Report of The Canadian Technical Mission On The Use of Prefabricated Steel Components in Industrialized Building in Europe, June 1967

"Industrialized Building in Steel"

Materials Branch
Department of Industry
Ottawa Canada

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CANADA DEPARTMENT OF INDUSTRY

(Canada)

REPORT OF THE TECHNICAL MISSION ON THE USE OF PREFABRICATED STEEL COMPONENTS IN INDUSTRIALIZED BUILDING IN EUROPE

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1967

prepared by
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in cooperation with the
members of the Mission

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FOREWORD

At the invitation of the Honourable C.M. Drury, Minister of Industry, a group of senior representatives of the fabricated structural steel industry participated in a technical mission to Europe. The purpose of this mission was to study the latest techniques developed for the use of prefabricated steel components in industrialized building.

The Department of Industry is pleased to publish this report which includes the conclusions and recommendations of the group, examples of industrialized building in steel in the countries visited and comments on other visits.

It is hoped that this report will create in Canada a greater awareness of the possibilities to increase productivity and efficiency through the industrialization of the building process.

R.D. Hindson
Director
Materials Branch

"Full-scale industrial methods must be applied to building by introducing standardization of individual components."

- Le Corbusier, 1920.

INTRODUCTION

Almost fifty years ago, the famous French architect Le Corbusier made the statement that industrialization of the building process was a prerequisite to the rationalization of the construction industry. He went on to say that "what is needed is to create mass-production-mindedness, mass-habitation-mindedness, and mass-building-design-mindedness".

These words still hold true today, and, although industrialization is playing an ever-increasing part in the construction industry, considerable advances are still possible.

As the transition from traditional building methods to industrialized production of standard components takes place, it will no longer be possible to consider individual components merely by themselves; they will have to be considered in relation to the method of manufacture of other components and their function in the building.

This evolution, which is now beginning to take place in Canada, points to the eventual development of a strong, capital-intensive, factory-based industry which will be unaffected by weather conditions. Thus in the future it can be expected that more and more components will be delivered to the site in a finished or semi-finished condition to be rapidly assembled into structures. But if there is to be a rational industrialization of the building process, the following essential requirements must be met:

- Dimensions of building components must be standardized.
- Components must be interchangeable.
- Continuity of production must be assured.
- The various stages of the building process must be integrated.
- Work must be organized in a systematic way.
- Mechanization and automation must take place whenever practical.
- Research and organized experimentation with new building techniques must be accelerated.

For its fullest exploitation, industrialization must also include new management techniques, new methods of co-ordinating the building requirements of the clients and new contractual and working relationships among clients, architects, builders, manufacturers and labour.

In 1966, the Department of Industry initiated the BEAM Program, in order to create a climate favourable to the greater industrialization of the building process and in order to increase productivity and efficiency in the manufacture and use of building equipment, accessories and materials.

To date, three technical missions have been organized within the framework of this program, to give a number of senior industry representatives the opportunity of studying the progress that has taken place in other countries in the industrialization of the building process.

This report records the observations, comments, conclusions and recommendations of the group of senior representatives from the fabricated structural steel industry who visited Germany, France, Italy and the United Kingdom in June of 1967.

PURPOSE OF MISSION

The purpose of the mission was to study industrialized building systems and techniques involving manufacturing and assembly of standardized steel components in the construction of low-rise and high-rise buildings.

ITINERARY

The itinerary covered the period from June 4 to 23, 1967, inclusive. During this time visits were made to sites, offices and factories in Germany, France, Italy and the United Kingdom. The members of the mission also attended the Twenty-Third International Congress of Steel Information Centres, at Essen, Germany. The itinerary included:

- A meeting with the German Advisory Board on Steel Application - Dusseldorf, Germany.
- Attendance at 23rd International Congress of Steel Information Centres - Essen, Germany. Theme: "Industrialized Steel Construction in the Service of Man".
- Industrial visits in Paris and Northern France with special emphasis on the Fillod and Bender Systems.
- Industrial visit to Milan, Italy - Plant and site visits of the FEAL System.
- Industrial visits in London and the United Kingdom with special emphasis on the SCOLA, SEAC, CLASP, IBIS and SF1 Systems.

MEMBERS OF MISSION

The Mission was composed of the following persons:

Mr. W. W. Baigent	Manager of Engineering, Eastern Structural Division, Canada Iron Foundries, Limited, Toronto.
Mr. J. W. Dunn	President, A I M Steel Limited, Vancouver, B.C.
Mr. E. L. Hartley	President, Frankel Structural Steel Limited, Toronto.
Mr. W. A. Hepburn	Vice-President, John T. Hepburn, Limited, Toronto.
Mr. R. G. Johnson*	Chairman, Canadian Steel Industries Construction Council, Toronto.
Mr. D. H. Munro	General Manager, Anthes Steel Products (1962) Limited, Toronto.
Mr. P. E. Savage	Vice-President, Engineering Services, Dominion Bridge Company Limited, Montreal.
Mr. D. L. Tarlton	Chief Engineer, Canadian Institute of Steel Construction, Toronto.
Mr. J. C. Valade	Vice-President and Chief Engineer, Central Quebec Steel Ltd., Trois-Rivières, Que.

Mr. D. G. Laplante	Head, Construction Section, Iron and Steel Division, Materials Branch, Department of Industry, Ottawa.

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*Also President, Canadian Institute of Steel Construction.

DEFINITIONS

For the purposes of this report the following definitions of terms are applicable:

(Building) Component - A factory-produced unit, member or assembly made of one material or of several materials. A component may be modular, and may serve one or more functions in a building, e.g. a structural wall panel.

Industrialization - The application of factory mass-production techniques to the production of building components. Industrialized building connotes a type of building which utilizes industrialized components to a substantial degree, particularly for structure, cladding and partitions.

Module - A unit of measurement used in the planning and dimensional coordination of a building and its various building components.

<u>System (Construction)</u> - A type of construction utilizing modular components so designed and selected that each integrates with the others with a minimum of individual fitting and a consequent saving in time and effort on site. Sometimes referred to as system building.

<u>Closed System</u> - A type of system construction wherein the majority of components are designed and detailed for use with each other only, usually by one manufacturer.

<u>Open System</u> - A type of system construction wherein the majority of components are designed and detailed for use with other components from various manufacturers and which may be made of various materials. An open system requires the adoption of modular coordination based on a standard module and particular attention to the establishment of tolerances and joining details to suit a variety of component combinations.

SUMMARY

The Mission had the opportunity to observe, at first hand, completed buildings, construction in progress and fabricating facilities for a number of different industrialized building systems in Europe. These ranged from flexible, open systems such as CLASP and FEAL to closed systems such as Bender.

There is wide acceptance of system building in Europe and this acceptance is continuing to grow. Both purchasers and manufacturers are optimistic and enthusiastic as to the benefits to be derived.

The impetus for industrialized system building in all countries visited came mainly from the purchasers rather than from the industry or industries involved. In some cases, however, manufacturers of building components have developed their "lines" beyond that which was required for the initial purchaser(s) and are exploiting the advantages of system building even for "one-off" buildings and in speculative ventures.

Government or quasi-government authorities such as school boards and housing agencies represent the purchasing groups largely responsible for providing the incentive for development of industrialized building systems. These purchasers recognized the need to control construction costs and maintain a rapid construction schedule despite shortages of skilled site labour and rising labour costs. In some cases (e.g. the French Ministry of Education) the purchaser prepared a performance specification, selected a manufacturer's system that was compatible and appointed a local architect to do the overall design, using the chosen system. In other cases (e.g. SCOLA) the purchaser himself (or consortium of purchasers) designed a system to make maximum use of standard components. The project architect then selected those components which he wished to use. Since there is usually more than one possible choice of each type of component, considerable variation in appearance is possible within the same basic system.

The advantages that Europeans appear to have gained by using industrialized building methods rather than traditional methods are listed below:

Advantages to Owner

- Savings in total cost of structure - 5 to 15 per cent.
- Reduction in time of actual construction - 30 to 50 per cent. (In many cases the rate of building could not have been maintained without using industrialized techniques.)
- Good quality relative to actual cost.
- More certainty as to final cost.

Advantages to Architect/Engineer

- Less design and drawing time.
- More certainty as to availability of components.
- More certainty as to unit costs.
- Easier and less costly procedures in the event that changes or subsequent alterations are necessary.

Advantages to Builder

- Reduction in on-site labour man hours, particularly skilled labour, by 25 to 33 per cent.
- Less uncertainty due to inclement weather.
- More accurate costing due to higher content of factory labour.
- Less fitting or adjustment on site because of greater dimensional control of factory-made components.

Advantages to Manufacturer

- Better opportunity for production planning and control and use of computerized control systems.
- Reduction in inventory and inventory control through use of standard components.
- Reduction in drawing office costs.

Fabricating techniques for steel building components did not appear to differ substantially from those currently used in Canada, nor did it appear that large capital investment for special automated equipment was always necessary.

Design of the steel frames was usually very basic. No unfamiliar or exotic design principles were evident and most designs appeared to be less complex than those which sometimes are used in Canada for similar types of structure. However, there was generally a close dimensional control on finished structural members and parts since structural members are intended to be erected with a minimum of special skills.

Most of the structural components, such as beams and columns, were fairly light sections, often cold-formed specially for the purpose. These components are used mostly in schools and residential construction. Because of their relatively small size and light weight, erection of these components is accomplished with a minimum of erection equipment and personnel.

In all industrialized building in Europe viewed by the Mission the single most important factor in a successful system appeared to be the proper degree of dimensional control of all components.

RECOMMENDATIONS

In assessing the Mission's recommendations certain facts should be borne in mind.

- The members of the Mission generally were favourably impressed with what they saw of European progress in industrialized building in the limited time they had available.
- The enthusiasm of those concerned with industrialized building in Europe, whether as purchasers, architects or manufacturers was encouraging.
- Industrialized system building appears particularly suited to structural and sheet steel. The necessity of close dimensional control and long-term dimensional stability favours the use of steel and the industrialization process is not new to the steel industry.
- It is doubtful that many of the European building components viewed could be applied in Canada without modification. This is due to differences in building codes, specifications, and the balance between labour and material costs, as well as intangibles such as style.
- The same degree of advantage that the Europeans find in industrialized building methods over

their traditional methods may not apply to Canada because our traditional building methods, the labour force, the market, and a host of other factors differ from the European situation.

- Of prime importance to the success of industrialization in the building process is assurance by the purchasing authorities of long-term markets in order to make available the capital required by industry to develop industrialized system building efficiently.
- As a corollary to the above point, there is a need for the development and adoption of building regulations, embodying modular coordination, which can be used on a national basis without basic modification or exception by all building authorities and owners.

The Mission concludes that development in Canada of industrialized building in steel will be advantageous to all concerned. The following 10 points constitute recommended guidelines for action on the part of interested and responsible parties:

THE PRINCIPLE OF MODULAR COORDINATION MUST BE ACCEPTED AS A PREREQUISITE TO THE DEVELOPMENT OF INDUSTRIALIZED BUILDING IF ANY SIGNIFICANT ECONOMY IS TO RESULT.

Experience in other countries has shown that the imposition of a modular discipline on the designer has advantages which far outweigh any minor curtailment of unrestricted freedom in design.

(2) THE BASIC MODULE SHOULD BE CHOSEN IN ACCORDANCE WITH INTERNATIONAL STANDARDS, OR PRACTICE, IN ORDER TO AFFORD THE LARGEST POSSIBLE MARKET FOR MANUFACTURED BUILDING COMPONENTS.

The 100-mm. basic module is the most widely accepted standard to date. In countries using the inch system the 4-inch module is recognized also. The important consideration is the selection of a module which offers the greatest potential for marketing of modular products.

(3) AN APPROPRIATE BODY SHOULD BE ORGANIZED TO ESTABLISH WORKING RULES PERTAINING TO DIMENSIONAL COORDINATION. THIS WOULD ENCOMPASS NOT ONLY THE SELECTION OF THE BASIC MODULE BUT ALSO THE EQUALLY IMPORTANT SELECTION OF TOLERANCES REQUIRED TO ASSURE COMPATIBILITY OF COMPONENTS.

It is suggested that a Modular Society of interested and responsible parties be formed to promote modular coordination through the gathering of informed opinion and the dissemination of information.

(4) <u>THE NATIONAL BUILDING CODE OF CANADA SHOULD BE EXTENDED TO INCLUDE MODULAR COORDINATION. EXISTING LAWS SHOULD BE CHANGED TO PERMIT AUTOMATIC ADOPTION OF THE NATIONAL BUILDING CODE BY ALL BUILDING AUTHORITIES.</u>

It is suggested that if the laws were changed so as to encourage easy and automatic adoption of the National Building Code of Canada by local building authorities, economic factors would assure that adoption occurred.

(5) <u>FUTURE DEVELOPMENT OF INDUSTRIALIZED BUILDING IN CANADA SHOULD BE BASED PRIMARILY ON THE PRINCIPLE OF THE OPEN SYSTEM, THUS AFFORDING THE GREATEST POSSIBLE CHOICE OF COMPONENTS FROM WHICH THE DESIGNER MAY MAKE HIS SELECTION</u>.

Modular coordination is a necessary prerequisite to the development of systems.

(6) INDUSTRIALIZED BUILDING SYSTEMS SHOULD AIM AT INTEGRATION OF MECHANICAL, ELECTRICAL AND OTHER SERVICE FACILITIES WITH THOSE COMPONENTS SUCH AS FLOOR, CEILING AND WALL PANELS, PARTITIONS, AND STRUCTURAL FRAMING, USUALLY REGARDED AS "STRUCTURE".

From a technological viewpoint, the integration of structure and services is one of the major advances offered by system building. However, the effect on the jurisdiction of unions and the problems which may arise must be considered and resolved.

(7) MANUFACTURERS MUST PLAY A LEADING ROLE IN THE DEVELOPMENT OF INDUSTRIALIZED BUILDING SYSTEMS. TO THIS END THE DEPARTMENT OF INDUSTRY SHOULD SUPPORT A PROGRAM OF INDUSTRIALIZED BUILDING IN CO-OPERATION WITH INTERESTED MANUFACTURERS AND OTHER PARTIES.

The active participation of manufacturers will ensure that maximum benefit is obtained in the manufacture and assembly of building components, based on optimization of capital, material, labour and technology.

(8) TO STIMULATE INDUSTRIALIZATION OF MODULAR BUILDING COMPONENTS THE FEDERAL GOVERNMENT (AND OTHER LEVELS OF GOVERNMENT WHERE APPROPRIATE) SHOULD TAKE THE FOLLOWING ACTION:

(a) SUPPORT FULLY THE PRINCIPLE OF MODULAR COORDINATION FOR GOVERNMENT-FINANCED BUILDINGS.

(b) ADOPT THE STANDARD BASIC MODULE (SEE POINT 2) AND ESTABLISH MODULAR PLANNING GRIDS FOR USE IN ALL GOVERNMENT BUILDINGS.

(c) DESIGN ALL GOVERNMENT BUILDINGS ON A MODULAR BASIS IRRESPECTIVE OF WHETHER THE CONSTRUCTION IS PLANNED AS INDUSTRIALIZED OR OTHERWISE.

The federal government is the largest single purchaser of buildings in Canada and hence is able to make a substantial contribution to the development of industrialized construction by adoption of modular coordination and planning.

(9) THE DEPARTMENT OF INDUSTRY, IN CO-OPERATION WITH SUCH OTHER GOVERNMENT DEPARTMENTS AND AGENCIES AS NECESSARY, AND THE CONSTRUCTION INDUSTRY SHOULD DETERMINE THE LONG-TERM MARKET

<u>IN CANADA FOR BUILDINGS WHICH LEND THEMSELVES PARTICULARLY TO INDUSTRIALIZATION.</u>

Possibilities exist in public housing, schools, urban renewal projects, large private residential ventures and perhaps other markets.

(10) <u>ARCHITECTURAL CENTRES OF LEARNING SHOULD BE ENCOURAGED TO STUDY AND TEACH MODULAR COORDINATION AND INDUSTRIALIZATION. IN PARTICULAR, THEY SHOULD BE REQUESTED TO DEVELOP ARCHITECTURAL CONCEPTS WHICH WILL EXPLOIT THE ADVANTAGES OF INDUSTRIALIZATION AND MINIMIZE POSSIBLE DISADVANTAGES SUCH AS MONOTONOUS REPETITION, UNIMAGINATIVE DESIGN AND SECOND-CLASS CONSTRUCTION.</u>

Industrialization offers a means to combat rising construction costs and to significantly increase productivity.
It is important that aesthetics and style not be overlooked.

EXAMPLES OF

INDUSTRIALIZED BUILDING

IN GERMANY

Houses at Hilden

Four tenant-occupied homes have been built at Hilden, on the outskirts of Dusseldorf. One has exposed columns and beams. Another has tubular steel columns inside, but they are somewhat awkwardly located with respect to the rooms. The "Berlin" house, designed by Architect F. Vellguth, seemed the most promising and best designed of those visited (see Reference 6). At present, modular steel homes do not appear to be a potent sales factor in Germany, being still in the development range.

