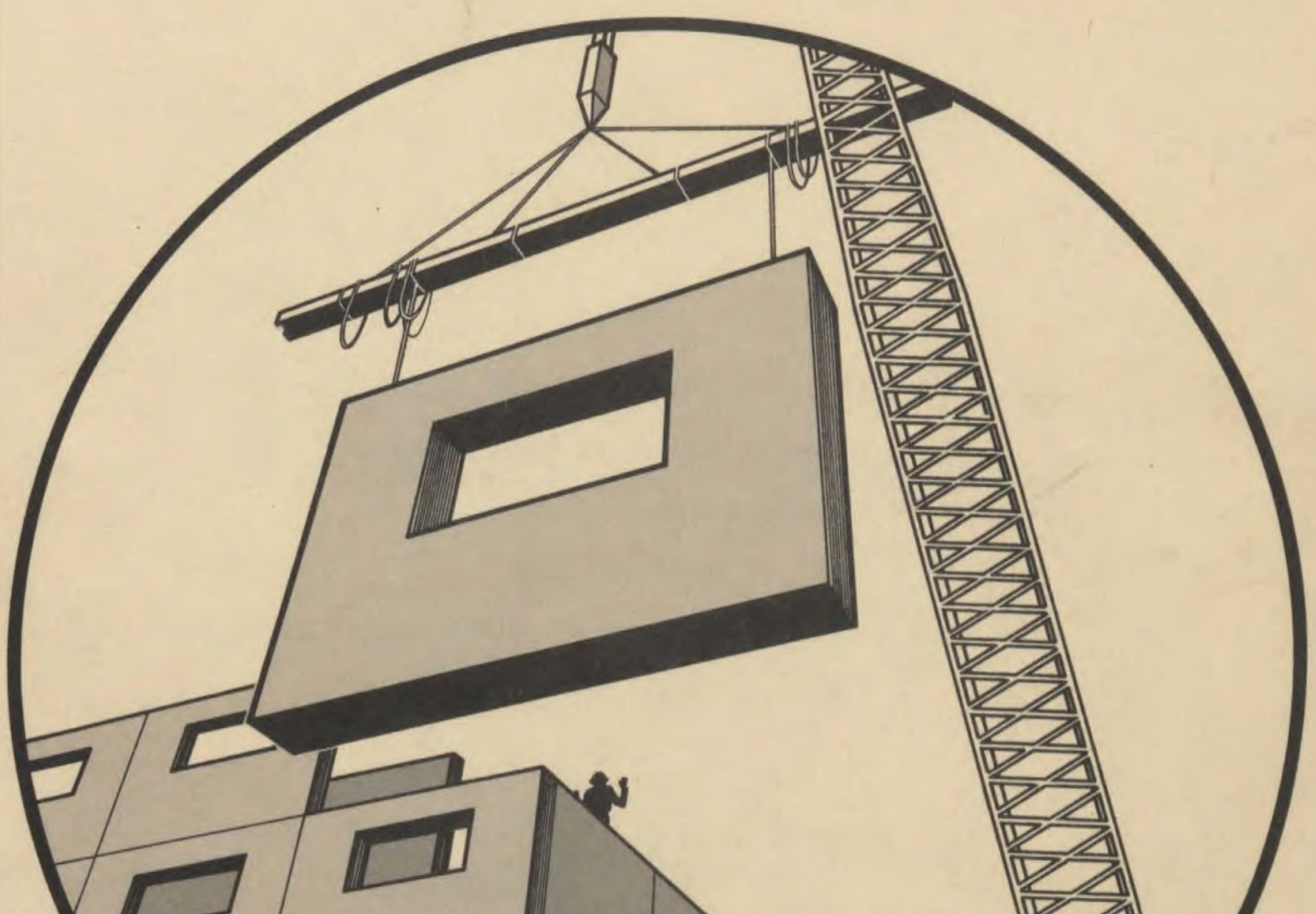
REPORT OF THE CANADIAN TECHNICAL MISSION ON PREFABRICATED CONCRETE COMPONENTS IN INDUSTRIALIZED BUILDING IN EUROPE

September 2-22 1966



Materials Branch, Department of Industry, Ottawa, Canada

DEPARTMENT OF INDUSTRY
OTTAWA

REPORT

Of the Canadian Technical Mission on the use of
Prefabricated Concrete Components
in Industrialized Building
that visited
Sweden - Denmark - France - Italy and England
September 2nd - 24th, 1966.

by

P. Eugene Marchand
Materials Branch

FOREWORD

The introduction of industrialized building systems and techniques has brought about new contractual and working relationships between clients, architects, manufacturers and builders. It has also given added importance to the rational organization of work on the building site.

In Europe, industrialized building has achieved greater productivity - in terms of the value of building per man hour worked - and greater speed of erection than traditional building methods. While some industrialized building systems achieve this speed in output at rather greater cost than traditional methods, many clients find this greater speed well worth paying for. Other industrialized building systems are highly competitive in cost, and when allied to efficient management and client organization, they can be the means of stabilizing costs over considerable periods of time.

