the existent range of requirements.

Question: IT IS INTERESTING THAT THE TWO CANADIAN SCHOOL STUDIES, AMONG OTHER DIFFERENCES, HAVE PRODUCED TWO DIFFERENT MODULAR GRIDS: 20" IN MONTREAL, 60" IN TORONTO. CAN THE PANEL INDICATE WHY THESE GRID SELECTIONS ARE DIFFERENT AND TO WHAT PURPOSE?

Mr. Roderick Robbie

One interesting point about the grids selected is that in both cases the numbers (20" and 60") are derived from the specific educational requirements of the boards calling the tenders. It is rather important to recognize that these two building programs were originated not as a convenience to the building industry but to assist the education process and hopefully to do it in such a way that the building industry could respond effectively. This is quite crucial because in the case of the Toronto boards, and I imagine in the case of the Montreal board, the owners have stated that educational functions come first, then cost, then aesthetics. These are the basic points and out of the investigation of requirements we found the 60" was a very economical planning grid for the laying out of these buildings. Before settling on 60", however, there was considerable dialogue between IRNES and SEF personnel and this resulted in the one grid number being divisible by the other. I mean that we selected 20" and 60" rather than 24" and 57" or some other more awkward numbers. Furthermore, a large number of industrial interests were canvassed before settling on this number (60") to determine from the market spectrum the acceptability of the 5' planning grid. We found a very wide acceptance of this number.

There was also the further point that it was the planning grid used on SCSD, it is the one used on the Florida system and it is one that has gained favour in certain areas outside education, notably in the construction of office buildings to which the systems resulting from these programs may be well suited. It would seem that whilst the number is unusual, there is, in fact considerable functional validity for it.

One other point with respect to dichotomy with 48". We believe the 48" planning grid or dimension has application in partition systems and we are not stating in our requirements that a bidder has to conform to 5' for partitions, or to 20" or 40" for that matter. He can use 48" so long as it is demonstrated that it is in fact suitable and economical.

<u>Mr. Bezman</u>

I would like to point out that in order to utilize all the spaces required within the schools, we had to find an increment compatible with the creation of those various spaces. On the other hand, we looked for the smallest common denominator among all of the functional grids corresponding to the components. After intensive research we found that a module of 20" would fulfill that purpose. I would also like to point out that three modules of 20" constitute a 5' module allowing manufacturers to present solutions both in Montreal and in Toronto. The smaller module has the advantage of providing more freedom for the manufacturer.

It is noteworthy that the URBS project has also used a 20" module because of its suitability for space requirements and because it facilitated obtaining the type of integration required.

Mr. Ehrenkrantz

The selection of the module becomes an extremely interesting subject particularly when investigating the use of a number of different module sizes. Within any given building system there will be a family of sizes; no one size is going to suffice for all types of products and all activities. The 5' module used in SCSD was very fine for structure. The partition module was 40". The door, plus frame dimensions and some of the folding partitions conformed to a module of 30".

One of the most important requirements is to develop not only the concept of a single modular dimension, but a group of related sizes for different functions or activities. I do not think that it makes too much difference whether the choice is from 60" down or from 20" up. The important thing is the ability to co-ordinate different products developed to appropriate and anthropometric sizes both in terms of the function within the building and in terms of the process of building so that progesss can be made in an effective manner. One of the most exciting aspects of our work in SCSD has been the development of related components each sized to their own activities and having common meeting points at appropriate dimensions. Instead of having a building design wherein each product is of exactly the same size with the ensuing problems in terms of tolerances, the relationship of a group of differently sized products working together provides an opportunity for aesthetic variation, as well as an opportunity to screen different dimensional problems in a rather exciting way.

Question: THERE IS CONCERN ABOUT A NUMBER OF THINGS IN THE SYSTEMS APPROACH TO SCHOOLS DEVELOPMENT; THE ARCHITECT MAY TEND TO LOSE CONTACT WITH AN AREA

IN WHICH THE PROFESSION HAS BEEN EFFECTIVE IN PROVIDING GOOD EDUCATIONAL ENVIRONMENTS. SECONDLY, THE COMPONENTS AND SUB-SYSTEMS ARE DEVELOPED AT CONSIDERABLE EXPENSE AND ARE OF LIMITED USE THROUGHOUT CONSTRUCTION. CAN YOU COMMENT UPON THESE?

Mr. Jonathan King

I am not satisfied with the kind of environment that is being provided in conventionally designed schools throughout the United States and Canada. So, I really don't think a shift in control of this provision is likely to lead to a serious deterioration. I suspect from our work in California and what I see happening in Canada, that it may even be a substantial improvement.

Mr. Ehrenkrantz

Controls still remain with the architect. We have gone through a process that involves the architect at every stage in the development of systems components and we have gone through particular procedures that have made it possible to provide new products and put them on the market. If I can describe just one incident -- two English architects visited us last summer to take a look at a SCSD building. On the way back, they visited factories and other schools that have been built around the country and happened to call on a well known architect. They asked the architect what he thought of systems building. He said that it is impossible, that he never would have anything to do with it and didn't believe in it. Then they asked if he was aware that the unit on the roof was an air conditioning system that was designed for SCSD. He replied negatively. This points up one of the benefits of SCSD, that it has become a vehicle to bring new products into being. Once these products are used initially, they become part of the regular building industry and provide better performance for the dollar. This gives architects an opportunity to design better buildings for their clients.

Question: CAN THE PERFORMANCE REQUIREMENTS DERIVED IN THESE VARIOUS SCHOOLS PROGRAMS NOT BE APPLIED LESS EXPENSIVELY BY CONVENTIONAL OR TRADITIONAL CONSTRUCTION METHODS? IT WOULD SEEM THAT SINCE SYSTEMS BUILDING IS GENERALLY MORE EXPENSIVE THAN TRADITIONAL, THE APPLICATION OF THE SYSTEMS PERFORMANCE REQUIREMENTS IN TRADITIONAL CONSTRUCTION WOULD RESULT IN BETTER QUALITY SCHOOLS AT

LOWER COST. CONVERSELY COULD CONVENTIONAL COMPONENTS BE USED TO SATISFY THE DERIVED PERFORMANCE REQUIREMENTS OF THESE VARIOUS SCHOOL STUDIES?

Mr. Jonathan King

If the performance requirements for systems schools are applied to conventionally constructed schools, the cost of the schools would be so high that they would not be built. Consequently, it would not be possible to take the user requirements, and the performance requirements developed, say, in SCSD and apply conventional components to them. As an example, many of the same performance criteria are met by the components employed in the Seagram building, but their application cost something in excess of $60.00 per square foot, which is more than most people are willing to pay for schools. However, in the Pittsburgh project in which Mr. Ehrenkrantz is involved, components are being designed and put out to bid because there is simply not enough time to go through the kind of industrial development process that was involved in SCSD, SEF and RAS.

Another consideration in this connection is one which requires a certain degree of modesty on the part of the architectural directors involved in these programs. That is an assumption that manufacturers of partitions and manufacturers of structural members and manufacturers of ceiling lighting systems may be able to bring to bear on the problem, kinds of intelligence and economies that are not usually recognized by the typical architects. Therefore, better products for the money may result from the creative efforts of the manufacturers as well as the creative efforts of the architect.

Mr. Robbie

The products available to the architect today, as Mr. Ehrenkrantz mentioned earlier, have all kinds of vertical standardization within given categories. Integration horizontally between categories is virtually unknown; hence the $60.00 per square foot cost of the Seagram building.

We felt that we ought to get both vertical and horizontal integration in school building coupled with much higher performance of the environment than we are presently getting. All the required flexibility, air conditioning, carpeting, etc. is obtainable economically only by the systems approach method. If it were possible to obtain the requirements by conventional procedures they would exist already. The derivation of performance requirements and ensuing developments of manufacturing procedures makes possible the economies of mass production. A program, meeting the requirements needs commensurate developments in bidding procedures. We wish to obtain better architectural environment and as far as we can see, our only way forward as an industry is by the systems approach route.