FIG. 1

FIG. 2

School at Herne

This school, of modular design, consists of a three-storey and a one-storey building joined by a glass-walled walkway entrance. The module appeared to be about one metre with a structural grid of two modules. The school employs a structural steel frame, precast concrete wall panels, wood sash and wood trim. The heating system is a hot-water radiator of the perimeter type.

FIG. 3

The outward appearance is neat but not outstanding architecturally. On the whole the quality of workmanship is high and maintenance has been excellent. A few details could be improved -- such as condensation run-off onto interior wooden window sills.

School at Bochum-Harpen

This school is two storeys high and employs a structural steel frame designed to the CLASP system, described later. The module used appears to be about 1.8 metres. Exterior wall panels are precast concrete with open joints. Interior partitions are gypsum board. FIG. 3

External appearance is neat but somewhat colourless. Quality of workmanship is fair to good and maintenance has been excellent. A feature of this school is a large glassed-in swimming pool and an adjacent interior sunken court which can be used as an amphitheatre.

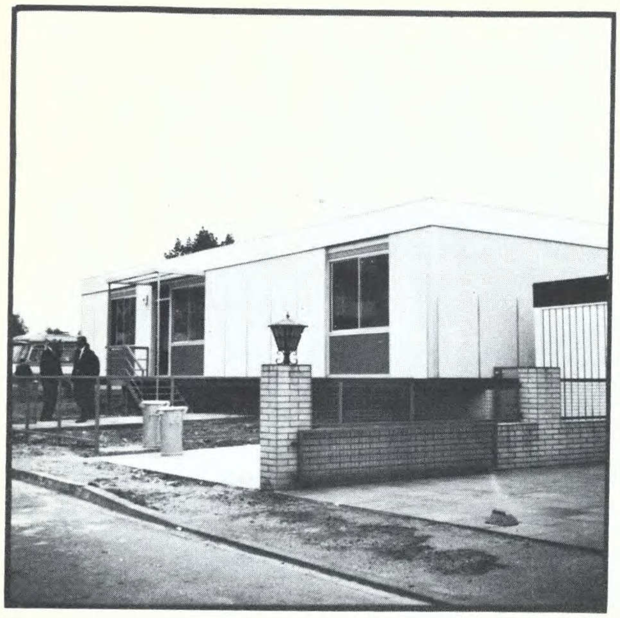
Ruhr University at Bochum

This project is fully described in Reference 5. The new Ruhr University at Bochum is an extremely large undertaking and construction is still in progress. At the moment there are some 5,000 students - a figure which will go up to 15,000 within the next year or two, and eventually the total population of students, staff and related personnel will reach 40,000. The design is modular on a large scale. The standard horizontal module is 24.6 x 24.6 feet, which represents a complete bay size. Standard storey height is 12.5 feet. All institutional buildings are 15 modules long, three modules wide and six to eight storeys high. The core area is divided into two units, each four modules long by one module wide.

The first institutional buildings constructed employ 32-ton ribbed, precast concrete slabs one full module in size and about one and one-half feet in depth. In some cases composite steel beams are used, in other cases the slabs are supported on column brackets. Welded steel H or box sections are used as columns. FIG. 4

Institutional buildings which are now under construction employ reinforced concrete columns.

Exterior wall panels are precast concrete with steel sash and trim. In general the buildings have a heavy, solid look from both the outside and the inside.



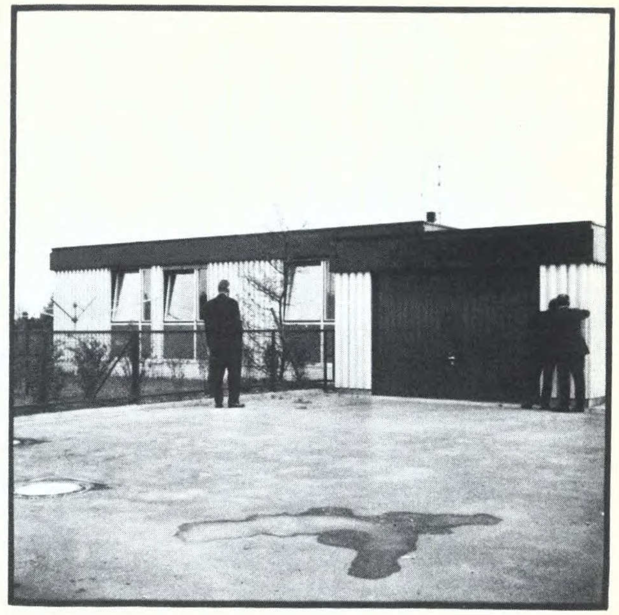


FIG. 1

MODULAR STEEL HOMES

HILDEN , GERMANY

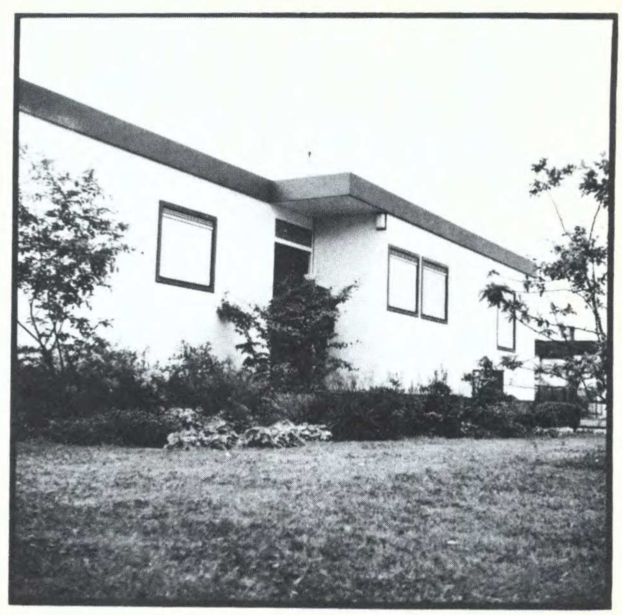
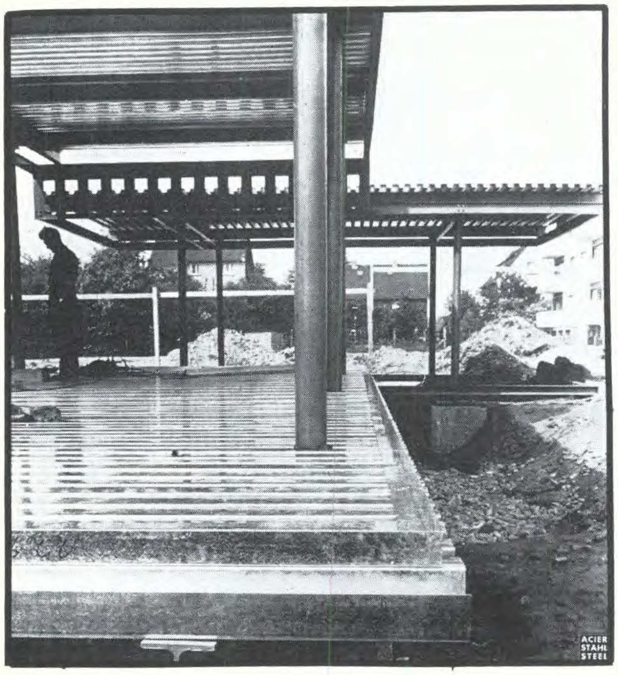
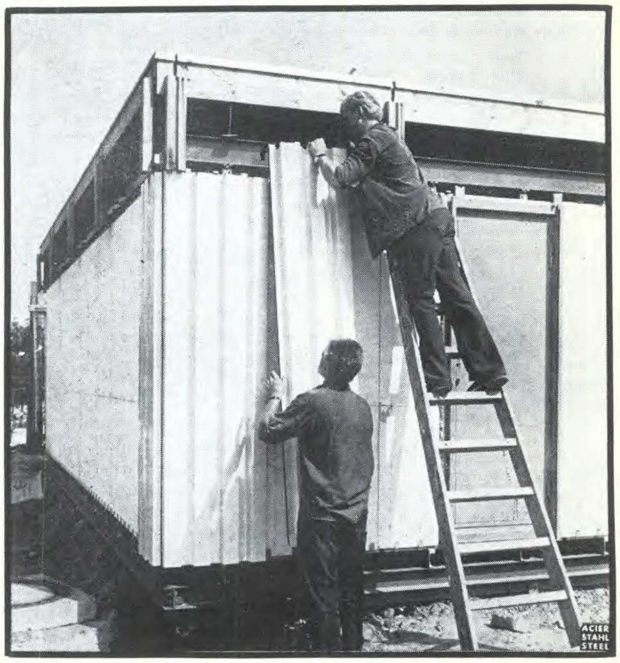
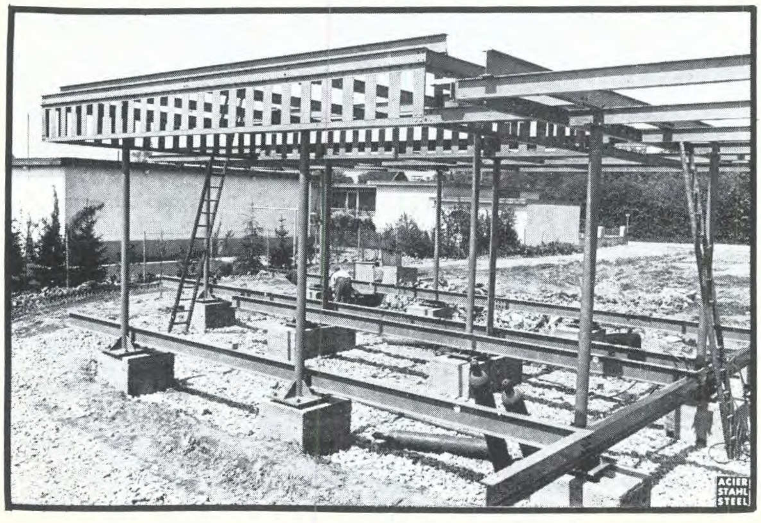


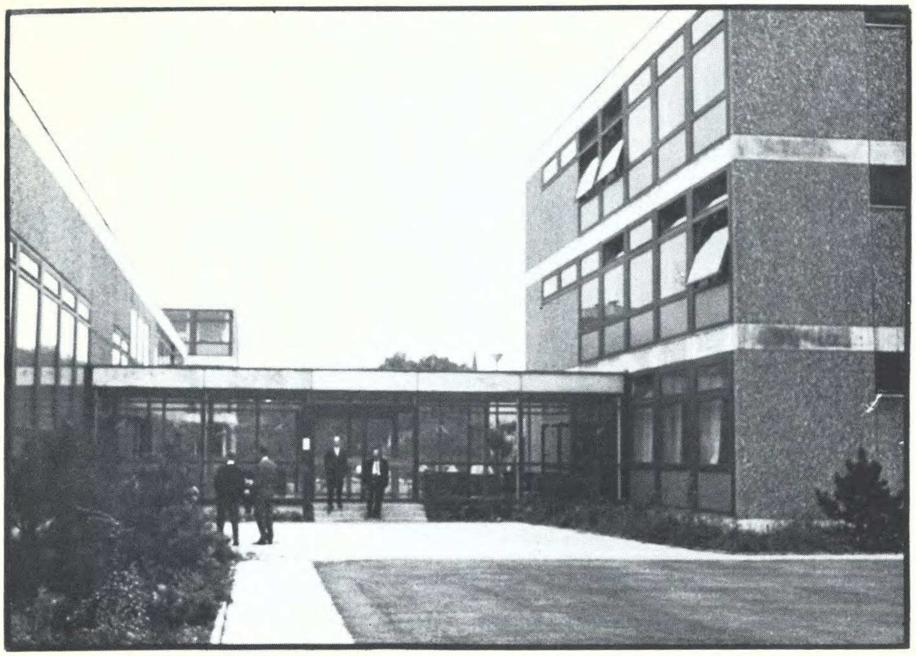
FIG. 2

"BERLIN" HOUSE







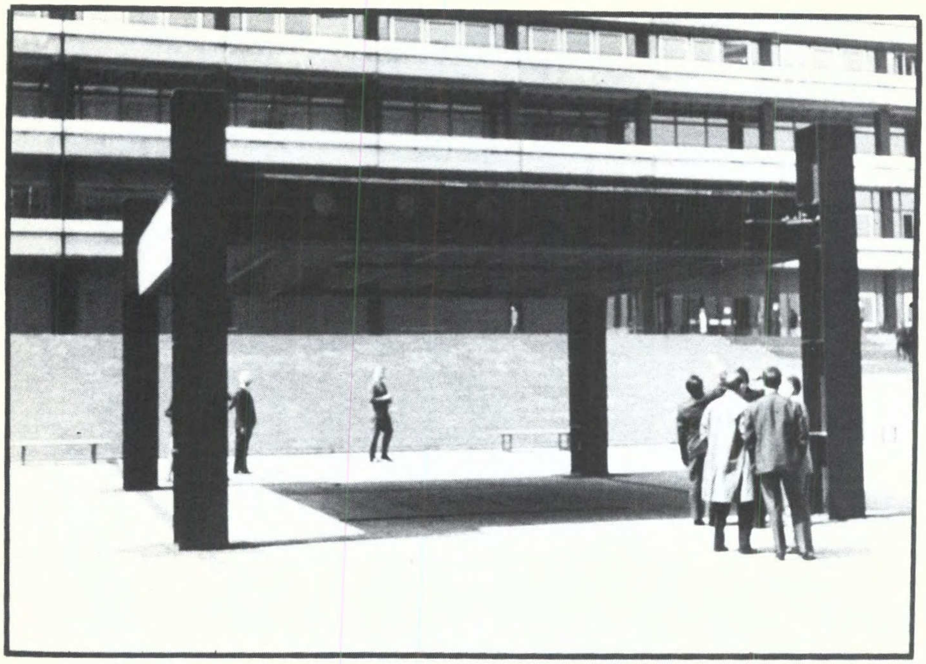


At Herne

FIG. 3

GERMAN MODULAR SCHOOLS

At Bochum–Harpen
(Clasp system)

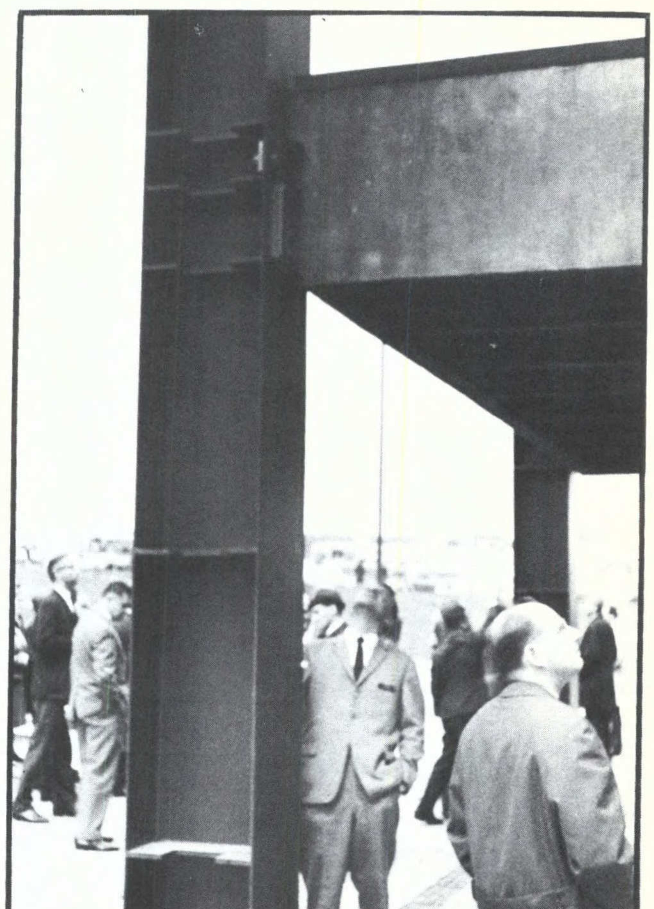


A Jumbo module.

FIG.4

RUHR UNIVERSITY BOCHUM

Steel columns support 32 ton precast slabs.



EXAMPLES OF

INDUSTRIALIZED BUILDING

IN FRANCE

"Bender" System Schools

This system was designed by the firm of which Mr. Jacques Bender is president and is an example of well-engineered, modular steel construction applied to school building. Architecturally the result is not outstanding, but fair.

Bender system schools employ a light structural steel frame consisting of rolled columns and lightweight trusses having all joints bolted. Field assembly is by bolting. The floor construction utilizes galvanized steel panels of a special type made up of five cross-ribbed, shallow, open "boxes" about 6' x 10" x 2-1/2", spot-welded together along the sides to form a component about 6' x 4'. These components are flanged at their ends and laid flush on the floor trusses. They are subsequently secured to truss chords by screw clips. The same box unit is used individually for stair treads. Floor finish is a rubberized floor covering laid directly on the steel panel. FIG. 5

Exterior wall panels, interior partition panels and column covers are all made of painted sheet steel. A foam insulation fills the interior of the twin-walled panels. Plumbing is largely plastic and electrical services are built into the wall panels and door frames at the factory. The module is 1.8 metres FIG. 6

(6 feet) horizontal and 0.9 metres (3 feet) vertical. In the schools visited, workmanship appeared to be of a reasonable calibre although some joining details could be improved.

The plant which produces the Bender components is located in a former auto assembly plant in Paris. The building and most of the equipment are old but are being utilized to the full extent. Material flow could be improved in a new plant.

In the engineering and drafting office each building component has been analyzed and detailed. Dimensional tolerances have been established for each part the same as for machinery design. All components are given numbers which are used on plans and bills of material. Drawings show only grid lines and component or part numbers.

"Fillod" System

Fillod is the name of the industrialized building subsidiary of de Wendel et Cie, which also owns mines, steel works and rolling mills. Fillod acts as general contractor as well as manufacturer and will consider projects of any size and type.

At present 55 per cent of Fillod's industrialized market is in schools; the remainder is in gymnasia, factories and offices. Their schools are built for approximately 45 francs per square foot and employ a FIG.7

module of 1.8 metres. In 1966 they built two million square feet of schools or about 25 per cent of the industrialized school market in France.

In the Fillod system, 55 per cent of the work is done in the factory and 45 per cent is site work, including foundations and landscaping. Typical building time for a school is six months - which was stated to be 50 per cent faster than when concrete is the main building material.

A coefficient system is used in pricing. For example, in schools, classrooms have a coefficient of 1.0, halls 0.8 and kitchens 1.4.

Prices have changed little since 1963, at which time the Fillod system offered a 10 per cent saving over traditional methods of construction.

All components of Fillod buildings are numbered and this numbering system is used in purchasing, and production. A computer is used to tabulate the quantity of each part required for a particular job. When different types of building are involved the plan for each type is done on different coloured paper for easy identification throughout all company operations.

Fillod schools that were visited employed a structural steel frame, a steel deck second-storey floor and a steel decked roof. Structural steelwork FIG. 8

is exposed inside and painted. Exterior wall panels are vinyl-coated sheet steel. Interior partitions employ gypsum board and appear to be non-movable. Structural and exterior wall workmanship appears to be good.

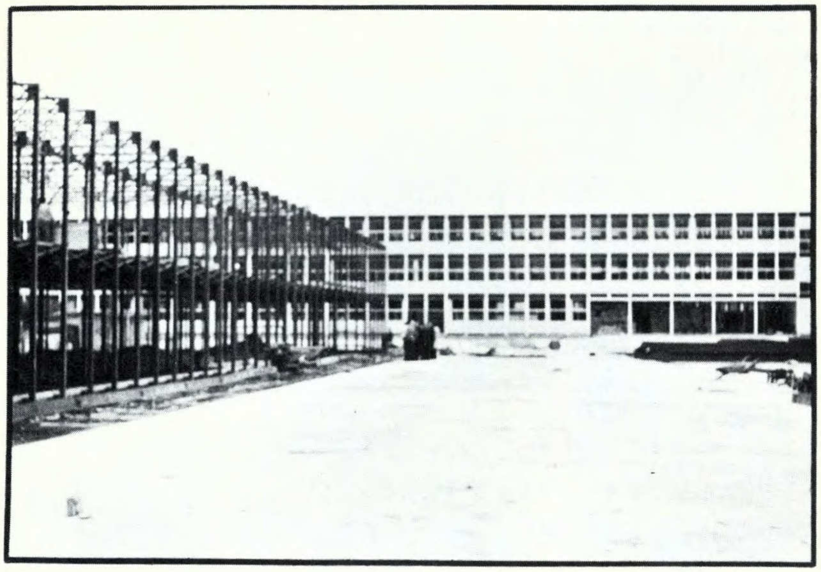
A single-storey office/laboratory built by Fillod had a substantially higher level of interior finish, indicative of the higher cost which the owners, in this case, were prepared to pay. FIG. 9

Notes on the French School Program

According to Mr. Jean Raynaud, Director of School Construction, Ministry of National Education, the idea of industrialized schools was nurtured by the government and it was they who contacted steel mills, fabricators and others in order to get industry interested in building this type of school.

In 1966 the total market for new schools in France amounted to 16 million square feet. Of this total about 50 per cent was scheduled to be built by traditional methods, and the remainder using industrialized systems.

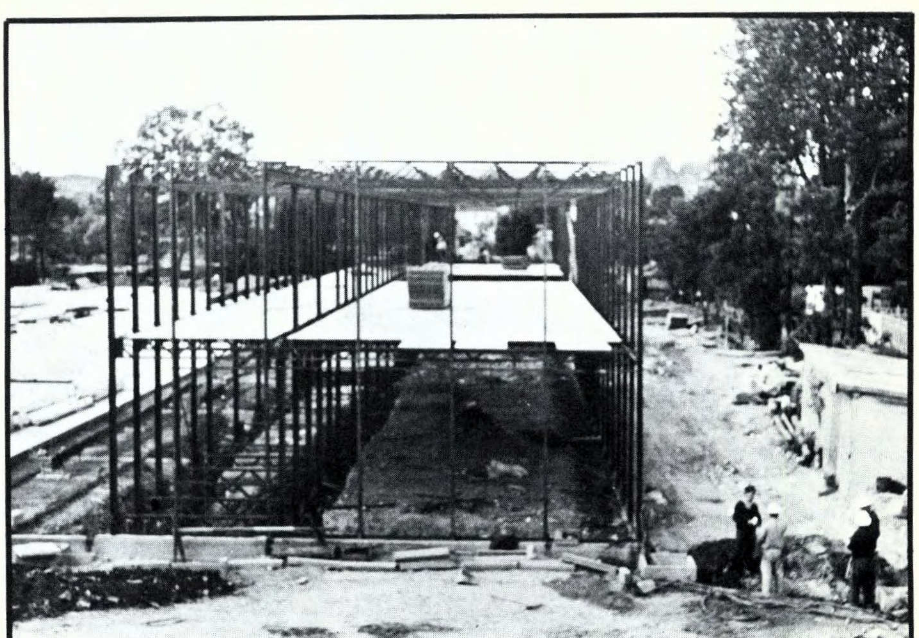
The Ministry of National Education sets out all basic requirements for French schools in a performance specification. Schools are built to accommodate either 300, 600, 900 or 1,200 students, as required. Orders for new schools are generally placed well in advance, allowing a favourable production schedule to be developed by the manufacturer.

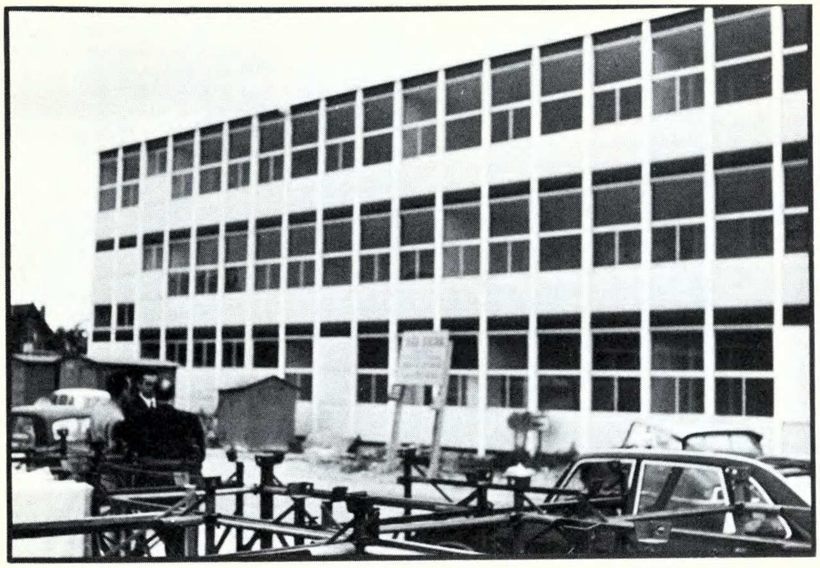


Site organization is important

FIG. 5
"BENDER" SYSTEM BUILDINGS
-FRANCE-

Light modular framing





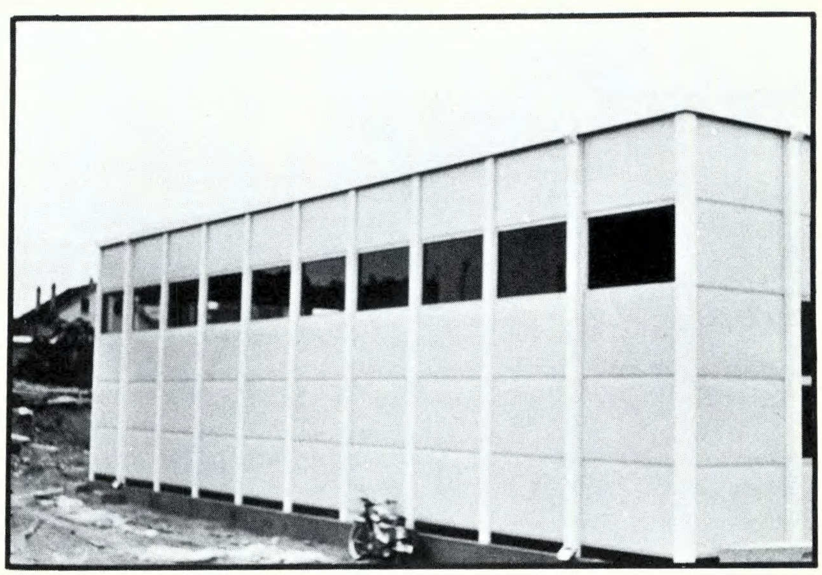
School under construction

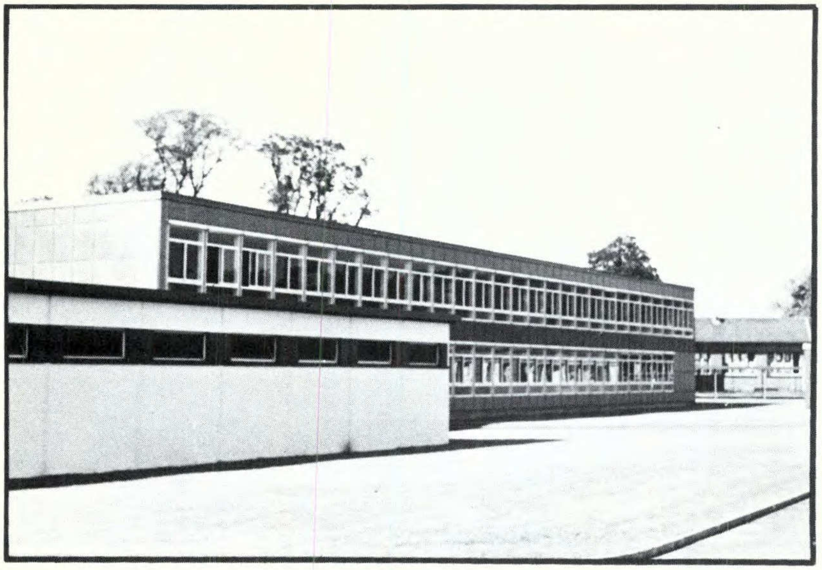
FIG.6

"BENDER" SYSTEM BUILDINGS

- FRANCE -

School heating plant





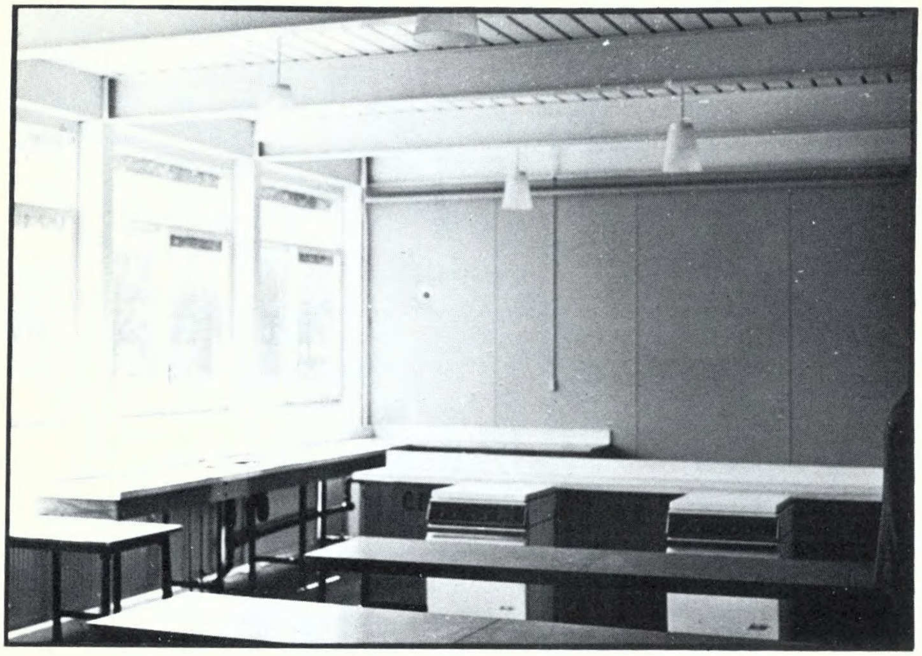
Vinyl coated sheet steel cladding

FIG. 7

"FILLOD" SYSTEM SCHOOLS

-FRANCE-

The mod look



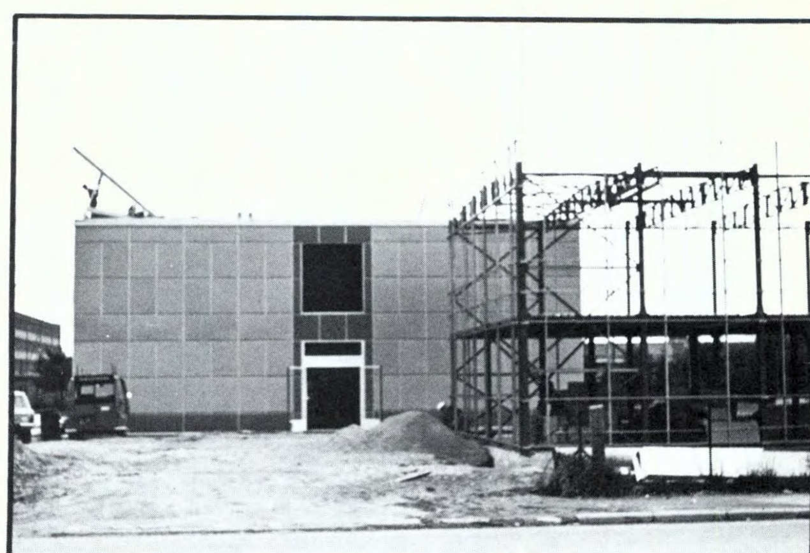
Eyposed steelwork

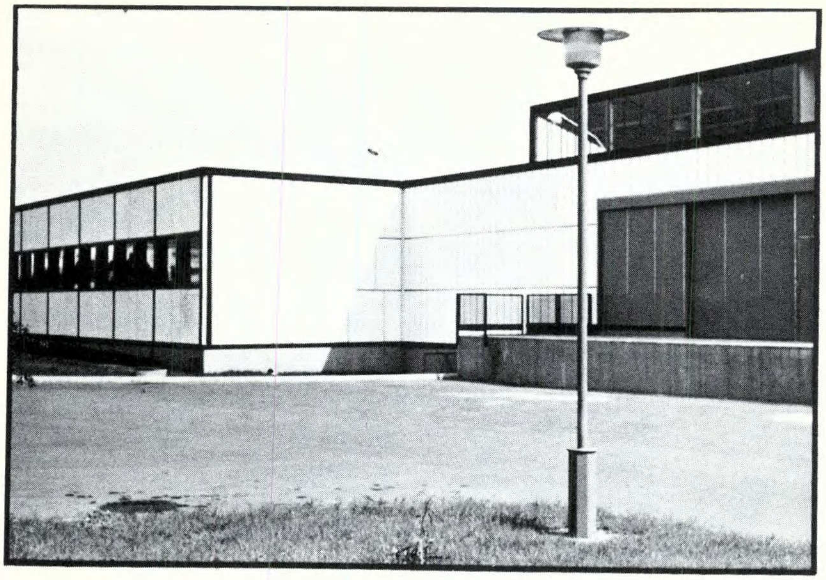
FIG. 8

"FILLOD" SYSTEM SCHOOLS

- FRANCE -

steel frame
steel floors
steel cladding





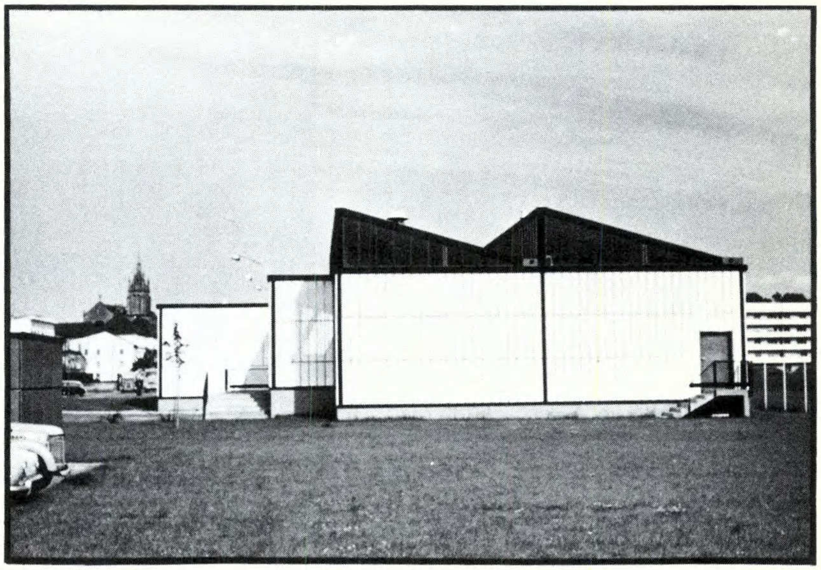
A mod-el example

FIG. 9

"FILLOD" SYSTEM FACTORY/ LAB

- FRANCE -

End elevation



EXAMPLES OF

INDUSTRIALIZED BUILDING

IN ITALY

"FEAL" System

FEAL is one of the foremost companies engaged in industrialized building systems in Italy. Plants are located in Milan and Rome and employees number approximately 1,000. Eight people work exclusively on research and development and are currently concerned mainly with improvements in air conditioning and heating systems and the development of plastic bathroom fixtures.