Mr. Corriveau

The main objective of our program is a reduction in cost and the main method of achieving this is by mass production. This is part of what we call the industrialization of construction. This is why the dialogue between the client and the manufacturer is opened by the specifications so that mass production will be a possibility. Otherwise if the specification is given to each individual architect there will be as many systems as there are schools. We expect to have mass production of all the systems by our methods. In other words, the desired result will be a manufacturer's catalogue of components which may be purchased and used by any architect afterwards. By this method we expect to reduce costs and this is the main objective.

LUNCHEON ADDRESS, Tuesday, April 30, 1968

LUCIEN LALONDE

To most of us, this conference has shown that a systems approach to building has indeed many elements. One of these is modular co-ordination, and it is with this aspect that the Department of Public Works is particularly concerned at this time.

I therefore propose to confine my remarks to this element of the systems approach.

As you are no doubt aware, the Minister of Public Works announced late in February that DPW will be going modular within a year. The announcement had considerable impact, judging by the amount of editorial comment, both in the popular press and in the trade journals. I am happy to say that comments have been favorable.

Our adoption of modular co-ordination has generally been hailed as a desirable step in the direction of a more productive building industry. Several editorials have since advocated that all federal departments involved in construction should follow suit, making modular co-ordination universal at the federal level.

There has been encouragement across the board, with exhortations that provincial governments also join the modular club, as a necessary step towards the development of systems building on a Canada-wide scale. The architects have fallen in behind us - the Ontario Architectural Association recently came out in favor of a recommendation that the provincial government adopt modular co-ordination. Central Mortgage and Housing Corporation also recently announced their support of our decision.

It is nice to have the assurance that in moving to modular co-ordination, we are not treading on anybody's toes. But when you consider the preliminary studies that led to our decision, the response is not too surprising. There has been, after all, a great deal of discussion of modular systems in recent months.

When the votes were counted, after what amounted to a survey of the industry through the BEAM program, it looked as though everybody was in favor of modular co-ordination, and waiting for someone to start the ball rolling. Knowing this, we were in a position to implement a modular program without having to resort to the arm-twisting methods of the hard sell.

Neither did we pluck modular co-ordination out of a hat. It did not suddenly occur to one of our more promising young executives that it would be a good idea if the Department of Public Works went modular. Our architects have been generally familiar with modular co-ordination for years, and our manuals have laid down standards for working with modules for some time.

But we could not unilaterally dictate to you, the construction industry, where and when modular should be adopted. First, because we do not have the desire to dictate. As a department which perhaps more than any other relies on a smooth working relationship between government and industry, we like to be assured that our policies have popular support with the builders. Secondly, it should be patently clear that modular co-ordination simply will not pay the dividends we hope from it without that support.

The BEAM Program gave us the assurance we wanted, and we have gone ahead with our program. In case there are some who have not been reading the papers, our modular program can be outlined as follows: first, the methods and standards for working with modular have to be made familiar to all employees of the department who will work on it, including architects, engineers and draftsmen. For this purpose, a team from our Design Directorate has been conducting seminars in DPW shops across the country. I am told that they have met with enthusiasm at every stop.

By the time the seminars are completed, about mid-May, all our personnel at headquarters, in each region, and at the district level, should have a sufficient working knowledge of modular. As the regions become sufficiently familiar with the system, each will begin to use it in all work designed exclusively by DPW personnel.

A pleasing indication of the kind of support we are getting was the invitation extended by the Halifax chapter of the Nova Scotia Architects Association to our design team to speak to their members on modular co-ordination while they were in the area. This sudden upsurge of interest may stem from a desire not to be left out of any fat government contracts, but I prefer to think that having read the book, people now want to see the movie.

Following the familiarization of our own personnel, and until the end of February 1969, we will encourage private consultants in any way we can to use modular in designs carried out for DPW. After a date which will be announced, and which we hope will be around the end of February, modular will become a requirement for all consultants working on DPW jobs.

The one-year period between the Minister's original announcement and full implementation of the system has been provided in order to allow all consultants who will in future be doing jobs for the department to become familiar with it and to prepare for its widespread use.

That is our program. There are, of course, a few questions that cannot be answered at the moment. There will undoubtedly be a few procedures that will have to be worked out as we progress. We will have to write modular into our specifications, and while indications are that modular components are and will be available in sufficient quantities, the development of a full-blown modular catalogue would be of great assistance both to us and to the bidders on future jobs.

But our problems should be minor ones, and we have little doubt that modular co-ordination will be a successful step towards more efficient construction; a benefit to both the industry and the taxpayer.

Our Canadian economy is a healthy one, as is amply demonstrated by our general standard of living. I am not troubled by visions of a foundering construction industry in Canada, and neither are you, I'm sure. The efforts of this industry have generally been adequate to the most demanding tasks, and its productivity rates with the best in the country.

But demands increase day by day - indeed, they mushroom. The Economic Council has shown some concern about our abilities to meet the construction demands of the coming decades. While we do notwant to be doom-criers, we must prepare for what the best expertise available forecasts will be a revolutionary increase in demands on the industry.

So we are dealing with more than the cost of providing accommodation for the public service. For any innovation of the sort we are making, a sufficient market has to be available to make the change economically feasible. Our construction industry is a very splintered one, and very few of the myriad units that comprise it are large enough by themselves to effectively influence the whole. It is reasonable then, to look to some source such as the federal Department of Public Works, with a real property inventory that includes more than 35,000,000 square feet of accommodation, to take the lead.

This is what we hope we are achieving in adopting modular co-ordination. If our construction program is all carried out on a modular basis, it provides a sufficient market to render the change to modular in a large segment of the industry economically feasible. Once it is apparent that a portion of the industry is geared to modular, with the anticipated advances in terms of efficiency, it then becomes possible, in fact desirable, that other major users of the industry's products begin to buy modular. Soon, all segments of the industry should switch to modular co-ordination in order to remain competitive.

And although we in Public Works anticipate short-run savings by switching to modular co-ordination, we realize that it is not until the system is used more or less universally that its true economies can be realized. That goal is still, I think, somewhat distant. But judging by the reaction of the industry to our announcement, I am encouraged to forecast that the goal will be reached far sooner than we had hoped when the decision was being considered.

I note with gratification that systems designs are being applied to the building of schools in a couple of metropolitan areas in Canada. School provision is another area of snowballing construction demands, and this is also a reasonable field in which to make a start.

And there certainly is room for improvement in the field of less costly construction of individual buildings. We can increase productivity significantly by tackling the cost problem 'from the ground up' as we recently demonstrated in the Department of Public Works. Long before our decision to adopt modular co-ordination was taken, we were working on methods of reducing the cost of office accommodation to the taxpayer.

After a concerted and imaginative design effort, our architects and consultants came up with a prototype design for a high-rise office building, the first of which is being built at Tunney's Pasture here in Ottawa. The design was a significant success, with the result that we are going to be able to put up a building which will provide well over 300,000 square feet of usable space at less than $18 per square foot. The price is low enough that other governments have expressed more than casual interest in the design. With a net-to-gross space ratio approaching 90 per cent we should indeed have an efficient building design and yet we haven't sacrificed anything in the way of pleasant working environment.

But we as a society still have a long way to go in reducing costs, in increasing productivity of construction. We all know that anything that serves to reduce the cost of housing is highly profitable. Anybody who pays school taxes knows that it would be desirable to get more space for less money. And all of us, taxpayers, home seekers, builders or civil servants would benefit from an increase in the speed with which construction demands are satisfied. What I'm saying is we would all benefit from the widespread use of systems building.

Now, the Department of Public Works cannot by itself bring about this transformation. We cannot, for example, coerce provincial and municipal governments into doing our bidding. We can encourage. We can take a few steps in the desired direction. Other agencies, federal or provincial, can do the same. With the co-operation of all concerned we can clear the way, at least, for the growth of systems building.

At the outset, we need an elaborate, detailed, efficient information system, where communication and co-ordination of data keeps us all, from the manufacturer to the customer, aware of the latest industrial developments.

The BEAM Program is committed to the development of an information system. This gives me cause for optimism, since one of the chief virtues of the BEAM Program is that it depends for its impetus not so much on the recommendations of government experts, but rather on what you in the construction industry, in its various fields of activity, recommend.

The idea of the industry advisory committee - made up of senior representatives of the teaching profession, the designers, the builders - is a highly commendable method of approaching the building problem, particularly in a country where the industry is highly diversified and government takes place on several levels.

An editorial in Heavy Construction News, which most of you probably read, recently stated: "Surely co-ordination of building systems - be it for design of schools, post offices or warehouses - can lead to more economical use of standard components through the nation."

But, and here is the rub: "Unless DPW's proposed modular co-ordination system can be integrated with the other programs, it will only add to the coming chaos."

That last comment is perhaps pessimistic, but it is nonetheless pertinent. In order to be effective, the steps we take must be concerted rather than divergent. Not only must each of us know what the other is doing, we must ensure that the systems we develop are in effect elements of the same basic system.

It is too much to expect that the thousands of interests that make up the construction industry see eye-to-eye in their everyday activities. Yet we all have at least one long-run goal in common. We all stand to benefit from the development of the ability to produce more buildings faster, and for less money.

To bring about this desirable end, we need first of all to recognize that while individually we will achieve little, we can through communication, co-operation and co-ordination produce by the turn of the century as much housing of various kinds as Canada has so far produced in all its previous history.

We are moving in the right direction. If there was no serious consideration being given to a systems approach by the industry, we would not be here. You are attending a conference, after all, which has been arranged through the co-operation of the Royal Architectural Institute of Canada, the Association of Consulting Engineers of Canada, and the Canadian Construction Association. You could hardly launch a discussion of construction topics with more auspicious backing.

This is an ideal forum for the discussion of both the problems and the prospects facing the construction industry. I don't think many of us will go away feeling that we have wasted our time. I hope, in fact, that we will all go away with increased enthusiasm for innovations that will lead to more industrialized building techniques.

If we do not, and if there is not an enthusiastic follow-up to the public works adoption of modular co-ordination, the DPW decision will, a year or so from now, look somewhat like the Cheshire Cat in Alice in Wonderland - it will all have faded away except the grin.

The author of Alice in Wonderland, Lewis Carroll, used to cut some pretty fancy logical capers. One of them has a moral for this gathering. I am sure most of you will recall the passage in which it is explained that you must run as fast as possible in order to stand still, and if you want to actually get somewhere, you must run twice as fast as that.

Well, construction demands are like that. I am sure that we here today will maintain, to the last man, that we are running as fast as we can. But looking a decade or less into the future, I have to conlude along with Lewis Carroll, gentlemen, that we are going to have to learn to run twice as fast as that.

PANEL DISCUSSION, Tuesday, April 30, p.m.

Question: WHAT ALLOWANCES HAVE BEEN MADE IN SCSD AND SEF FOR INCLUSION OF FUTURE ELECTRONIC TEACHER AIDS AND OTHER PEDOGOGICAL EQUIPMENT?

Mr. J. King

In SCSD we were very conscious of pedagogical equipment and worked quite hard at making accommodations for it, but our assumption was that the current pedagogical equipment would change much faster than the accommodations and spaces of the building. Therefore, rather than take a prescriptive point of view, we took a permissive point of view. For example, one of the requirements for the SCSD partitions was that the faces of partitions be independently removable so that conduit, and electric wiring could be run up or down any partition within the building. Also, as Mr. Ehrenkrantz described this morning, there was a five inch free-way for electrical services, TV conduit, and so on in the ceiling lighting sandwich. It is, therefore, very simple in SCSD to make any sort of electrical connection around the building. We also included science laboratory equipment within the SCSD furniture bid and that again was geared to flexibility of use. We did not have time to get into rear screen projection units and things of this kind which, given more time and maybe a little more staff, we might have included in the program.

Mr. Rankin

I would like to add that the academic research done by the SEF group carefully examined the equipment currently available for use by the educator. We fully agree with Mr. King's position that the equipment is changing daily. We have recommended to the Metropolitan Toronto School Board that a performance specification group be set up to look into this area on a specific basis. The present study has included research on such equipment and we have proposed space for wiring and electrical and electronic systems, thus providing reasonable facilities for any type of pedagogical equipment both available now and in the foreseeable future.

Question: COULD MR. WALTERS COMMENT ON THE ROLE OF GOVERNMENT IN THE BUILDING INDUSTRY IN BRITAIN WITH PARTICULAR REFERENCE TO A SYSTEMS APPROACH?

HOW DOES MR. WALTERS FEEL THAT A SYSTEMS APPROACH FITS THE NORTH AMERICAN SCENE?

Mr. R. Walters

It appears to me that the problem facing you, as it faces us in Europe, is not one of technical invention. We are not really short of ideas or technical inventive capacity. We have a problem of organization and co-operation, essentially, and this tends to bring one into a discussion about the role of government. In Great Britain, the active participation of the government in the affairs of the construction industry is only five years old. There was some interest in the industry before that, but not on the scale we have now, and the philosophy behind it is very much one of partnership. We take the view that government should never do anything if industry can do it; government should become involved, preferably only at the request of industry, to participate where industry needs assistance. There is a very healthy attitude towards government in our industry as I am sure there is in yours, but industry likes to get government's help when it is in trouble. When things are going well, however, industry wishes to be left alone. I think this is basically correct.

I am impressed and encouraged, and I congratulate you on this conference because I think you are starting in a most admirable way. The whole concept of co-operation is expressed in the way this conference has been set up. As to how you deal with the problems of organization and co-operation, my personal view is, that having listened to the discussions during these two days, the systems approach, based on what Mr. Ehrenkrantz started with, the Educational Facilities Laboratory in California, and what is now being developed in Toronto and Montreal offers you a favourable way ahead. In other words, I think your principal way ahead is to look for areas in which the client who controls the money and has large requirements for buildings can get together with professional people to discuss user requirements with them, and to investigate how demand can be organized on a large enough scale to create the conditions in which broad industry participation can take place.

This seems to be a method, a process, a system, admirably suited to the North American scene. It does not require the same degree of government or public intervention that we have in Europe. It suits North America very well, it is highly flexible and I would commend it as an excellent way to bring your industry fully into the situation where all sectors are co-operating together to make the Canadian building industry the best in the world.

Mr. G. Corriveau

In reply to the suggestion made, I would like to express the opinion that the BEAM Committee would be the answer because, the idea of a systems approach to building was first expressed by this committee. This committee has taken up this challenge. It has already formed an information committee which was needed by the industry and other organizations. Moreover, it has informed the population and the industry about the work done in this field, putting itself at the avant-garde. It has also initiated the necessary dialogue, and has created the information channels required.

For these reasons I would like to congratulate this committee for the work it has done. This surely places Canada at the avant-garde. This is why I reiterate my initial suggestion that the BEAM Committee assume the responsibility for this problem.

Question: I WOULD LIKE TO KNOW, IN RELATION TO THE URBS PROGRAM, HOW THE VARIOUS PROBLEMS WERE STATED AND SOLVED. COULD YOU ALSO COMMENT ON THE PROBLEMS PRECIPITATED BY PARTITION AND CEILING DESIGN IN PROJECTS SUCH AS SEF.

Mr. E. Ehrenkrantz

The matter is not solved in the case of URBS at the moment because we have not yet nominated successful bidders. There is a group of proposals before the University of California now, and we will be accepting price proposals sometime in June, so I cannot answer at this time. Before I pass this along I would like to say that in SCSD our requirement was for room to room sound attenuation, not for the ceiling per se, and this was left entirely up to the co-ordination of the manufacturers. In the case of the successful bid the ceiling and the ceiling lighting system also served as fire protection for the structure. It was topped by an inch of mineral wool bat and did not degrade the quality of the partitions enough to reduce room to room sound attenuation. This was sometimes left to solid steel panels, occasionally punctured when the fire resistant material was used for absorption of sound as well. There were, however, no particular specifications relative to the ceiling because the real question was how would the system perform acoustically when put together.