Seventy per cent of FEAL's business is as manufacturer and general contractor for modular buildings. The remaining 30 per cent is as manufacturer of components for use by others. The company will design the entire building for a customer and use steel framing largely because it gives them the dimensional accuracy which they need to avoid problems in installing their curtain walls. The steel frame usually is designed on either a 60-centimetre (2-foot) or 120-centimetre (4-foot) structural module and the basic module for all components is 30 centimetres (1-foot).

FEAL has built some 250 schools in the past five years at a cost of approximately 4,600 lire per square foot. The usual school is four storeys high and utilizes a 120-centimetre (4-foot) horizontal module and a 60-centimetre (2-foot) ceiling module.

FEAL also builds apartments, offices and factories, many of which are of high quality. The FEAL system is an open one, so that differences in the outward appearance of their buildings are marked. FIG.10

In the FEAL system all piping is factory-installed and is either plastic or iron. The trend is towards a maximum use of plastic.

Sites visited included two seven-storey apartment blocks under construction, a completed six-storey apartment block and a school which has been in operation for four years. Basic construction of these is summarized below:

a) Two Seven-Storey Apartment Blocks (under construction)

Steel frame - rolled shapes, filler beam floor system.

Floor - concrete cast in place on arched, snap-in, removable metal forms between filler beams. Concrete deck acts compositely with filler beams which are encased except for underside of bottom flange.

Exterior walls - metal and glass panels.

Module - 30 centimetres (one foot).

Structural steel not fire-proofed.

b) Six-Storey Apartment Building (completed)

Steel frame - rolled shapes, filler beam system.

Floor - as above.

Exterior walls - precast concrete panels.

Sash - metal.

Interior finish - wood panelling.

Structural steel columns exposed in interior, painted but not fire-proofed.

c) School (in operation for four years)

Steel frame - no fire-proofing.

Exterior walls - anodized aluminum and glass panels.

Partitions - metal.

The completed apartment building which was visited was of good quality throughout and built for approximately 8,600 lire per square foot including all interior finish, basement and underground garage.

The school which was visited was also in good condition despite four years' use by 500 students.

Partitions in a FEAL system building are movable and of good quality. In fact, all interior finish and workmanship appeared to be superior. An exception to the generally good workmanship would be the field welding of the filler beams in the apartment buildings under construction. The welds would not have been acceptable by usual Canadian standards.

FEAL makes effective use of wood veneers, marble, aluminum and plastics to improve the aesthetics of their buildings.

In the production of components FEAL are also efficient. Each element of a component is numerically coded and all this is programmed on a computer. They appear to be ahead of other firms in such things as the installation of plumbing and electrical services in partition components.

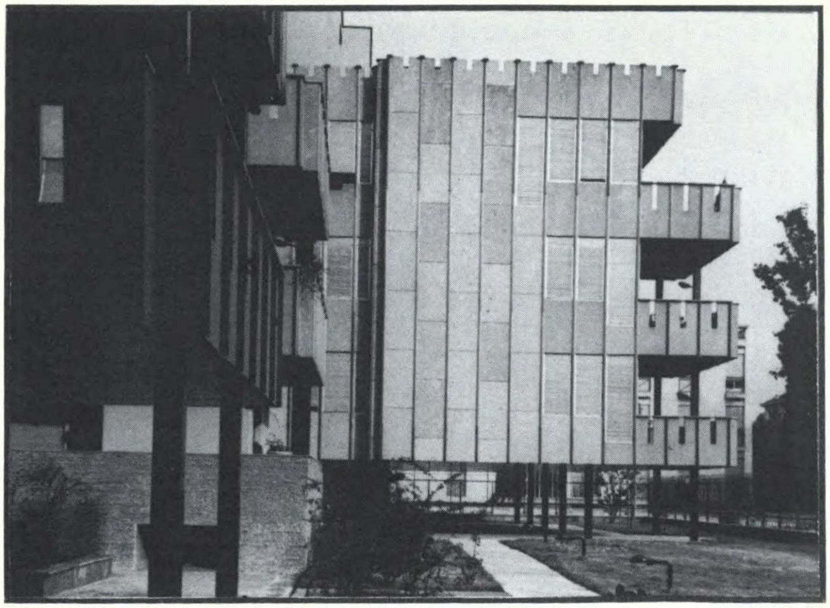
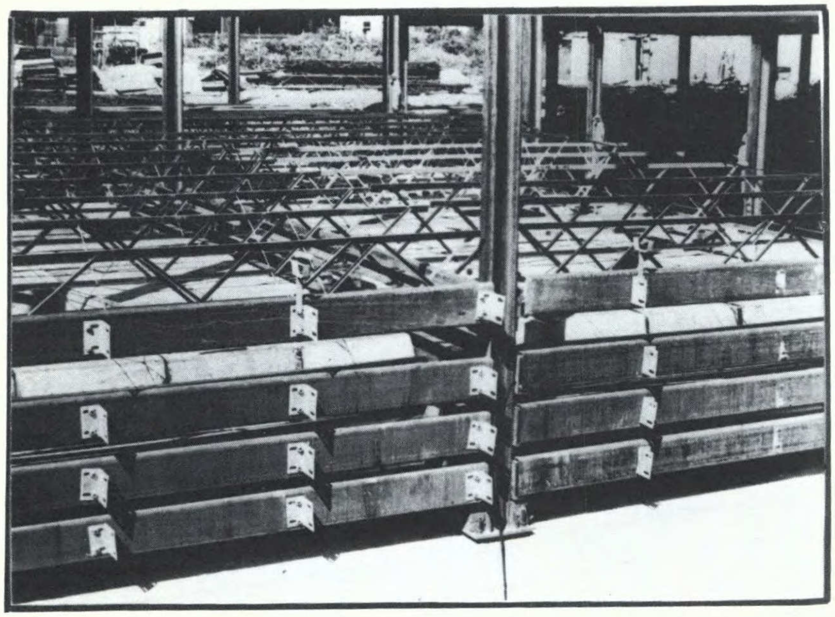
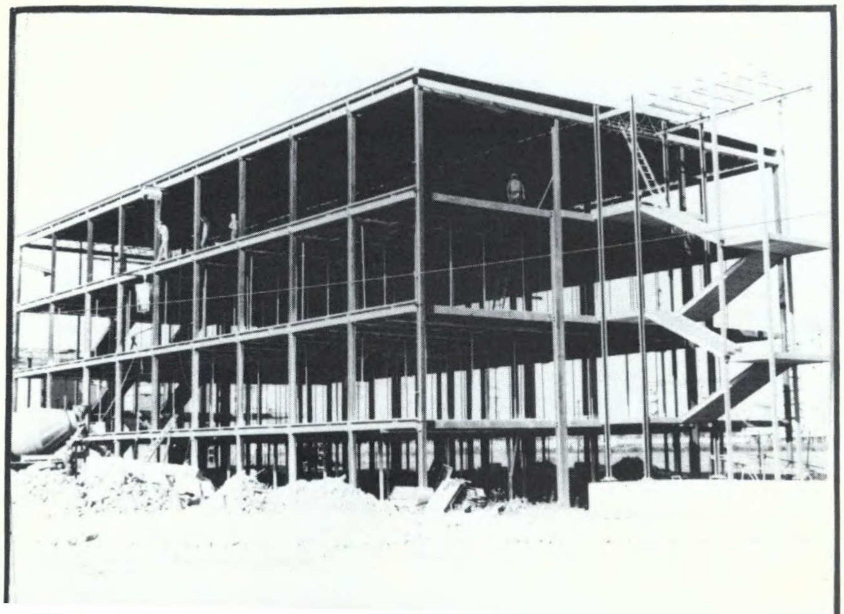


FIG. 10 "FEAL" BUILDINGS- ITALY

Apartment features exposed steel with precast wall penals.



'Lift-slab' technique is standard.



School frame after floors raised into place.

EXAMPLES OF

INDUSTRIALIZED BUILDING

IN THE U.K.

"SF1" Apartment Buildings, London

The SF1 (Steel Frame, One) system was developed for low-rental, high-rise apartment construction by the Greater London Council. Principal features include modular coordination, a steel frame, a steel-and-concrete core and glass-reinforced plastic exterior wall panels. FIG. 11

The design, for 20- to 25-storey apartment buildings, is based on a 6-foot, 8-inch module. This is the size of the cladding panels, which is related to the room dimensions chosen. The structural steel frame has a grid of two modules (13 feet, 4 inches). Floors are modular precast slabs placed directly on steel beams. Partitions are composition board core with asbestos board facing.

Frame drift is minimized with cast-in-place concrete encasing the steel-framed core. Lateral deflection is held to 1:1000 or less.

Exterior cladding is of glass-reinforced, pressure-moulded, plastic panels, stiffened by a light metal frame. A continuous tubular gasket around the periphery of the panel provides a weather seal. Panels are either windowless or incorporate a metal-framed pane which pivots 360 degrees about the horizontal centroidal axis. Panels are mounted on a steel frame and erected in units of six (three high x two wide) comprising an area of about 360 square feet and weighing about three tons. The plastic outer skin is pressure-moulded in the U.S.A. and the complete panel subsequently assembled in the U.K. Twelve units (72 panels) can be erected per day. (See also Reference 7). FIG. 12

The SF1 system, as applied to the first two buildings now under construction, costs three per cent more than the least expensive concrete alternative but can be completed in eight months instead of 18. SF1 panels cost about £50 each and weigh approximately 10 pounds per square foot including a window.

The SF1's outward appearance is definitely modular since each panel is seen distinctly. Overall appearance is superior to most other London apartments built by conventional methods. The fibre-glass panels should weather well and are not subject to staining or colour change, being slightly off-white.

"SEAC" Schools

SEAC (South-Eastern Architects Collaboration) schools utilize a steel frame characterized by hollow, square, light-gauge steel columns, castellated beams made from rolled sections and open-web steel joists. The SEAC-I system is based on a 2-foot 8-inch module with spans up to 32-feet. The SEAC-II FIG. 13

system is based on a 2-foot module with spans up to 60 feet. (See Reference 8).

A one-hour fire rating is required for the columns and is achieved by rigid insulation inside a snap-on metal facing consisting of two channel-shaped units. The resulting vertical joints are sealed with a special mastic.

SEAC steel frames, as exemplified by the 14,000-square-foot, single-storey SEAC-I which was visited, take about four weeks to erect, with a small crew and minimum erection equipment. Alignment of curtain wall supports takes almost the same period of time.

"SCOLA" Schools

SCOLA (Second Consortium of Local Authorities) schools employ a light steel frame consisting of open-web joists, columns made of four angles battened together, and flat-bar X-bracing. Floors are precast concrete units about 3'-4" x 1'-8" x 2", grouted after placement. These units rest on cork strips laid on top of the joists for the lessening of sound and vibration. Floor finish is applied directly to the grouted precast slabs, resulting in some unevenness which apparently is tolerated. Exterior walls are plywood and glass panel attached to the structural frame by cleats. The module employed is three feet, four inches at present, with plans under way to switch to a 2-foot module.

Visits were made to a grammar school under construction, a junior school to which an addition was being made, and a secondary school under construction. The latter was two storeys in height with a single-storey wing. Interior partitions were wood stud and gypsum board, apparently not industrialized. Total construction time was scheduled to be 26 months and the cost was quoted as £5 per square foot, including a warm-air heating system. FIG. 14

Fabricating Plant of Sanders and Forster (East London)

At this plant both SEAC and SCOLA steel framing systems are fabricated. Castellated beams are produced from rolled shapes which are first cut with a Litzka machine and then manually welded as the two parts pass through an alignment and clamping device. Steel strip is roll-formed into channel sections, two of which are manually welded toe-to-toe to form a box column.

All material for open-web joists (SCOLA System) is blast-cleaned and automatically painted by cross-travelling nozzles on leaving the blast device. A zinc-rich paint which dries in approximately four minutes is used. After assembly all SCOLA structural components are dipped in a bath of rust-inhibiting paint, then stored for drying prior to shipment.

In the drafting room, the production schedule is developed from the order record. Orders for both SEAC and SCOLA schools appear to be placed well in advance, up to two years.

"IBIS" System

IBIS (Industrialized Building in Steel), developed by Richard Thomas and Baldwin, a large producer of steel sheet, is perhaps the most long-ranged and pre-planned of all current systems. Aimed particularly at the housing market, the main feature of IBIS is careful planning of a host of basic parts which can be utilized in a variety of building components.

It was the view of the spokesman for IBIS that industrialized systems which depend on the use of standardized building components such as wall panels, or structural members of fixed sizes in a closed system, cannot be successful except in a limited and possibly short-term market. IBIS thus concentrates on maximum flexibility with a large stable of basic standard parts which can be used in a variety of building components.

IBIS homes, not yet marketed, use steel only where it makes sense, otherwise different materials are used. About four tons of steel per house are required, all cold-formed. RTB also is developing containers for storing and shipping IBIS components. Display models of IBIS homes depicted a deluxe bungalow, a two-storey dwelling, a duplex and a multiplex. FIG. 14a

The IBIS system employs a steel frame of rectangular tubing, steel stud partitions with gypsum board facing, gypsum ceiling and clipboard floors. Exterior cladding is colour-coated steel sheet at the second storey. From ground floor to second floor the panel has a sprayed-on ceramic-sand coating that is claimed to be almost vandal-proof and child-proof.

<u>"CLASP" System</u> (York University, York)

The new University at York is the largest single project to employ the CLASP (Consortium of Local Authorities) system co-operatively developed with Brockhouse Steel Structures Ltd. The CLASP system is basically a modular steel structural frame to which may be attached a variety of walls and floors. The module of the Mark III CLASP System is three feet, four inches. The newest system, Mark IV, uses a 3-foot structural module combined with a 1-foot horizontal and a 2-foot vertical planning grid. FIG. 15

A unique feature of CLASP is that, in a special form, it can be used in areas where there is danger of foundation settlement, the structural system being designed to accommodate large vertical displacements.

CLASP utilizes square hollow tubular columns, truss-type floor beams and roll-formed box-type bracing members. Wherever feasible, single-bolt connections are used. Maximum spans are 60 feet for gymnasia, otherwise 30 feet for single-storey and 27 feet for multi-storey (Mark IV). Steelwork weighs four pounds per square foot for single-storey buildings and seven pounds per square foot for buildings of two to four storeys. FIG. 16

At York University exterior walls consist of precast concrete modular components which are fairly attractive. Interior partitions employ gypsum board on wood studs and are not attractive, since little attempt is made to conceal joints and wood trim is poor quality. In a building under construction wood was being used for the floors and roof in what appeared to be cut-to-fit site work. Modular wood sash was being installed. FIG. 17

Brockhouse Steel Structures Ltd., Clydebank Works, Glasgow

At this plant the structural components of the CLASP system are produced. Layout is efficient and the whole plant, which is neat and tidy, produces about 700 tons per month. Insofar as is practicable, fabrication is done on an assembly line basis. Manual welding is predominant, however. One noteworthy feature is a very large pickling-painting-drying production line which is highly automated.

CLASP System School, Glasgow

A visit was made to a two-storey school under construction near Glasgow. CLASP-System steel framing, precast concrete exterior walls, wood floors and wood sash are being employed.

"TRUSTEEL" System

At the Skerne Works, in Darlington, components of the Trusteel system are fabricated. This system is designed for houses and small apartments and is a framing system only. All members are formed from light-gauge steel.

There are two Trusteel systems and two principal methods of fabrication. In the older method (Mark 2) most members are lattice-type, employing many small pieces which are shop-assembled by riveting. All rivets are small (1/4-inch diameter or less), pneumatic riveting is fast and dimensional control quite good. In the newer method (3M) members are roll-formed or stamped from sheet or strip with a minimum amount of shop assembly. Despite the apparent efficiency as well as better appearance of members in the 3M system, orders are still received for the older lattice-type.

The Mission visited a three-storey apartment building under construction, which employed the "3M" framing system. Since all members are quite light, frame erection can be done entirely by hand with no erection equipment. It is often done by a carpenter and two or three helpers. The structural module is one foot and the basic module four inches. Despite its lightness the 3M frame was very sturdy. FIG. 18 In this particular building the floor construction for the second floor, which divides a lower single-storey apartment from a two-storey apartment above, is interesting. Above the ceiling consisting of plaster on 3/4-inch gypsum board, two inches of sand is poured between each floor joist for sound abatement. Rockwool is then placed to the top of the eight-inch-deep joists and the whole overlaid with plywood sub-flooring which in turn receives hardwood flooring. It is claimed that this construction is effective in stopping noise transmission.

The Mission also visited a two-storey, three-bedroom house under construction which used the Mark 2 system. The Mark 2 has a module of two feet, nine inches and it is claimed that the steel frame for a two-storey house can be erected by three men in 12 hours. Close manufacturing tolerance (1/32-inch) assures a dimensionally accurate frame - a decided advantage to the builder. The frame costs about £400, which represents approximately 20 per cent of the total cost of this type of house. FIG. 19

Red Road Apartment Buildings, Balornock

This large apartment complex on the outskirts of Glasgow was visited briefly. The project is a low-rental, high-rise (28-storey) development subsidized by the Glasgow Corporation and contains 1,356 apartments. Design is modular, comprising a steel frame, concrete floors cast on steel "Holorib" deck and precast concrete exterior wall panels. (See also Reference 9). FIG. 20

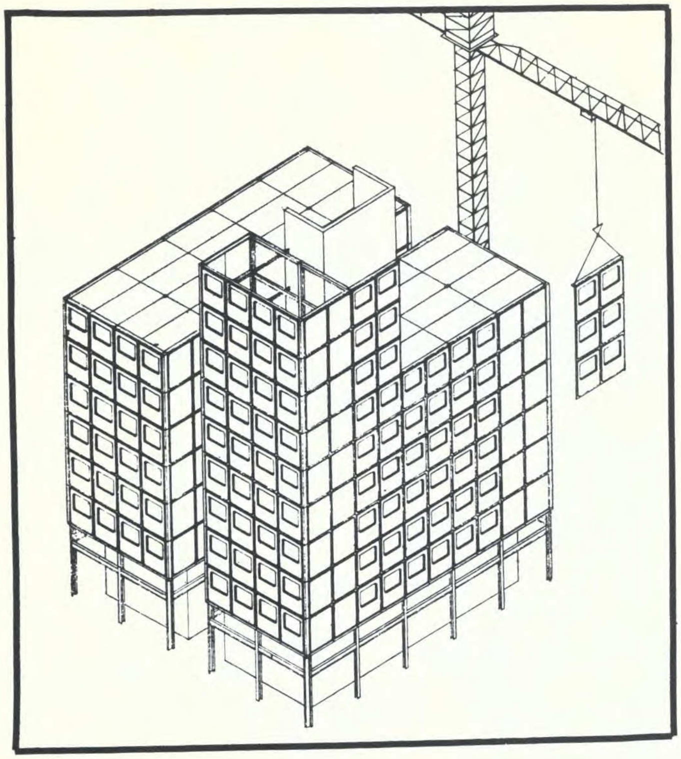
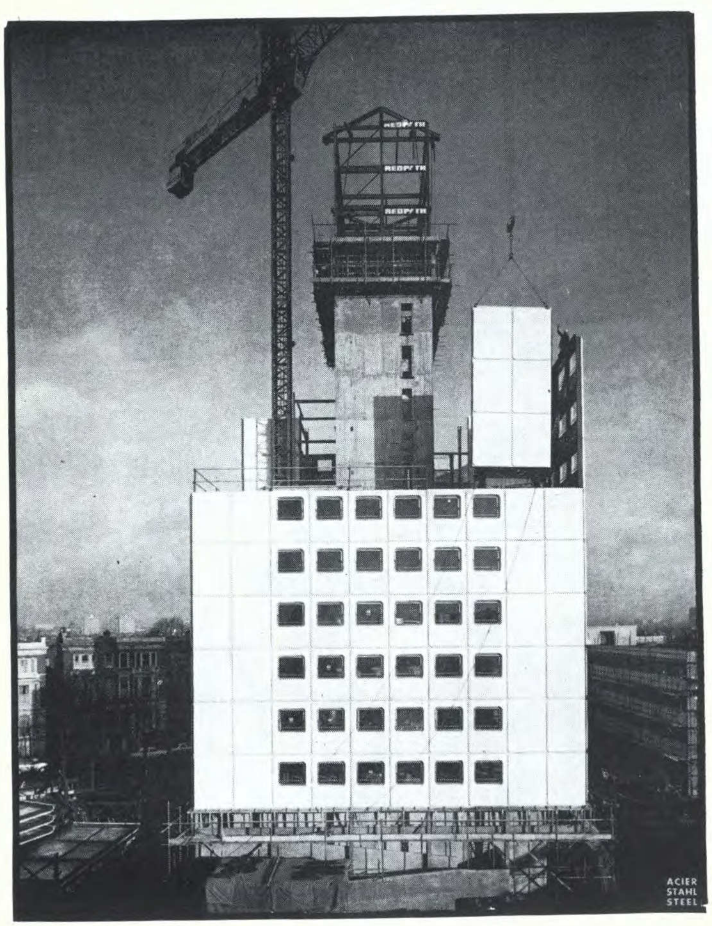


FIG. 11

"SF 1" LOW RENTAL APARTMENT - LONDON

The mod look
in steel and plastic.



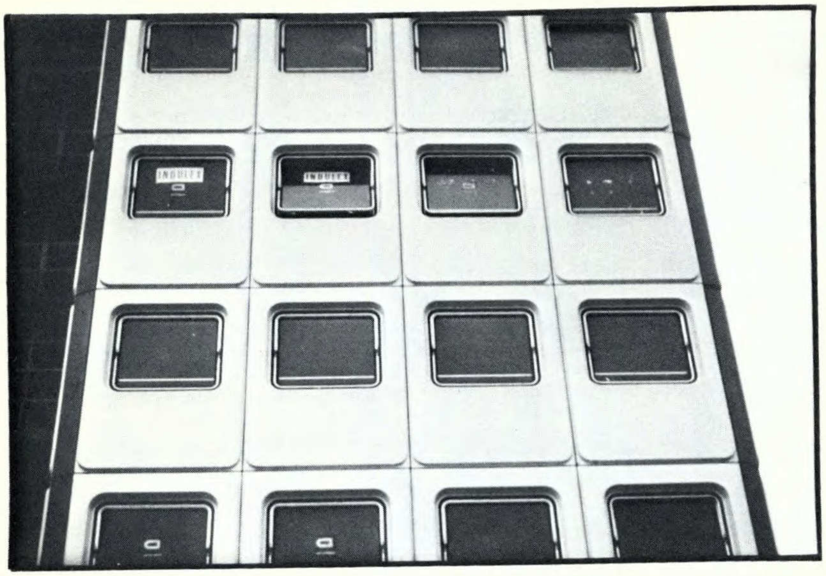
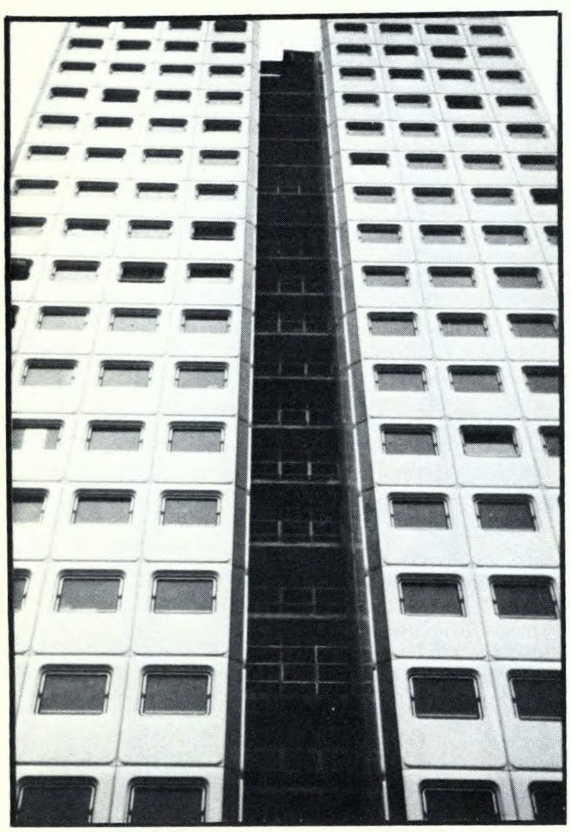
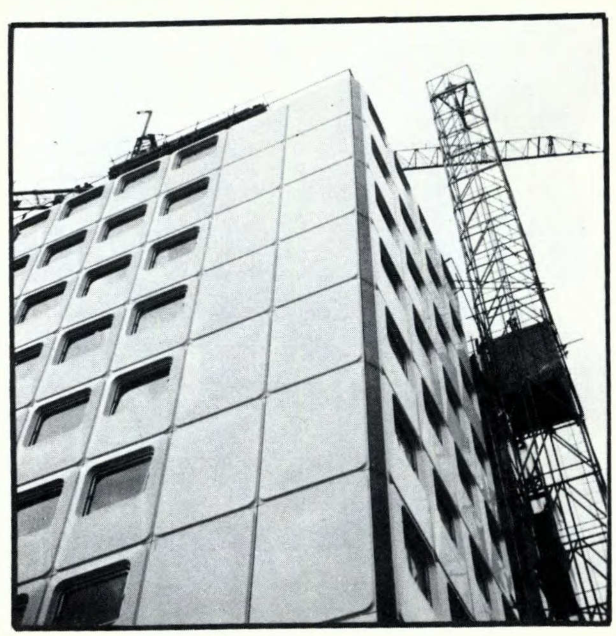


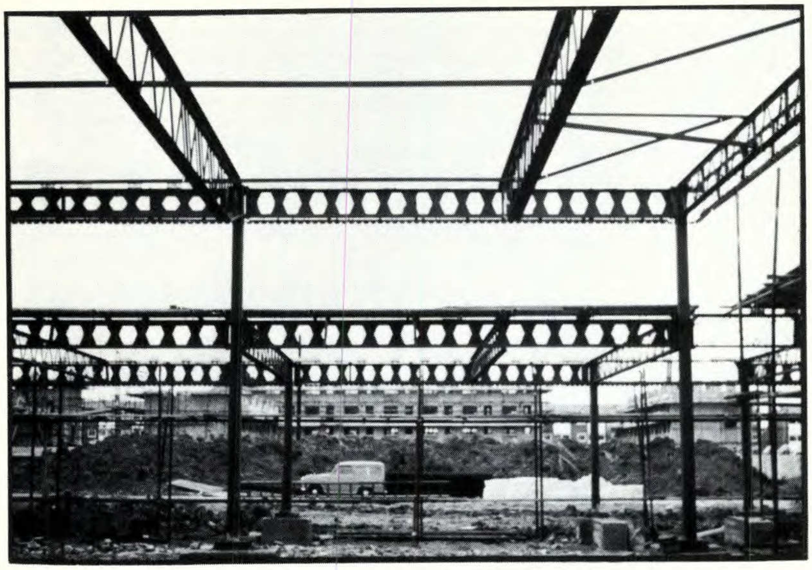
FIG. 12

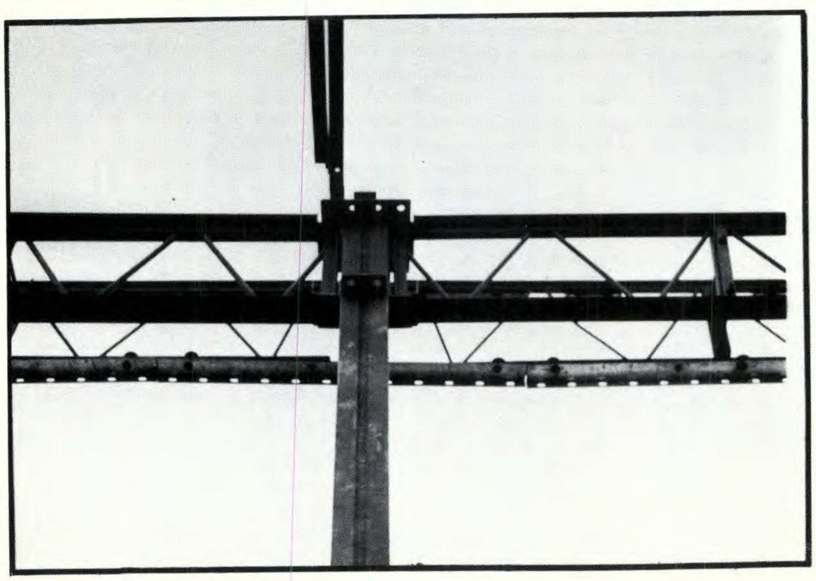
SF 1 SYSTEM- LONDON

Low rental high rise housing by the Greater London Council









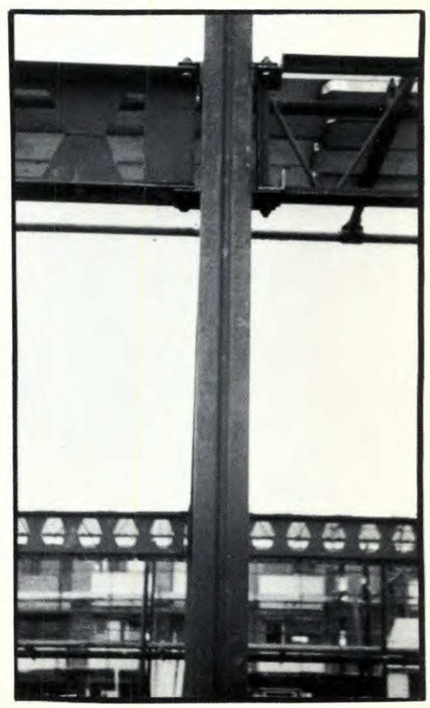
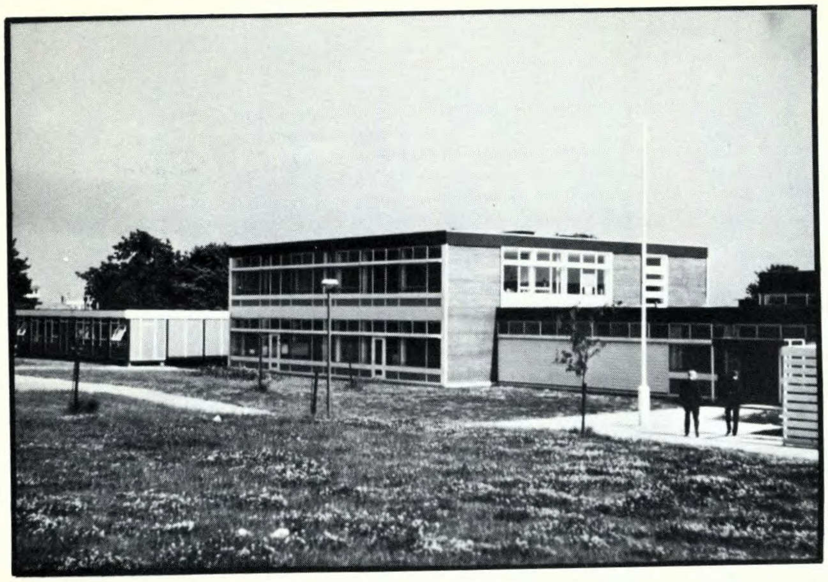


FIG. 13
"SEAC"
SCHOOL
SYSTEM-
ENGLAND

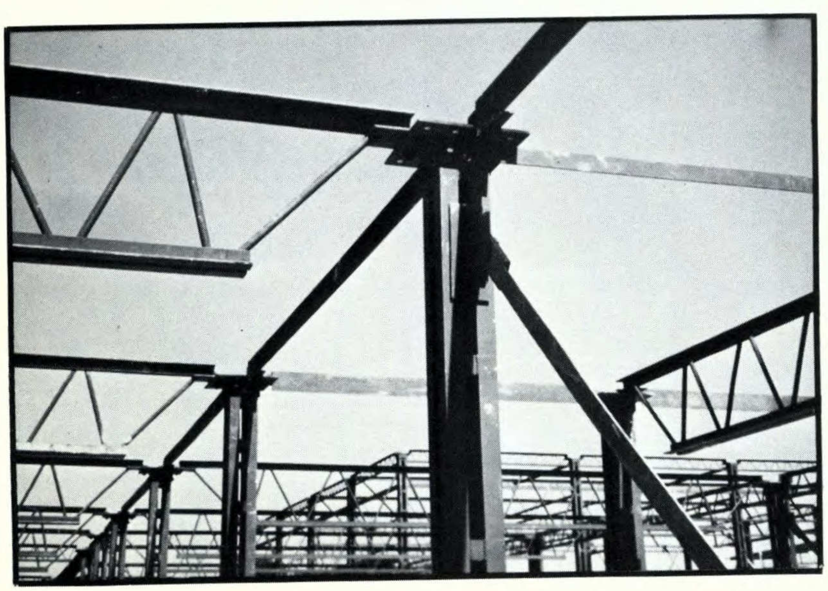
Castellated beams, open web joists, and light gauge tubular columns.