Mr. Rankin

In the SEF program, there are requirements that the ceiling must have certain attributes in terms of sound absorption and in terms of reflectance for the lighting ceiling unit. We have not laid down a requirement that it should be a suspended system. We believe that there is a variety of possible solutions which could include a sandwich that is hollow core, a concrete sandwich perhaps with built-in lighting reflectors into which lamps could be placed, thus maintaining proper spaces for atomosphere sub-system duct work and for receiving partitions where required with a jointly proposed room to room attenuation. We have tried not to be specific in terms of requiring a suspended ceiling.

Question: I WOULD LIKE TO ASK MEMBERS OF THE JESPERSEN TEAM AND MR. CORRIVEAU TO DISCUSS THEIR FEELINGS ABOUT HOW THE BUILDING INDUSTRY HAS TO RESTRUCTURE IN ORDER TO MEET FUTURE DEMANDS?

Mr. Holm

This question is difficult to answer because it depends upon who goes into the manufacturing end in this country. It has been done in different ways. When we started in Denmark, the Jespersen organization built a factory and developed a company policy that did not allow the company to erect structures made from their own components. It was Jespersen's idea that he would compete with a colleague in the general contracting field and private contractors would erect the structures. This year, due to a change in the competitive picture, it became necessary to take a large project and carry it through to a finished erection. In Sweden, our licensee operates in both ways; he sells components to contracting firms, (general contractors who buy from him), but he also has a department which erects and takes turnkey projects. The Laing organization in England contracts for turnkey projects only. The organization of a business depends directly upon the licensee's purpose.

Mr. Corriveau

Our total program for the IRNES system includes approximately 3 million square feet of schools spread over a period of 3 years. I think personally that the modification, the main change in the industry will come in the form of changes of habits rather than from the possibility of continuous production or production capacity because I do not see that 1 million square feet per year for 3 years will really create an impact on the production capacity of the industry. It seems there will be plenty of time to modify methods of production according to new ways of thinking. It will be a different approach to the solution rather than changing the whole possibility or capacity of production.

Question: COULD THE PANEL COMMENT ON THE CONTRACTUAL AND WORKING RELATIONSHIPS BETWEEN CONTRACTORS, SUB-CONTRACTORS, MANUFACTURERS ETC. IN THE SCHOOLS SYSTEMS DEVELOPMENT PROGRAMS?

Mr. Rankin

The general contractor will assume his traditional liability just as the other professionals will assume their liabilities in their individual fields. As Mr. Robbie pointed out this morning, the sub-system tenderers who are successful for each sub-system will obtain a contract with the Metropolitan School Board. This contract in turn will be assigned to the six Borough Boards for the schools participating in the program. The design teams working for the individual school boards will utilize the products, the systems and the sub-systems produced to construct the schools. The specification will be written. What in fact we are doing is asking for a pre-bid of 75% of the building.

The general contractor's role of on-site coordination and organization does not change. The general contractor maintains a traditional control. In terms of the programming of the work, he will work in a slightly larger context in SEF because the Metropolitan Board will be setting up a co-ordinating agency to assist as a clearing house, not as an arbitrator but as an assist to all other people building schools in the SEF program and the general contractors will deal with that Board. The general contractors will have the approval or an approval requirement for each of the sub-system contractors. The sub-system contractors are required to install their systems; the general contractor will have fewer labour personnel with whom to deal than in his traditional role.

Question: IS IT PLANNED TO PUBLISH THE PROCEEDINGS OF THIS CONFERENCE AND WILL THIS CONFERENCE BE FOLLOWED UP BY OTHER CONFERENCES OF THIS TYPE? WILL THERE BE MORE CANADIAN CONTENT IN FUTURE CONFERENCES?

Mr. Hindson

We are planning to publish the proceedings of this conference and make them available to all who attended, and as a service, make them available to the design professions and to industry.

You asked if there are going to be more conferences. This will be partly dependent upon you and upon the other people in the audience, and upon the action this conference generates. We have made no commitments in this regard so far. The Industry Advisory Committee, after this conference has concluded, and after they have had the time to assess the conference, will consider future action and recommend accordingly. But again that recommendation will be largely dependent upon the action and interest that is generated by the conference throughout the country.

On the question of more Canadian content, I think that Canada has been well represented. Canadian content has been rather considerable. One advantage arising from our choice of speakers is having people from Denmark, from England and the United States whom Canadians would not ordinarily have the opportunity to hear, to talk to and of whom to ask questions. It is almost like an industrial mission in reverse; instead of organizing a small group of Canadians to visit Denmark, the United Kingdom, the United States or other countries, we invited these various speakers to come here so that many more Canadians can hear what they have to say. In the case of an industrial mission, a maximum of ten people would have such an opportunity. We are very grateful that they came here to make their presentations to the five hundred participants at this conference.

Question: COULD YOU COMMENT UPON THE DEGREE OF VERTICAL INTEGRATION NOW TAKING PLACE IN YOUR INDUSTRY AND UPON THE EXTENT OF THE TREND TOWARDS SYSTEM BUILDING. WHAT HAS BEEN THE RESULT FROM THE POINT OF VIEW OF MANUFACTURERS BECOMING INVOLVED IN INSTALLATION WORK AND WHAT NEW FORMS OF ORGANIZATION HAVE EMERGED?

Mr. Petersen

The question of integration cannot be answered briefly. There are obvious developments towards integration in Denmark and it is a growing trend both horizontally and vertically. Our objectives are to build apartments economically. The buildings are produced by components from many different manufacturers. One could say that the supply of concrete wall components is just a subcontract comparable with the supply of refrigerators. But this is not wholly true; refrigerators and kitchen cabinets are produced for the open market in the usual way. It is not as natural to assume that concrete components can penetrate the open market in this way. It can be done, however; it is done to a certain extent in Denmark. Modular coordination provides the answer and now there are 4 or 5 factories around Copenhagen which supply dimensionally identical floor components and/or wall components to the open market.

On the other hand, these factories producing concrete products have a relatively high investment compared with the turnover. Therefore, they are financially rather sensitive and for the most part are linked with a building system. Most of them are also linked with a contracting business and thus there are contracting firms providing their own components. Again a firm erecting its own concrete components may also bid for contracts within the construction industry involving the erection of components not produced by the firm. There are these various alternatives.

There has been, in Scandinavia, a certain trend toward another type of integration where the client, the design team, and, shall we call it a management contractor (I think this term was used yesterday), integrate into one organization. The integrated team then finds manufacturers who can supply the walls, floors, cabinetry, refrigerators, etc. It appears certain that developments such as this will evolve with innovation and research. I can also foresee that architects, engineers and site managers will lose their identity to some extent in working within integrated teams; but whether that situation will expand into package deal arrangements, I cannot say. There will certainly be markets open to the integrated client organization and for designs which include flexibility in layout and other innovations, and in which manufacturers behave generally as subcontractors.

Mr. Wood

This rather depends on the prevailing conditions, I think. Where the erection of the components or the fixing of the components calls either for special plants which most contractors do not have, or for special skills which most building labourers do not have, it is almost certain that the erection has to be controlled in the early stages, at least, by the component manufacturer. When brick is produced the producer knows that he does not need to have his own brick laying team, but in producing a concrete wall panel, the necessary heavy cranes for handling are not usually easily available and not many workers have the skills for erecting the panels. It is, therefore, essential for the manufacturer to erect the panels himself. It is quite likely that the time will come when such panels become standard components. Then there will be trained teams for the erection of panels, and there will be contractors' cranes available for their erection. In time, manufacturers may not have to do the erection work.