FIG. 14 "SCOLA" SCHOOL SYSTEM - ENGLAND



Typical school

Curtain wall alignment



Light steel framing

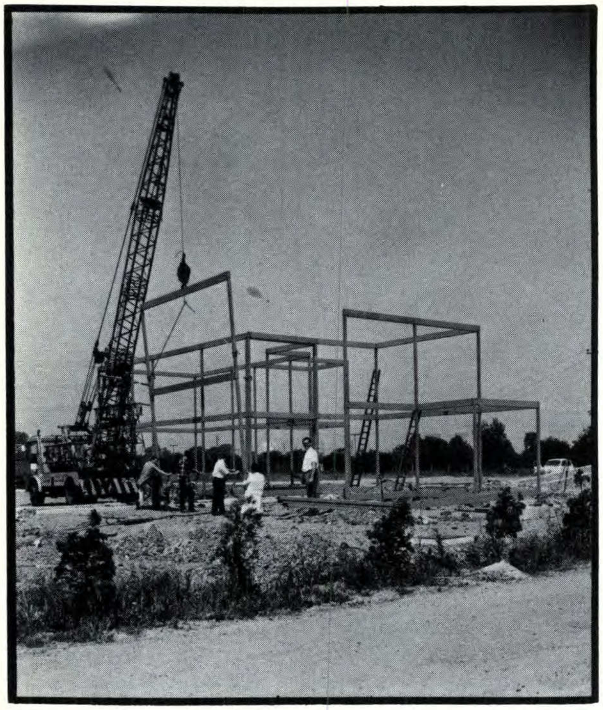
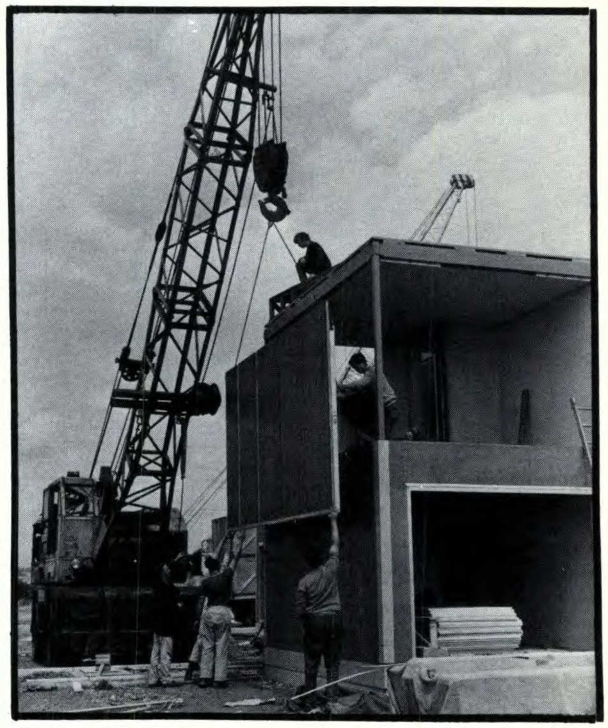


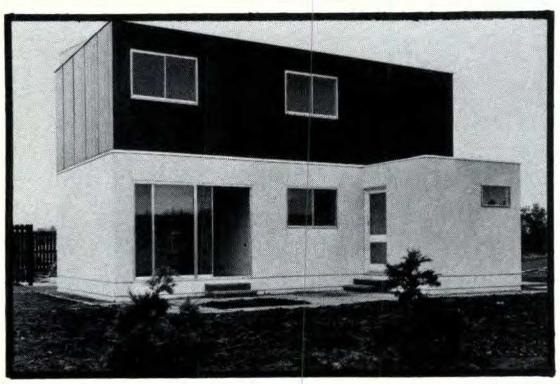
FIG. 14a

"IBIS" SYSTEM PROTOTYPE

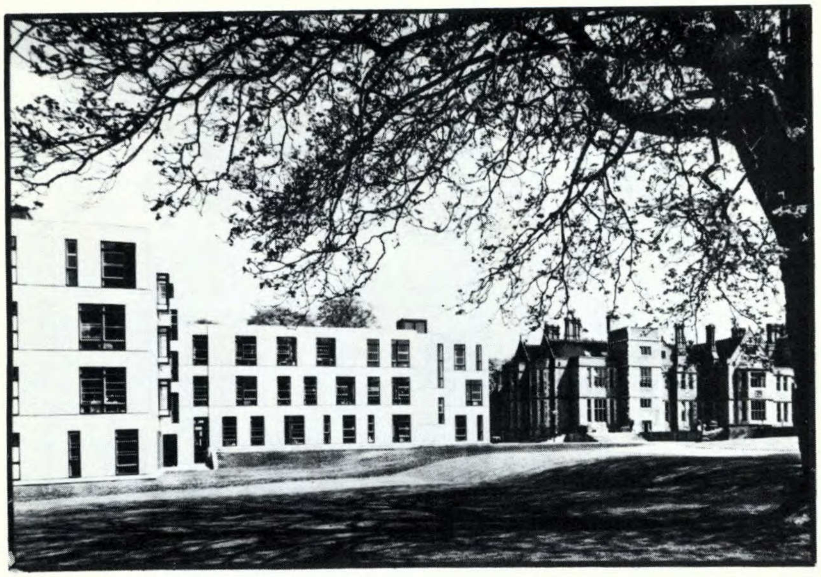
◀ Steel framing.

Wall panel ▶ Installation.





◀ Completed prototype home.



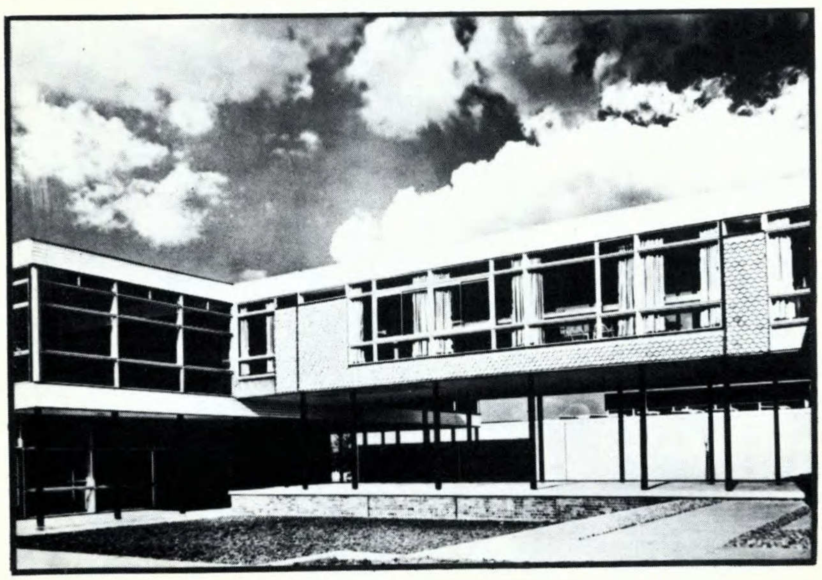


FIG. 15
VIEWS OF YORK U.

A mod campus for mod students.

FIG.16

"CLASP" SYSTEM FRAMING AT YORK UNIVERSITY

CLASP FEATURES:
Cold formed bracing
single bolt connections.

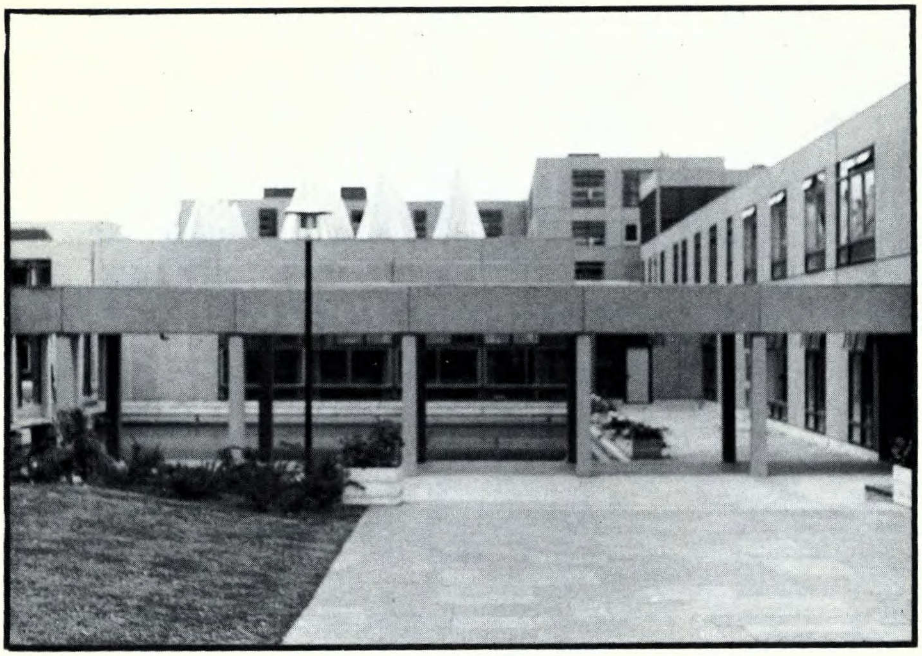
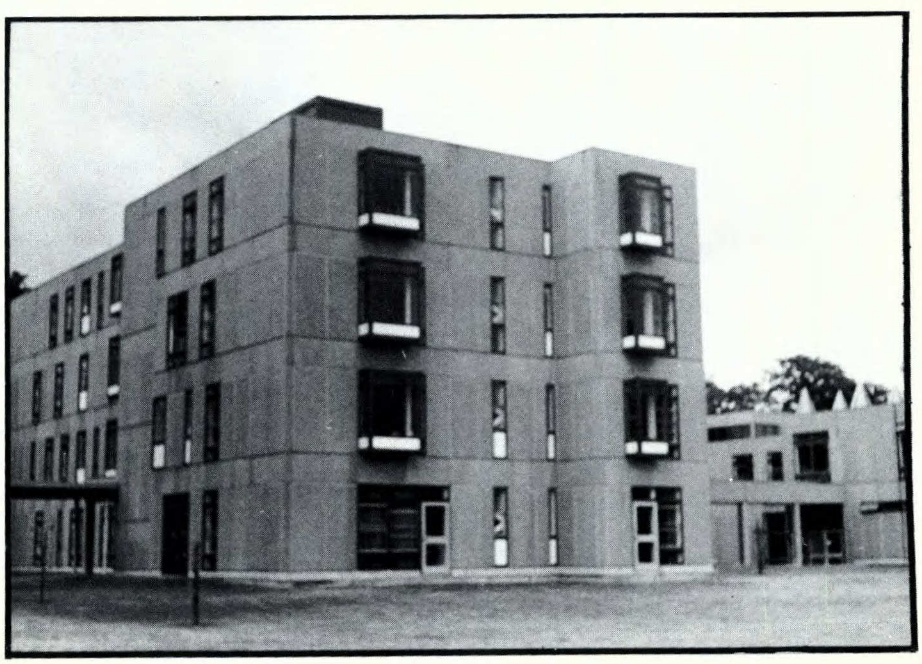


FIG. 17

YORK UNIVERSITY

Precast penals on a 'Clasp' system steel frame



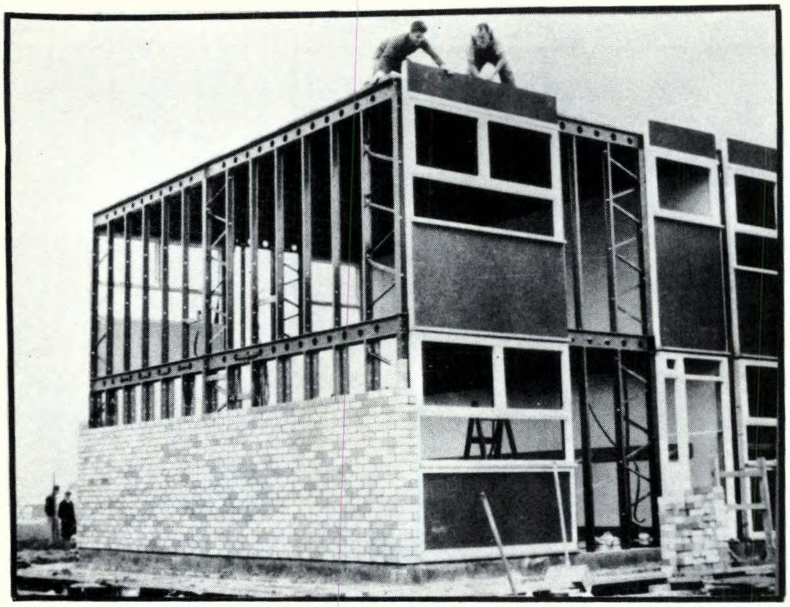
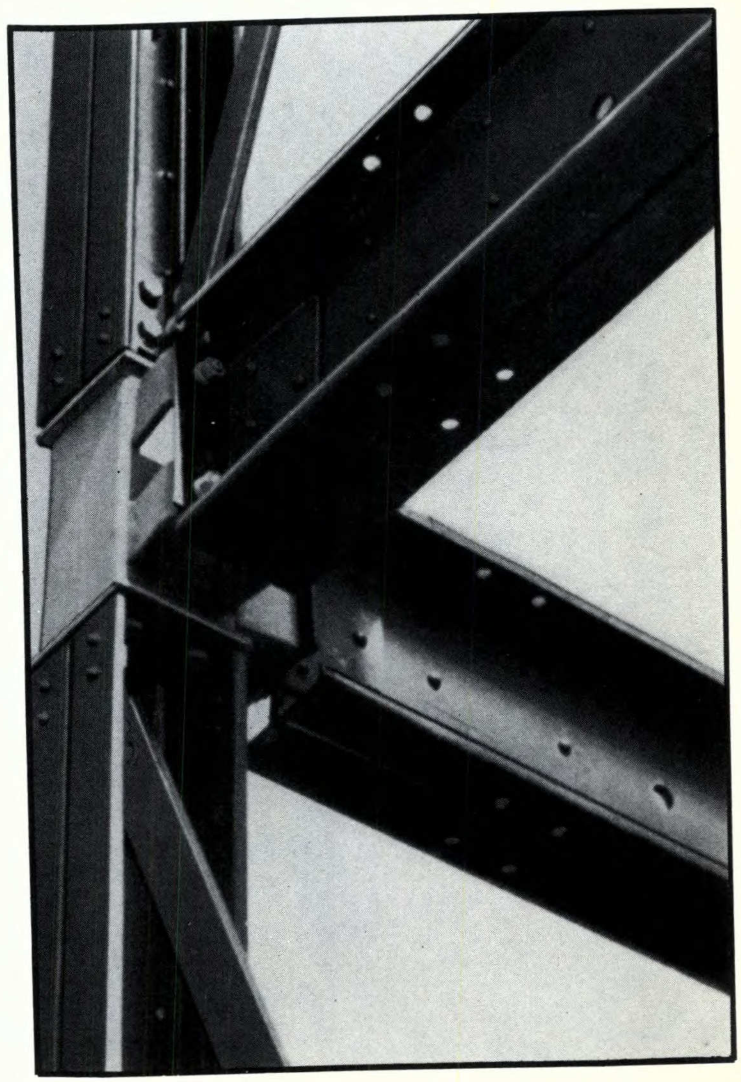
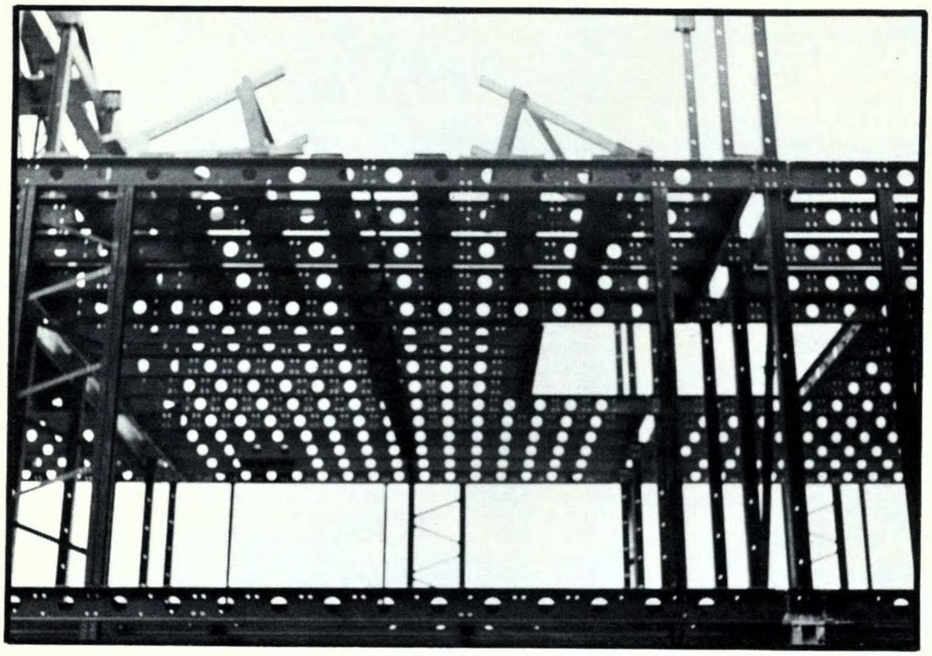


FIG. 18
"TRUSTEEL" SYSTEM

Construction of row housing using 3M system.