Mr. King

Mr. Auerbach mentioned the Place Ville Marie development in Montreal and in this connection, I think it is very important to keep in mind that within the context of systems building and industrial development, projects like Place Ville Marie probably cost a great deal more than the sum total of the schools built under the SCSD project. The Place Ville Marie project may be of sufficiently large scale that it can itself serve as a vehicle for industrial development. The typical college dormitory would be, by comparison, a small project and one which will not of itself serve as a development vehicle for better components.

Regarding the second question, the bids in SCSD were based upon installed prices. This requirement was not because of absolute conviction that this was the most intelligent way to get the buildings constructed, but simply because we did not know whether or not we could nominate bidders unless we knew what the products cost, installed in the building.

Some of the SCSD bidders were in the normal habit of installing their own products in buildings and some of them were not; the question then became one of decision as to which group could accommodate the project best and which technique worked best. We also forced, by the nature of the bidding, a number of manufacturers to get into kinds of subcontracting outside of their normal scope. For example, everywhere in those buildings at five foot centres is a spider, serving to integrate the ceiling, the structure and fulfil a number of other functions. Inland Steel Products who successfully bid the structure could not manufacture the spider and had to ask "Fastex" to manufacture them. "Fastex" only makes fastening devices for industries other than architectural industries. Inland successfully bid the ceiling system consisting largely of steel which they could fabricate, but did not fabricate the light sticks, so they went out and purchased these from yet another firm. In effect, this simplified the process from the standpoint of the SCSD staff. Rather than the staff becoming involved in all of the small details of every one of the little pieces making up the building, the procedure was simplified in these four major component categories.

Question: CAN YOU COMMENT UPON THE LABOUR RELATIONS ASPECT OF THE SCSD PROGRAM, SUCH MATTERS AS JURISDICTIONAL DISPUTES, ETC.?

Mr. King

We experienced a minimum number of problems in connection with the trade union aspect of SCSD. I think the reason for this was that we approached the Joint Labour Council in California early in the project and asked them to assist us with any problems of a jursidictional nature that arose. There did not seem to be any serious problems except in connection with plumbing. We, therefore, decided not to proceed with any systematization of the plumbing for those schools. It was not a very significant slice of the financial pie, in any event.

Jurisdiction has proved to be a problem in other areas, of course. For example, there are problems in bringing lighting fixtures into New York City that are not manufactured by Local No. 3. If they are brought in the Union will take them apart and assemble them again, and this becomes rather expensive.

We found with several other systems projects that the unions have acted extremely well. I know of one major city where a trade practices case was recently taken to the Supreme Court and won. We thought there would be a very negative reaction on the part of unions following this. We discussed it with the unions. Their feeling was: "Don't come to us with a fait accompli at the end of the program, come to us early, let us discuss the problem and we will see if we can make some allowances because we are as interested in good schools at low cost as anyone else."

Altogether we found a good deal less trouble in this area than we had anticipated but unless it is anticipated, there are likely to be problems.

Question: CAN YOU PLEASE COMMENT ON THE UNITED STATES GOVERNMENT SYSTEMS APPROACH TO OFFICE BUILDINGS?

Mr. King

I can see no reason why the GSO building program for offices in the United States should not be used as a generator of building systems and components just as the programs of the major school systems have. There has been considerably less work done in either the United States or Canada-- as far as I know --on the performance requirements for office structures than on the performance criteria for school and collegiate buildings. I am not entirely certain why more has not been done except that I think there are very few corporations which build office buildings in large numbers. They tend to be built one at a time in most cases and the Government, generally speaking, is not taking any leadership position on this subject in the United States. But it seems to me that there are certain obvious criteria in connection with office design that would provide for a very acceptable opportunity for a systems approach.

Mr. Walters

In the United Kingdom, we have had what we call development groups in existence since the 1950's and these all operate in association with public authorities and with the central government. Essentially these are groups which are both studying user requirements in depth and developing new technologies and setting up development programs. There are development groups operating on housing, on school buildings, on hospitals, on office buildings, on quite a number of building types connected with the Armed Services and even on prisons. In other words, in each of the building type situations where the public sector is the principal client, there are now organizations which provide for this kind of work to be done. For example in the office building field, serious work is going on, including development projects on the concept of open offices, which would be familiar to some of you. This is getting away from the concept of putting everybody in a separate box and involves very interesting problems not only for the designer of the building, but with relation to activities and social attitudes of people working in offices.

The question is how many such situations can an economy create and deal with effectively. It is quite clear that in Canada, such work is successfully being done in the school building field. I think it is simply a question of looking around for situations where there are clients, either a very big one having a very large development project, to which Mr. Jonathan King quite rightly referred, or else a number of clients with common interests who are prepared to come together recognizing that they have a common problem to solve, and are prepared to finance the setting up of the research and development program similar to the existing schools programs.

Question: CAN YOU PLEASE COMMENT UPON THE FACTORY MAN-HOUR REQUIREMENTS FOR THE PRODUCTION OF ELEMENTS?

Mr. Holm

The Danish factory is rated to produce components for 2,500 apartments per year, each approximately 1,000 square feet of floor area. That is on a two-shift operation which we have found to be the most efficient. On a two-shift operation, the plant will produce concrete elements of 325,000 square meters of combined floor and wall areas, or 3 1/2 million square feet. In order to man the plant for two shifts, we have 60 operators and maintenance crew, and 7 managerial and supervisory staff. The average total man-hours per square meter of element is 0.4 or 4/10 of one man-hour per square meter or approximately 4/100 of one man-hour per square foot of wall or floor produced.

NATIONAL CONFERENCE

ON

A SYSTEMS APPROACH TO BUILDING

Skyline Hotel
Ottawa

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1968

RAPPORTEUR'S REPORTS

SESSION 1

RAPPORTEUR: Mr. David C. Aird

"The Design of a More Human Environment" - Mr. Guy Desbarats

"The Need for a Systems Approach to Building"
- Mr. Ezra D. Ehrenkrantz

"The Role of the Designer Team in Developing a Systems Approach to Building" - Mr. Roger T. Walters

"The Manufacturer/Contractor and the Systems Approach to Building" - Mr. Kenneth M. Wood

SESSION 2

RAPPORTEUR: Mr. H. Brian Dickens

"A Systems Approach to Housing and Urban Development"

- Mr. Marius Kjeldsen
- Mr. Johannes F. Munch-Petersen
- Mr. Jens C. Holm
- Mr. Erik Andersen

SESSION 3

RAPPORTEUR: Mr. Guy Saint-Pierre

"A Systems Approach to School Construction"

- Mr. Jonathan King
- Mr. Ezra D. Ehrenkrantz
- Mr. Roderick C. Robbie
- Mr. Gérard Corriveau

SESSION 1

RAPPORTEUR: David C. Aird

I should like to refer to Mr. Guy Desbarats' remarks which set the tone of the conference and defined the systems approach. As he stated, "there are many definitions of the systems approach to building". In essence, however, the systems approach is an extension of the scientific method or any other logical presentation in which we first state the problem, construct a model, test that model, check the test and the results, and apply the knowledge developed.

In incorporating modern methodology into the construction industry, we must do a number of things. First, define the market. Second, recognize that the market has goals and problems. Third, construction is a sub-system of the market and as such must participate in setting the market's goals. Fourth, construction must have its own set of goals. To do this, there is a need for considerable research.

Briefly, the significant problems relating to this methodology were pointed out as these: that there is a lack in the construction industry of long-range planning; that there is very little research of significance being done and none at all in component assembly, which is the heart of the applied form of a systems approach in construction; that there is a low rate of innovation in our industry; that our rate of innovation is about one-half that of the national average of manufacturing industries and about one-twentieth that of the electronics and other growth type industries; that we have a one-shot approach to design and that within this context of a one-shot approach, the architect falls outside of the construction cycle, with all that this implies. What is really required is a need for higher aspirations by those who manage and direct the construction industry, not just merely improved concepts that are required but new concepts. Mr. Desbarats warned us against extrapolation of our present ignorance, an expression which I like very much.

Mr. Ezra Ehrenkrantz put forward his thoughts and philosophy in concise, well-organized terms. He traced for us an historical and traditional evolution of our disciplines. He indicated that these have had the effect of fixing habits which are not particularly or necessarily suited to our present times and conditions, logical though they may have been at the time of their evolution.

Industrialization had been slow and narrowly limited within the construction industry. Intermeshing of components which were industrialized relied heavily on manual assembly at the site. But today we are approaching increased industrialization with many more components available. Environmental factors have become of much greater concern to those who are involved in design and living with the products of design, and our aspirations for society at large have increased. But, against this there is a wide gap in terms of the performance of the industry to meet these new requirements, and performance has not kept pace with the available technology.

He indicated that this is perhaps a reflection of the construction industry self image as a service rather than as a producer. He pointed out that service industries are generally low in productivity and are in effect subsidized by the production industries. By extension he theorized that perhaps construction is being subsidized in this manner.

To change will require either adaptation from within or innovation by invaders coming from outside the industry. He noted that it is very difficult under these conditions for people within the industry to innovate and left the warning that we - the construction industry - might be faced with invaders. The solution, according to Mr. Ehrenkrantz will require major changes in society and a need for construction to set its own goals. I wish to emphasize this point because it is crucial, recurring throughout all of our lectures; the need for the industry to set goals, including specific market goals.

Mr. Ehrenkrantz provided us with details on a number of interesting factors that relate to the problems, including the definition of user requirements as needs. These needs could be expressed as "performance standards", as in the cases of the various educational facilities development programs in North America. In this connection, bidding for construction projects might better be based upon considerations of annual, or as he refers to "moving out" costs rather than initial costs which are really only in the order of ten or fifteen percent of the total outlay by the user over the life of the facility. Also there is the need to move to more management contracts as a logical development of the systems approach.

Mr. Roger T. Walters spoke about the problems that are facing the industry and the solutions they have attempted to achieve in Great Britain. He summarized the problem very simply as that of applying the lessons learned in product manufacturing industries to the process of building. These lessons he enumerated as follows: Creating a large market; (again we see the reference to marketing and sales), standardizing the end product; continuous production; institution of quality control measures; and finally planning the input, process and distribution as an integrated system. These are the lessons from product manufacturing that need to be applied to construction and building.

He took a realistic approach in pointing out the differences between product industries and construction, and why the lessons learned in the former have not easily been transferred to the latter. Buildings are not portable and in themselves create the environment. They are not purchased like other commodities but are intrinsically specific to the customer, who is not necessarily and not usually an individual.

Mr. Walters emphasized a very important exception to the above situation -- that of private enterprise housing. Here the product is sold to an individual rather than an organization. The difference is so fundamental that a systems approach to building will probably develop in one way for private enterprise housing and in another for other building types.

The emphasis in the building industry as he sees it developing, is the need for a continuous market. The lack of this assumed continuous market has prevented the private house building industry from adopting procedures which are more closely allied to product industries as we know them.

Turning to other types of building construction, he pointed out that building technology and rationalization have progressed most rapidly in the public sector where organization of requirements into large orders and continuous demands has taken place. Only the public sector in the European experience has been able to carry out this task of developing a market which is large and continuous. Quoting Mr. Walters precisely, "the systems approach is necessarily dependent on someone, somehow organizing a large and preferably continuous demand. This results in what is termed a 'program' approach, the main feature of which is that it must be initiated by the client."

As an alternative we could use the "model" approach in which all buildings are treated as consumer durable products. The "model" approach is accomplished by process-oriented, integrated organizations, within the construction industry itself, not by the client. This approach results in "closed systems" dependent upon large volumes but which do not necessarily need to be compatible with other systems and therefore, are perhaps less inhibited. Less difficulty is involved in marketing this type of system if the vendor is prepared to develop the market and has the resources to do so.

A compromise of a sort is the third approach -- the "component" approach - with agreed standardization of preferred sizes, fixing positions and compatible joining. In this approach - the "component" approach - the contractor becomes a highly efficient assembler. The "component" approach depends upon agreement on conventions by all suppliers and by the assumption that large economies can be realized in spite of the fact that the whole process is not an integrated system.

Mr. Kenneth M. Wood gave us an idea of the problems faced by an organization which has gone into the systems approach. He spoke from a point of view of the manufacturer/contractor. He outlined the criteria for successful systems building: First, the plant output must be maintained at a very high level, over a long period of time. Second, the plant cannot be amortized over one contract and, therefore, the building system itself must have a long life.

The maintenance of a large demand and a continuous demand depends upon at least five factors as Mr. Wood enumerated them. First of all, the system must be a functionally effective system offering speed or cost advantages over conventional methods. Second, the system must not only be efficient in itself on a general basis but efficient in each individual contract. Third, the system must come under continuous review and improvement. Fourth, the system must have an adequate sales organization, (again the market aspect). Fifth, the system must be unaffected by government or regulation changes. I suspect this is something about which he feels quite strongly.

Mr. Wood discussed the relationships which exist between those who manage a systems approach. He pointed out that, in his opinion, the manufacturers of the key components must be responsible for site assembly and therefore presumably take the dominant role. But in fact organizational matters can take a number of forms. There can be domination by the designer and this we were warned makes it difficult for manufacturers to control profitability in the earlier stages. Very often, under this arrangement, the manufacturer/contractor would end up having to withdraw or be forced to withdraw due to failure. He did not recommend domination by the designer. Domination by the manufacturer/contractor is the basis of most European systems. He points out that the deficiency appears to be of increasing sophistication of requirements, making given systems less successful as the years pass.

Mr. Wood recommends the third arrangement, which is a partnership arrangement between the designer and the manufacturer/contractor, without domination by either but with a close and intermeshed working arrangement. This has been difficult to achieve in the European context. I gather it has been more feasible because the client and the designer in many cases are both in the public sector. In any event, this is the best arrangement if it can be accomplished and, almost necessarily, a result of this is the "model" approach in contrast to the "component" or "program" approach.

I would like to say that from these four lectures a number of important thoughts came through to me. First, the major problems we are dealing with here are not technical problems and in this regard, I say that no technological break-through is required. We have most of the required knowledge and the ability and the skills available now for solving our problems. Second, there is a need to mesh together the ambitions and needs of society with the performance of our industry - our construction industry and design professions. At present there is a wide gap between performance on the one hand and the aspirations, needs and ambitions of our users and buyers on the other. Third, performance to date by conventional methods has failed to meet the demands of society and, therefore, if the systems approach is to be adopted, the industry and the professions must re-assess and review their capabilities and potentialities. They must recognize that they comprise a sub-system of a broad social system, with the need to set goals, objectives and particularly develop a marketing orientation. There must be close co-ordination among all the professions, the contractors, labour and the clients. Existing disciplines in themselves are incomplete and incapable of solving the construction problems.

We have heard a great deal about our social problems; for example, whether designers are really humanists as they would like to consider themselves. Are they sensitive to other people's needs? - the other people being the users who have to live and work in the product of the designer's designs and construction. Or, are they simple artists who are sensitive to their own needs but not necessarily to those of others? I am a user, and not an artist and I have seen some severe short-comings.

There must finally be acceptance of the need for continuing change, in organizations, management structures, methods, design philosophy, client roles and society's needs. I believe that our speakers were pretty well unanimous in developing this theme and that these are the problems that confront us and have to be solved.

SESSION 2

RAPPORTEUR: Brian Dickens

Representing as I do, the Division of Building Research of the National Research Council, I have had a great interest in the developing field of system building in recent years. I personally and some of my colleagues have been privileged to visit Europe on occasion to inspect some of the projects including those of the Jespersen system described to you yesterday. You may have seen papers by one of my colleagues, Mr. R. E. Platts who spent 12 months based in the U.K. and travelling extensively in Northern Europe examining these new developments and reporting on them for our Division.