Framing members are cold-formed and riveted.



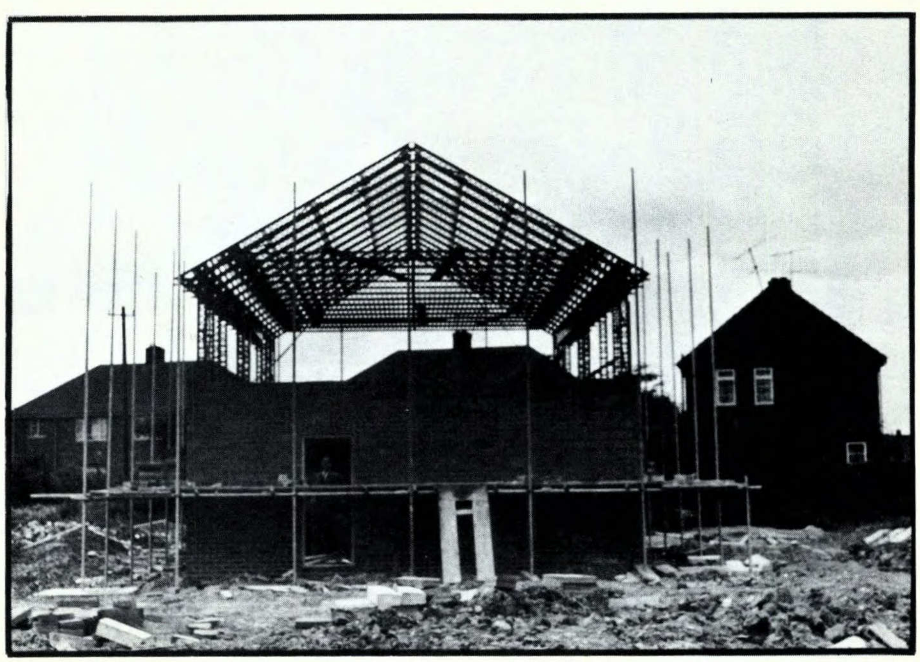


3M system in multi-plex housing.

FIG. 19

"TRUSTEEL" SYSTEMS

Mark 2 system used in single family dwelling



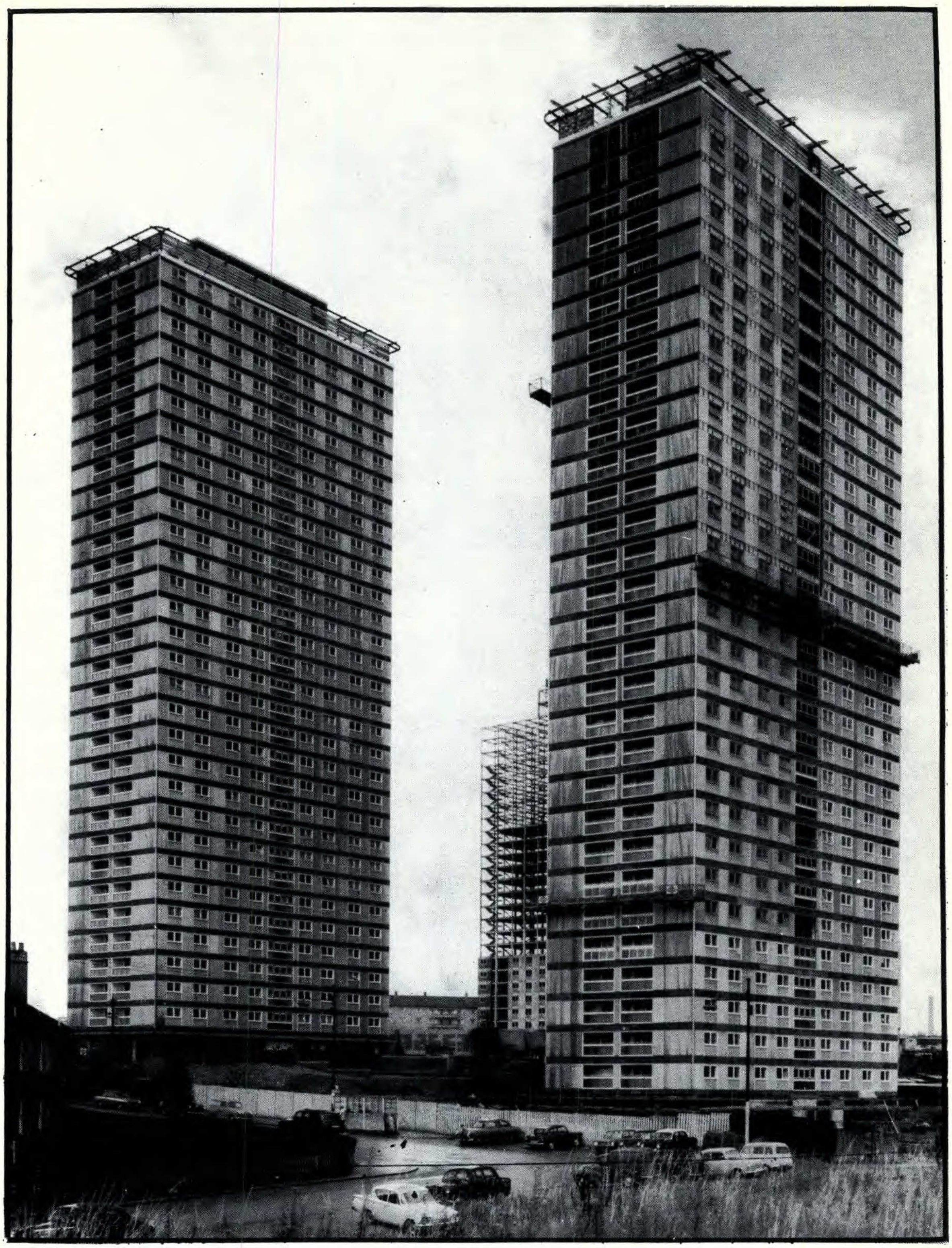


FIG. 20

RED ROAD APTS.-BALORNOCK, SCOTLAND

Rising above the Scotch mist in mod style.

APPENDIX I

ADDITIONAL VISITS

During the course of travel the Mission had the opportunity to visit certain organizations, sites and plants that were not directly related to industrialized building in steel. These are briefly described below:

German Advisory Board on Steel Application, Dusseldorf

The Mission visited the manager, Dr. Odenhausen, and met other members of his staff. The Advisory Board is supported by the steel producers and fabricators in Germany, who pay dues on the basis of tonnage. The Board acts as an information centre on the use of steel in Germany and works closely with manufacturers seeking new applications for steel products.

New Bridge over Rhine at Dusseldorf

The Mission visited the site of this new bridge under construction. It is a cable-stayed design featuring box girders and orthotropic deck. Girders are assembled on the site from plant-fabricated components. Welding and rivets are being used.

Plant of Hoesch AG, Hamm, Germany

This plant is new and equipped with modern equipment including cold-formed mills, a continuous coating line for sheet and a welded beam mill. All components for Hoesch modular homes and industrial buildings are manufactured here.

Hoesch manufacture a welded beam with rectangular hollow roll-formed flanges, which has the advantage of requiring much less lateral bracing compared to rolled shapes or welded FIG. 21 beams made from three flat plates. This beam unit is used in Hoesch pre-engineered industrial buildings which are supplied as a complete package.

Fabricating Plant of C.F.E., Lauterbourg, France

Cie Française D'Entreprises (C.F.E.) claims this to be the most modern structural steel fabricating plant in France. It has automatic horizontal transfer tables to route material from aisle to aisle for multiple drilling and punching both horizontally and vertically. Other features include a nine-head oxygen cutting machine and modern welding equipment, a blast-cleaning chamber and electrostatic painting operation and a control centre for scheduling all fabrication. This plant can produce about 4,500 tons of fabricated structural steel per month. All stock material is stored inside.

At another plant in Paris, C.F.E. produces industrialized buildings. Entire "cubes" are factory-produced and shipped to the site. FIG. 22

Inclined Ship Transfer between Rhine and Marne Canals

This is an interesting innovation which, when completed, will eliminate 17 locks, save one day's journey and handle 39 boats per day. In essence a boat will enter a lock at the bottom of an inclined ramp and the entire unit (lock plus boat) will be lifted 300 feet up the incline and be deposited in another canal.

C.F.E. is the designer and general contractor for this ship transfer, which is the first of its kind in the world.

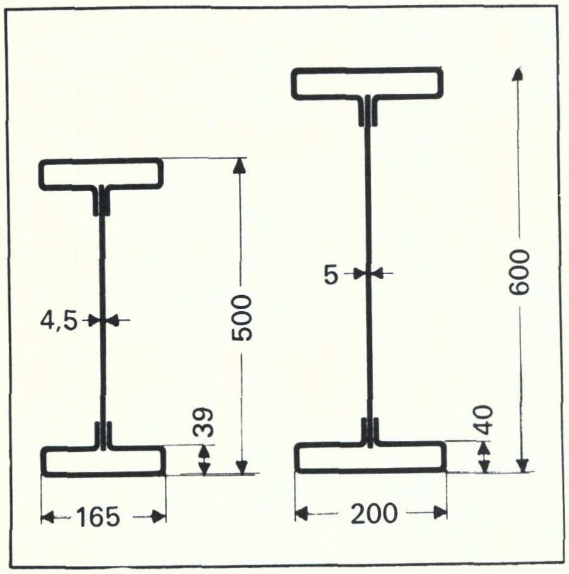
Tinsley Viaduct, U.K.

Tinsley Viaduct is a twin-level steel structure under construction between Rotherham and Sheffield, designed under the direction of

Sir Gilbert Roberts of Freeman, Fox and Partners. Although the original design was in concrete, a steel alternative proved more economical and met the required time schedule. Each level is six lanes wide plus walkways. The design consists of two welded continuous box girders with cross beams, outriggers and concrete deck at each level. There are no expansion joints in the entire 3,400 feet of length. The top deck of the twin-level viaduct will be heated in winter to avoid icing hazards. Construction time will be 27 months, of which there were nine to go in June, 1967. Steel tonnage amounts to approximately 12,500 tons and the total cost is about $15 million. A proprietary type of cadmium-plated high-strength bolt is used for field connections. The 3/4-inch size is tightened to a preload of 66 kips, almost twice that currently specified for a similar-sized A.S.T.M. A490 bolt. FIG. 23

<u>Cleveland Bridge Plant, Darlington, England</u>

The Cleveland Bridge and Engineering Company is a long-established concern which fabricates heavy structural and bridge work. They have been associated with many well-known bridges in the U.K., such as the Forth Bridge, and the Severn and Tay Bridges, as well as others throughout the world. They also are the fabricators and erectors of the Tinsley Viaduct. Their plant is old and has been changed from a rivet shop to a welding shop. They seem to be knowledgeable in the use of electro-slag welding and use it whenever practical. They claim that if the material to be electro-slag welded has at least twice the required minimum Charpy impact value, the as-welded joint will meet or exceed the minimum specified value.



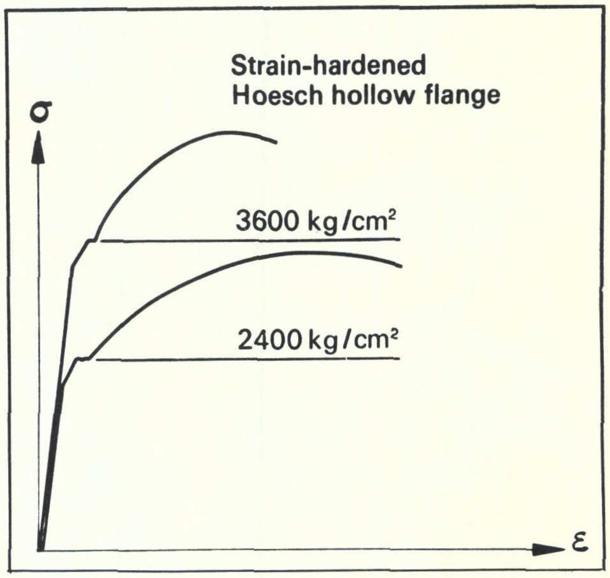


FIG. 21

HOESCH HOLLOW FLANGE SHAPE

Manufacturer claims overall economy.

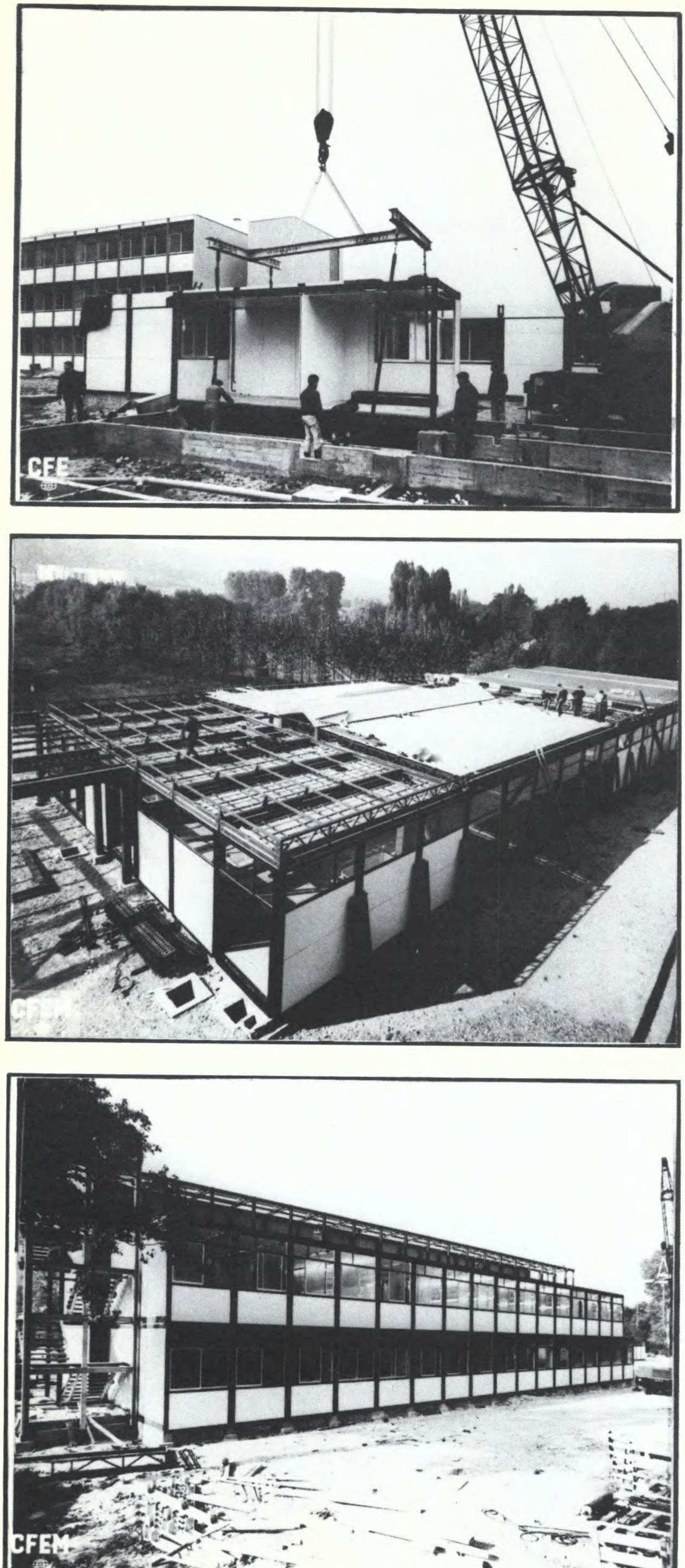
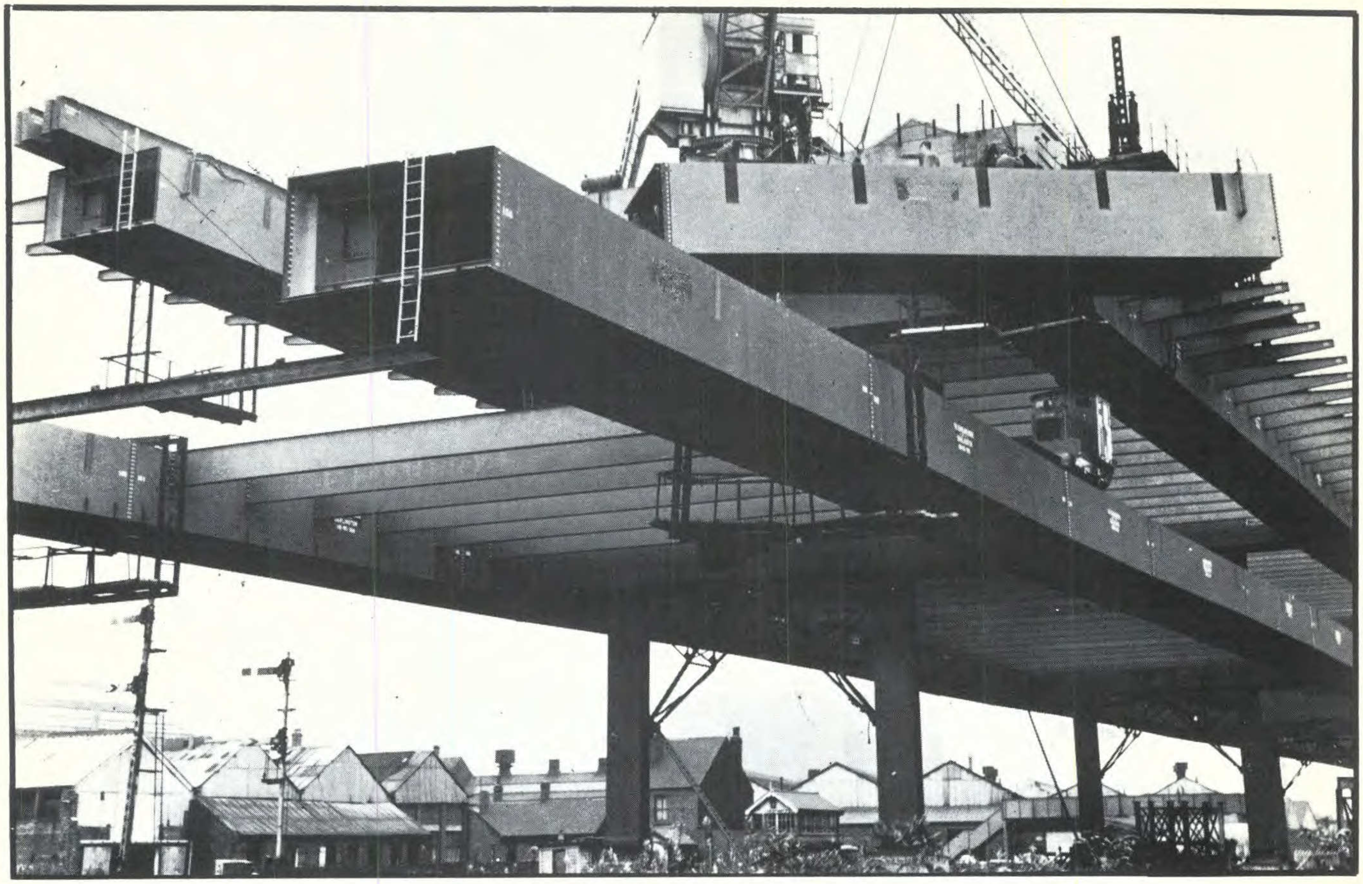