There was a great deal of interesting information presented by our guest speakers from Denmark and from the comments I have heard I think they have contributed much that is of interest to you and that you will take away from this conference. You have heard first-hand from people who are intimately concerned with the development, the processing and the construction of a building system.

The first paper dealt with the industrialization of house building in Denmark as background to the development of the Jespersen system. This was followed by three papers describing the design philosophy, the manufacturing operation and the site organization of that system. The first paper was by Mr. Kjeldsen and the three following papers were by Mr. Munch-Petersen, Mr. Andersen and Mr. Holm. In discussing their contribution, I propose to summarise what I think are the underlying principles which emerged from their papers, review with you the key points and attempt to relate them to Canadian conditions.

Denmark is a relatively small country, but we should recognize that the Danes face similar problems to our own in terms of their urban housing situation. Their people are grouped in growing pockets of population as ours are. They have a desire for high quality housing and this has to be designed for relatively cold climates. They have a proportion of multi-family housing very similar to ours and they have private contractors producing this housing. There is one significant difference; the client, as we heard, appears to be a large non-profit society or co-operative or even the state, and as my colleague, Mr. Aird, pointed out in his summary of the Session 1 discussion, this has significant implications for the development of system building. The tying of state credit or state support to long term planning can foster market continuity and therefore continuity of production.

This is obviously of considerable importance. As Mr. Kjeldsen stated in his opening remarks; industrialization does not begin with a new building technique, it begins by creating conditions that promote the development of industrialized building. These conditions he cited as: uniform building regulations preferably tied to performance requirements, a high degree of national standardization combined with dimensional co-ordination, long range planning and continuity of production.

It is significant, I think, that system building has seen its greatest advance in areas of strong government participation. This was very evident at a conference I attended, held under the auspices of the Economic Commission for Europe. Here it became plain that the countries with strong government direction of the building industry were the ones which had carried the building system to its greatest development.

In Canada, where housing is privately initiated and where the client demand is not readily organized, the necessary conditions for the development of a market to make it viable for new systems such as we have heard described are difficult and complicated further when a government decides to use the building industry as an economic regulator. Within these limits, however, I think it is useful to note that the Canadian builder has achieved a great deal. Our own studies of traditional single family housing of wood frame construction indicate there has been a marked decrease in site man hours since the early 1950's; a reduction in the order of from 1100 or 1200 then, to 600 or 700 today. This has been attained simply by organizing the building process around the assembly of the basic shell. Even the so-called traditional builder today, the man who would not be considered a system builder or prefabricator has a 25% labour content in his on-site cost and 75% material content. You should note I am talking on-site costs.

These achievements have been made by what Mr. Kjeldsen described as the rationalizing of traditional construction. This is another phase of the industrialization process and I would like to define the process in the way we normally think about it. It is the reform of an industry by eliminating the waste in labour, time and material. I think you will agree that within this context industrialization can take many forms.

It applies to traditional construction as well as to systems building. The determining factor is the way construction is organized and carried out and not the construction method itself. For example, a well-organized contractor using traditional methods may produce higher economies than someone using the more advanced methods, who is not as well organized. The construction method, however, may well affect the degree of rationalization. This was made very clear in the presentation yesterday and I think is the main reason for the developing interest in building systems such as the Jespersen.

I shall not attempt to summarize all of the many apsects and details provided yesterday on the Jespersen system, but I would like to mention a few of the key ones. The Jespersen system is one example of several concrete systems which have achieved considerable success in Europe in recent years. It is interesting to think that concrete is used here as a single material providing structure, fire and sound resistance and finish. The system features precise, modular precast concrete panels. It is produced in a highly mechanized factory and it has flexibility in floor layout and façade application. In the Gladsaxe Project, we were told that 35 different floor layouts had been possible using 85% standard floor panels and 80% standard wall panels. With this high degree of standardization the project architects were still able to attain a remarkable degree of flexibility in design. The system had been applied to three-storey apartments and up to 16-storey apartments. It has been used for office buildings and has recently been used competitively for one- and two-storey buildings by the development of precast concrete basement panels.

The speakers described several technical developments, mentioning the use of special erection tools developed in making the erection of the system more efficient and vertical battery casting methods which as some of you may know can offer advantages over the horizontal mold system. Of particular significance, I think, is the close tolerance to which the panels are made. This very close dimensional control makes possible dry assembly, an important aspect in view of our Canadian climate. They have been able to carry to quite a fine degree the prefabrication or the systematizing of the mechanical services and the joinery. The finish, you heard, was excellent. No plastering is required. Wall-papering or spray painting is applied directly on the concrete walls and ceilings. When I was in Scandinavia some years ago, I was informed that the elimination of plastering is of fundamental importance if the benefits obtained by a system of this type are to be maximized.

Regarding savings of man hours achieved over traditional forms of construction in Denmark, the speakers explained that the Jespersen system required 400 man hours per apartment compared with 1450 for traditional forms. They mentioned that another 400 man hours per apartment accrued in the factory compared with perhaps 300 to 400 man hours of factory content of materials used in traditional building. The result -- a substantial reduction in man hours. The point most strongly made was that this represented a reduction in skilled man hours in many cases, a matter of some importance not only to the Danes but also to other European countries and to Canada. As our own building needs increase, a great shortage may develop in the crafts.

Initially, this reduction in man hours was the main concern but naturally the object of reducing costs was also of paramount importance. Costs were reported to have been reduced to the extent of 15% in direct savings and another 5% for shorter construction financing.

One aspect which I think was dominant above all others in the presentation was the question of management; the most important single factor, it seemed to me, in the success of system building. The systems approach, as was described, uses the site as an assembly line extension of the factory. The high quality and the productivity attained is obtained only by the co-ordination of the entire process, design and assembly. This is accomplished in a unique way. The Jespersen organization ties these two processes much more closely together than is common in Canada by using the design co-ordinator and the site manager in rather different ways than we do and by achieving a close working relationship between them. It suggests that our traditional methods of planning, administering and executing building contracts may need some revision if we are to attain the benefits offered by system building. Perhaps the most urgent need is for improved communication between designer and builder. The architect in his traditional role in Canada does not attain a close relationship between design and production. This suggests that we may need changes in our contractural procedures. We are all aware of the idea of the package deal and the negotiated contract. Some of us are concerned because it affects the customary approach to competitive bidding, but perhaps this needs to be re-examined. The designers need improved knowledge of construction methods if they are to take advantage of systems so that the assembly can be more closely integrated at the design stage.

In summary, it seems evident that system building is not a radically new building technique; it is rather an evolutionary one. The speakers illustrated that like any other development it is affected by top level decisions. Planning and building policy on a national scale can profoundly influence the form and extent of system building. If it is to be widely used, large scale production must be actively encouraged and planning should proceed in close collaboration with the industry and be flexible. There seem to be two cardinal economic principles for us in Canada. The first is that we had better make certain we select systems that are adapted to the size and type of contract involved; and second, we must avoid the situation where too many systems are chasing too few contracts.

Given the right climate, acceptance will depend on the technical competence of the system, the overall cost and its acceptability to the user. Finally, I would like to remind you of the four P's that Mr. Kjeldsen brought out very nicely in his summary: Programming, Projection, Planning and Production. I would like to add a fifth: Profit.

SESSION 3

RAPPORTEUR: Guy Saint-Pierre

Having just heard the remarks made by our four speakers this morning, I have no intention, at this moment, to summarize their speeches but instead will underline the most important ideas expressed by them. Mr. Jonathan King, Vice President of Educational Facilities Laboratories, has made a review of the excellent work done by this non-profit corporation established by the Ford Foundation to help schools and colleges by the encouragement of research, experimentation and the dissemination of knowledge regarding educational facilities. He mentioned that one of the most difficult problems is to obtain from users a clear and rational expression of their needs. Before initiating a component system, E.F.L.* looks for three main criteria: economical solutions, solutions which will give best results, and solutions which will save time in the construction of schools. He added that the creation of an adequate market is a prerequisite before the industry can be expected to carry out the necessary research to develop a system building.

Mr. King reviewed the work done by E.F.L. for which the main realization so far is the School Construction System Development (SCSD) in California. In this project, the demands of thirteen independent school boards have been united during a six-year period and a building system with five major components was developed. Quoting directly from Mr. King he said, "I do not believe that we have effected important savings on unit costs, but, on the other hand, I believe that for the same price, we obtained a better product, a product which gave the school an improved learning environment. The traditional systems were unable to offer such improvements at the same costs."

Mr. King commented briefly on other projects by the E.F.L. group. Essentially, he said that the main benefits were: first, the possibility to have now school developments that were non-existent in the past; second, a better knowledge of needs in the field of educational learning; and third, a new look in our school buildings.

I would like to congratulate the E.F.L. group not only because of their financial participation in research programs but also for the excellent documentation on school construction they have published.

Referring to Mr. Ehrenkrantz's speech, the Chinese saying that one picture is worth a thousand words, seems appropriate. Since he presented close to 100 pictures it means that I have to summarize 100,000 words. Briefly, he emphasized the need for well defined user requirements and for the proper translation of these user requirements, which are essentially related to educational specifications, into performance specifications, thus allowing the designer and manufacturer to bring forward satisfactory and economical solutions to these user requirements.

This is a new task. In the past, conceptual and creative work was assigned to professionals on a project by project basis for all sorts of reasons, professional fees probably being one of them. By grouping a series of projects together, however, meaningful research into defining user requirements much more precisely than has been done so far can be accomplished. Mr. Ehrenkrantz gave us a very good example of what exactly has been done at SCSD , and the type of interflexibility that has been obtained. In view of the major investment in social capital in the United States and in Canada the progress being made in the field of student housing is undoubtedly very pertinent to our problems today. He summarized by saying that no fewer than 800 schools using the SCSD system and sub-systems have been constructed so far. In the years to come, these developments will have a marked effect on school construction in North America.

Mr. Ehrenkrantz touched briefly during the question period on the new roles of consultants. This also applied to the new roles of manufacturers, contractors and school boards. By using the well-known five basic human needs of McGregor, one may wish to say that in the future we might move from a need for security to a more sophisticated need for a sense of fulfillment and participation. I presume that once we have gone through the transition period everyone should be happier.

Roderick Robbie of the SEF Program* explained that the basic philosophy of education is changing and that this should be reflected in our approach to school construction. He said that out of this new philosphy, two main ideas emerged. First, a very great emphasis on the optimum development of each individual student, whereas formerly the

* Study of Educational Facilities
(Metropolitan Toronto)

emphasis has been upon group development, in which the group ideal is the goal, with little importance being given to students consistently at the top of the class or the bottom of the class. The second new trend has been the need for flexibility in the use of interior space. This trend was obvious at SCSD, and is being reinforced in the SEF Program.

He went on to describe briefly the different administrative arrangements that had to be established in Toronto, the grouping of a number of separate school boards and the setting up of an advisory committee to the Metropolitan School Board for the development of this project. He explained the current research that had been directed in the educational field by his colleague Mr. Vallery and in the technical field by himself. He touched on various other significant aspects which included the use of portable and relocatable school facilities which might provide a solution to changing demographic trends within urban areas. This is a very important subject for research and follows some specific projects in the United States. Another important subject to which Mr. Robbie referred was the optimal use of valuable downtown properties. Building on such properties could conceivably combine school facilities with offices and housing units.

Mr. Robbie indicated that following their market studies, the Metropolitan School Board had a requirement for no less than a million and a half square feet representing 26 schools that would use system buildings.

Ten major components will be used in SEF. This represents a significant departure from both the SCSD project and the Montreal project, in that the number of components in the latter two is only five. He indicated that following discussions with industry their first real test will be during the bidding period from July 9, 1968 to January 7, 1969. On that date, bids for all components will be evaluated.

Mr. Robbie indicated that there were three major problems in going forward with system building. First, we must have a uniform building code throughout Canada. Second, there is a need for a testing agency on a national basis, providing fair evaluation for unsuccessful proposals submitted by manufacturers in the bidding. Favourable tests might permit them to recover a part or all of the investment made in research. Third, a need on the part of industry, and this is a complex problem, to have a central agency which would be the spokesman for all segments of the construction industry. The same remarks would apply to labour organizations. Lastly, government financial assistance to industries and a need for the professions to provide a co-ordinating function in the development of components.

Mr. Corriveau, member of the IRNES* group told us of the evolution of their project in Montreal. Here, the situation is very different from the one existing in Toronto, since the Montreal Catholic School Board is responsible for a large portion of school construction in Metropolitan Montreal. He commented briefly on the five major phases of their research program through which they are looking for valid solutions to their problems. For instance, following educational research, they are searching for a code in which their pedagogical needs will be expressed while, from the economic standpoint they require a sophisticated study in this area in which little information exists. The total cost, the cost per unit, the maintenance costs also factors like fuel, natural gas versus electrical power, etc. Moreover, the economic research must be completed by some technical research. Here, I do not intend to blame the mechanical and electrical engineers of Montreal, but being familar with this problem, I would like to relate to you something which indicates the importance of knowing exactly the technical aspects in the calculations.

A code can seriously limit, on one hand, the engineer, and on the other, give him complete freedom. For example, what is the quantity of hot water needed daily in an elementary school per student? In collaboration with the engineers of Montreal, this question was studied in eighteen schools built during the last five years. The results were astonishing: the quantity of hot water used daily for each student in these schools located in the same city, and therefore under the same climate, varied from 1.9 to 12.13 gallons. With such results, it is easy to see the consequences for the boiler plant and for the mechanical system. This example illustrates the reason why the study of all the technical aspects, and they are numerous, is so essential if we wish to have a first class knowledge of needs and requirements for electrical services, ventilation, heating, etc.

When this research phase is completed, there will be a study in which efficiency will be evaluated. At this time, or in a few weeks, the IRNES group will publish their findings and this will be followed by the construction of a prototype school.

* Institut de recherches et de normalisations économiques et scientifiques Inc.

In settling upon the design of components, Mr. Corriveau enumerated three principles which appeared to him to be very important. First, the modular system must be used. Second, the integration (not simply a juxtaposition) of the components must be done in such a way that the framing will serve to solve other problems existing in a building; for example, he mentioned a building in Flordia, where the framing is used as ducting for the circulation of air. And third, he underlined the necessity to standardize the technical elements of calculation and the quality of the materials used in the school building. He spoke also of flexibility in the settling of questions of spaces as a major need in our schools. This flexibility means three things: first, the spans will be greater; second, the walls and the ducts will not be definitely fixed and located; and third, the surroundings of the schools will be improved.

So, in their research, the IRNES group has determined the best conditions (air, temperature and humidity) for the learning process. This has been done in co-operation with the St-Justine Hospital (a children's hospital). In their estimates of efficiency which will be made public soon, six criteria have been mentioned: framework, mechanical system, electrical system, wall system, lighting system and ceiling system. These six, identical to those of SCSD are quite different from those expressed by the Toronto group. For instance, in the structural framing, the modular co-ordination has some definite characteristics. The ceiling has been standardized to four heights: 9'4", 13'4", 17'4", and 22' (gymnasiums and auditoriums). The horizontal module has been fixed at 12", the vertical one at 8", and both are multiples of the international basic module of 4". The bays of the framing will measure 20' except some intermediary ones of 10'. The spans themselves will have five dimensions: 20', 30', 40', 60' and 80'.

The main question that now exists is how to interest Canadian industry in this project. To reach this goal, the IRNES group in collaboration with the Montreal Catholic School Board will create a demand evaluated at $45 million. At this moment, tenders are being received and in three weeks, the industry will be in a position to place tenders for each sub-contract.

APPENDIX

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