FIG. 22

INDUSTRIALIZED BUILDINGS BY C.F.E.- FRANCE



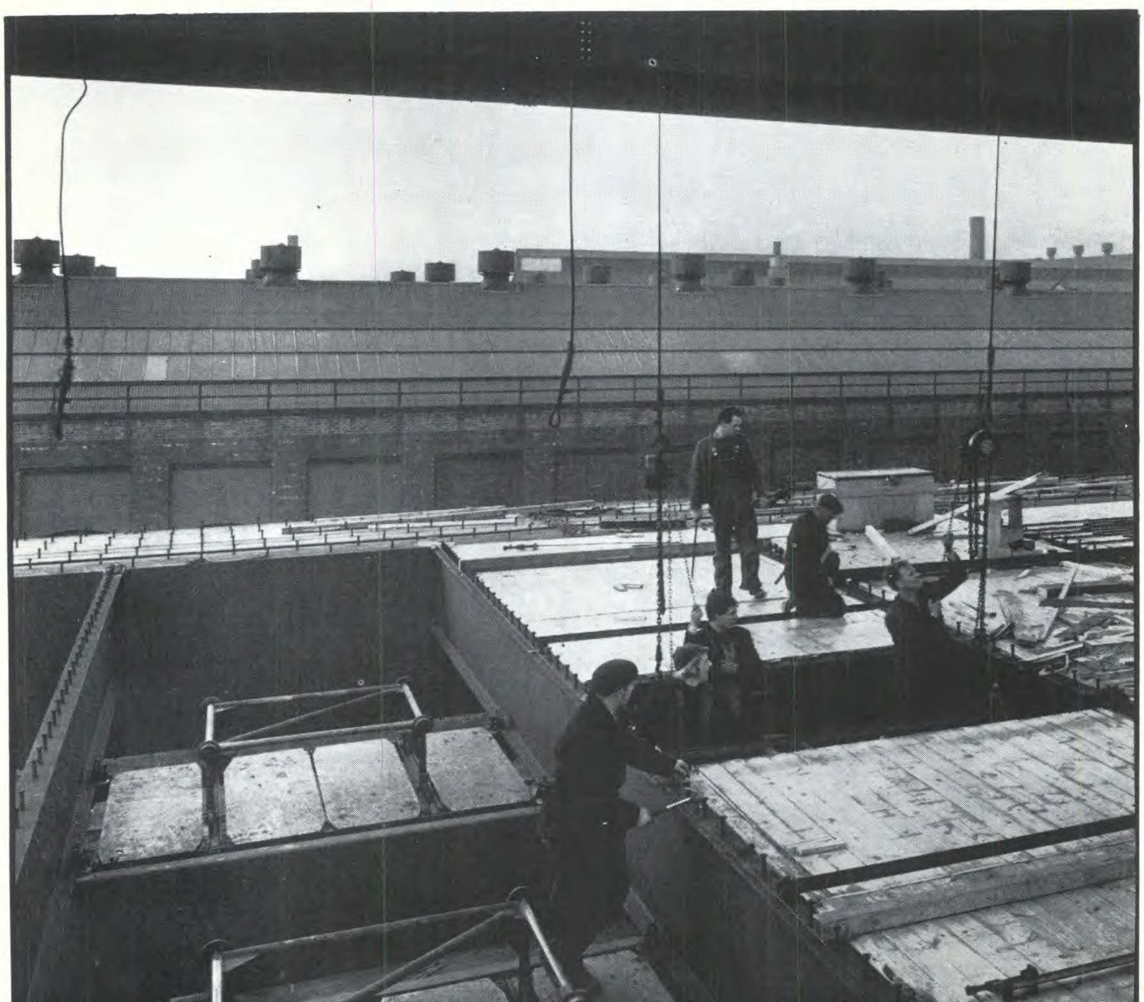


FIG. 23
TINSLEY VIADUCT

Modern
but not
mod.

APPENDIX II

Comments by Individual Members

Appearing below are some edited comments by various members of the Mission. These give a random sampling of individual reaction and opinion and supplement the Summary and Recommendations of the report.

". . . There is also the intangible of "style" to consider - acceptance of which varies from country to country and even from region to region within a country. However, the philosophy of modular construction and industrialized building is the important concept, and this, being simply a philosophy, can be transplanted to Canada."

". . . In the United Kingdom the Ministry of Public Building has issued papers on Dimensional Coordination (DC1 and DC2) . . . manufacturers of open systems adhering to these papers will produce compatible components."

". . . The main advantage to European industrialized building was the saving in time . . . next was the saving in on-site labour. The savings in cost were less evident . . . it seemed that insufficient credit was given to the savings in cost (financing) resulting from the saving in time."

". . . On . . . systems for schools . . . the French government has been very active in promotion. They were not so active when the bills became due . . . However, there is no doubt that the advancement of industrialized building of schools in France is due to an overall control by the Ministry of Education."

". . . The main force behind industrialized building in Europe was the need to meet the demands of large programs in short periods of time. In Canada the rising cost of on-site labour, the diminishing force of on-site tradesmen and the expected demands on the construction industry in the future will create similar needs."

". . . The standardization of the building code requirements was necessary to the success of the system."

". . . I think we should zero in on the Canadian government using the modular building principle."

". . . I had expected to find that the use of a building system would result in a product of monotonous repetition. This . . . was soon dispelled . . . because all the systems, particularly the open systems, are sufficiently flexible to allow individual architects considerable freedom of expression while remaining within the constraints of each particular system."

". . . We should definitely recommend a speed-up in arriving at a National Building Code covering modular co-ordination as well as establishing national modules."

". . . Time is on our side. The cost and conditions imposed by site-labour and the shortage of tradesmen will force industrialized building on us. As was noticed in Europe, speed of erection and dimensional reliability demands the steel frame so that factory-built components can achieve their full value."

". . . The active participation and enthusiasm of the architectural profession was evident."

". . . Unfamiliar design principles were not evident . . . all design seemed very simple and basic. The open-web steel joist, as we know it, does not seem to have been exploited."

". . . Fewer automated welding machines were observed than are seen in . . . our shops. Canadian labour costs undoubtedly would mean more automation in our plants."

". . . The main difference between industrialized building and traditional building is in philosophy of approach, i.e., standardized components for mass markets in place of custom fabrication for specific projects."

". . . Competitive costs should be a prime consideration in the study and development of industrialized systems."

". . . As industrialized building in Canada appears inevitable, the steel industry should take the initiative in developing industrialized building as a means of creating a competitive advantage over other leading construction materials. The steel industry should make itself the leader in the large market that will result."

". . . One of the noticeable discrepancies between the philosophy of modular coordination and its application in Europe was the lack of agreement on a standard planning module by the various purchasing groups. Each purchaser had his own ideas based on his own needs. This seems to be one aspect that needs serious consideration before going too far along the road in Canada. To what degree is modular coordination and standardization desirable?"

APPENDIX III

23RD INTERNATIONAL CONGRESS OF STEEL INFORMATION CENTRES

Held in Essen, Germany, on June 6, 7 and 8, 1967, the Congress had as its theme "Industrialized Steel Construction in the Service of Man". The main emphasis was on progress being made in this field of steel application. Highlights of some of the papers which were presented are noted below.

1. "Technical Organization of Industrialized Building Systems"
   - J. Bender (France)

   Mr. Bender emphasized the importance of dimensional control, compatibility of components, suitable packaging and handling of material, also layout and storage of material on the site for maximum efficiency. He stressed the need for site organization to make full use of the benefits of industrialization. It is important that the right components arrive at the right place at the right time. (See Reference 1).

2. "Effect on Man of EM - Radiation Shielding Present In Sheet Steel Buildings"
   - Dr. W. Ranscht-Froemsdorff (Germany)

   The author presented some very interesting data to show the effect of sheet steel cladding in suppressing atmospheric electrical charges which have adverse effects on many people. He concluded that steel-clad buildings are desirable for hospitals, mental institutions, offices and homes, or wherever mental wellbeing of persons is important.

3. "Recent Research in the U.K. on the Effect of Fire on Structural Steelwork"
- G. B. Colbridge (U.K.)

Mr. Colbridge explained and interpreted the work being carried out by the Fire Research Station in the U.K. This research is aimed at assessing the effect of actual fires on steel frames. Results are encouraging. (See Reference 2).

4. "Behaviour of Steel Structures Exposed to Fire"
- J. Witteveen (Netherlands)

Mr. Witteveen described work being done in Holland to assess the different behaviour in a fire of continuous and simple-span beams, including the effect of section size and thickness as well as the effect of cladding thickness.

5. "Krupp System Hospitals"
- W. Becker (Germany)

The author stressed that the Krupp organization does not offer complete hospital designs but will assist architects in the selection of a complete system. He stated that architects do not agree on the module to be used and said that attention to detail was the key to success in system building. An example shown employed steel panels, precast floors, composite beams, 18-inch floor construction depth and lowered corridor ceilings.

6. "New Vienna Emergency Hospital"
- A. Hoch (Austria)

The complete complex consists of a four-storey hospital, a six-storey operating and X-ray building and an eight-storey nurses' residence. The hospital is designed with a heliport roof. Mr. Hoch stated that industrialized construction resulted in shorter construction time and that the use of steel framing reduced plumbing and electrical costs. Floors are precast concrete, insulated, on steel joists. A 1.4-metre module was used. Fire rating of 1-1/2 hours was required. The author stressed the fact that the architect needs full co-operation from industry in the design of buildings such as described.

7. "Industrialization of Hospital Construction in U.K."
- W. J. Jobson (U.K.)

Mr. Jobson outlined the need for industrialization, stating that the demand for new buildings exceeds the capacity of the available labour force. In the U.K. £2 to £4 billion of new hospital construction is needed. Preference is for three- or four-storey structures. Industrialization affords savings up to 25 per cent. For maximum economy, plumbing and wiring should be installed in wall and partition panels at the factory.

8. "Industrialized School Construction in France"
- G. LeMeur (France)

The author traced the development and application of industrialized school building in France and predicted that the traditional building method eventually would disappear.

9. "Composite Effect of Profiled Steel Sheet and Concrete"
- S. Bryl (Switzerland)

The author presented the results of a series of tests on the load-carrying capacity of galvanized steel deck with a concrete fill. No shear development was used. Some composite effect was noted and this might be utilized in design. Further studies are under way. (See Reference 3).

10. "Construction of GEAI Flats"
- M. Lods (France)

The author presented an illustrated description of this system which is basically a lift-slab design, the "slab" in this case being a light lattice space frame fabricated mostly from rod about 3/8-inch in diameter. The resultant thickness appeared to be in the order of six to eight inches.

11. "Government Subsidized Multi-Storey Housing" - M. Bourguignon (Belgium)

Mr. Bourguignon described a low-rental housing project in Brussels. The building is 17 storeys, and of steel-framed, braced construction. Exterior curtain wall is steel and glass. Floor is galvanized steel deck overlaid with 3/4-inch of cork, hardboard and linoleum. (See Reference 4).

Papers were given also on four projects which were visited by the Mission:

12. "University Buildings in Bochum" - J. Rüping (Germany)

See comments under heading "Ruhr University at Bochum" (p. 23). Also Reference 5 and Figure 1.

13. "AZM System Prefabricated House" - E. Heurermann (Germany)

14. "Berlin Experimental House" - F. Vellguth (Germany)

See Reference 6 and Figure 2.

15. <u>"The SF1 System of Multi-Storey Construction for the Greater London Council"</u>
<u>- J. W. Davidson (U.K.)</u>

See comments under heading "SF1 Apartment Buildings, London" (p. 46). Also Reference 7 and Figures 11 and 12.

Other papers presented at the Congress were:

16. <u>"A Belgian System of School Construction"</u>
<u>- P. Ramboux (Belgium)</u>

17. <u>"VOEST" System Prefabricated Schools"</u>
<u>- E. Zwiedinek (Austria)</u>

18. <u>"Steel Schools in the Netherlands"</u>
<u>- J. Heijligers (Netherlands)</u>

19. <u>"College for Nurses in Vienna"</u>
<u>- R. Krapfenbauer (Austria)</u>

20. <u>"Youth Hostels in France"</u>
<u>- G. Repeczky (France)</u>

21. <u>"Sandwich-Type Steel Panel Construction"</u>
<u>- H. Witte (Germany)</u>

22. <u>"Industrialization of Low Cost Housing"</u>
<u>- W. Bresselurs (Belgium)</u>

23. <u>"Use of High Strength Bolts in System Building"</u>
<u>- R. Negri (Italy)</u>

It is intended that all papers will be published in future issues of the magazine "Acier-Stahl-Steel".

<u>Field Trips</u> forming part of the Congress program included visits to:

1. Industrialized Steel Homes at Hilden, Germany.
2. Industrialized Schools at Herne and Bochum - Harpen, Germany.
3. Ruhr University at Bochum, Germany.
4. Plant of Hoesch AG, Rohr-und Bauterlwerk, Hamm, Germany.

LIST OF REFERENCES

1. "The Technical Organization of Industrialized Construction" - J. Bender - Acier-Stahl-Steel, November, 1967.

2. "Recent Research in the U.K. on the Effect of Fire on Structural Steelwork" - G.B. Colbridge - Acier-Stahl-Steel, September, 1967 (published by Centre Belgo-Luxembourgeois d'Information de l'Acier - 47, rue Montoyer, Brussels 4).

3. "The Composite Effect of Profiled Steel Plate and Concrete in Deck Slabs"- S. Bryl - Acier-Stahl-Steel, October, 1967.

4. "The Burgomaster Ed. Machtens Multi-Storey Block of Flats at Molenbeek, Brussels" - M. Bourguignon - Acier-Stahl-Steel, June, 1967.

5. "The University of the Ruhr, at Bochum" - J. Ruping - Acier-Stahl-Steel, June, 1967.

6. "The 'Berlin' Prefabricated Steel House" - F. Vellguth - Acier-Stahl-Steel, July-August, 1967.

7. "The SF1 System of Multi-Storey Construction for the Greater London Council" - J.W. Davidson - Acier-Stahl-Steel, July-August, 1967.

8. "Coordination in Building" - R.F. Freemantle - Proceedings BCSA Conference on Structural Steelwork, September, 1966.

9. "Red Road Multi-Storey Flats at Balornock, Glasgow (Great Britain)" - Acier-Stahl-Steel, April, 1966.

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10. "Progress in Steel Construction Work" - Proceedings of 1964 Steel Congress of the High Authority of the European Coal and Steel Community.

11. "The Comprehensive Industrialized Building Annual (Systems and Components) 1966" - House Publications Ltd., London, England.

12. "Towards Industrialized Building" - Proceedings of Third CIB Congress, 1965 - Elsevier Publishing Company.

13. "Industrialized Building and the Structural Engineer" - Proceedings of 1966 Conference, The Institution of Structural Engineers.

14. "The Application of System Building to Larger Buildings" - F. Reinitzhuber - Acier-Stahl-Steel, February, 1964.