It is hoped that the systems and techniques discussed in this report will be of value to the reader and give some indication of possible future trends in the development of industrialized building in Canada.

Director,
Materials Branch.

Let the houses be changed and arranged in order and this will easily be done when they are first made in parts on the ground and then the framework can be fitted together on the site where they are to be permanent.

Leonardo da Vinci, 1515.

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DEFINITION OF TERMS

Traditional building

"Traditional building" describes the bases of design, organization and execution of building which have come to be recognized as normal practice over a considerable period of time in any country or region. Traditional building is usually characterized by the fact that all operations follow a set pattern known to all participants in the actual building operation, and by dependence on skilled craftsmanship for interpretation of instructions and execution of work.

Prefabricated building

This term refers to the transfer of varying proportions of the operations of manufacture and assembly of components of buildings from the building site to factories or workshops which may be independent of the site or associated with it. In this connection, the terms "partial prefabrication" and "semi-traditional" are sometimes used. Prefabrication is also sometimes known as "non-traditional" or "new traditional".

Industrialization of building

The concept of industrialization has been defined in a comprehensive but precise sense as follows:

(1) Continuity of production implying a steady flow of demand;

(2) Standardization of product;

(3) Integration of the different stages of the whole production process;

(4) A high degree of organization of work;

(5) Mechanization to replace manual labour wherever possible;

(6) Research and organized experimentation integrated with production.

It also involves the use of new techniques and new materials and the use of traditional materials in new ways. It involves the fullest exploitation of new methods of co-ordinating the building requirements of clients and new contractual and working relationships between clients, architects, engineers, builders and manufacturers.

Components or elements

A component or an element is a preassembled part of one material or an integration of various materials that may serve one or more building functions.

Systems

A system is a co-ordinated series of industrialized building components designed to meet specific needs. It implies a generic system of component parts which in turn may be subdivided into two categories:

(a) A "closed system" whereby the majority of the components are sized and detailed for use with each other, usually by one manufacturer, and are assembled with a strict uniformity of approach for a particular building system.

(b) An "open system" whereby the components from various manufacturers may be fitted or integrated alongside one another to form one or more conventional building types. This system requires dimensional co-ordination and a high degree of liaison between the various manufacturers in establishing tolerances, fittings, and joining requirements.

PREFACE

The writer undertook a study tour of Europe to investigate the applicability of European industrialized building techniques and systems as a means of increasing efficiency and productivity in the Canadian construction industry. After analysis of the findings, a technical mission to Europe was sponsored by the Department of Industry for a further study of leading industrialized building systems making use of precast concrete wall and floor elements.

Six senior executives of Canada's concrete construction industry, whose names appear in Appendix 3, were selected to participate with the full co-operation of the Canadian Prestressed Concrete Institute, the Portland Cement Association and the National Concrete Producers' Association.

In the period of three weeks, the members of the Technical Mission visited 13 plants and 24 construction sites and studied seven proven system building methods in five different countries of Europe.

While the amount of time available to study each system was limited, there were enough basic similarities in all of them to provide the members with a good understanding of most facets of industrialized building systems.

The members of the Mission would like to express their sincere thanks to all the representatives of the companies visited for the very friendly reception and co-operation extended to them and for the excellent relationship which was established.

INTRODUCTION

The Second World War left Europe in a state of devastation, and the need for rebuilding was extremely urgent. Even in countries that had not experienced the full rigors of war, there were housing problems. The grave housing shortage and the financial and economic difficulties caused by the war compelled the countries of Europe to adopt cheaper, faster and rationalized methods of construction. It was felt that the solution to the problem of housing lay in new industrialized processes, particularly prefabrication, and in the early stages, a great many prefabricated systems were developed using primarily wood or wood combined with plaster or lightweight concrete and steel. But large scale prefabrication of these types of structures enjoyed only a very limited success and, in general, the houses put up did not meet the requirements of the would-be occupants.

The standard of living increased enormously in the postwar years. There were shifts of population as new industries opened up and there were also sizeable increases in population. The scarcity of sites and the increased cost of land forestalled any hope that building single family dwellings would solve the housing problem in Europe.

Science and industry took an interest in housing construction at a relatively late date, but both have tried systematically to replace the traditional craftsman's methods by new processes. Through their research and development work have come our modern building materials of steel, glass, aluminum, concrete and plastics, while continual research into actual methods of building is introducing new techniques on the site itself, as regards both the structure and the interior finishing. In this connection, the increased use of machinery and the greater industrialization of manufacturing building materials are playing a decisive part.

Prior to 1939, precast concrete was restricted to prefabricated floors, chimney blocks and staircases; today its use ranges from window lintels to architectural panels. A great deal of emphasis is being placed on large-size elements, and much research is being done to reduce weight per square foot to enable easier transport of such items as totally prefabricated storey-high room-size wall elements, including installations and finished surfaces. This type of element is helping to simplify the construction of multi-storey apartment blocks.

At present, there is no single European country where there is not a pressing need for more homes, apartments, hospitals, schools, etc.

A number of major European contractors are obtaining excellent results in solving this problem by producing factory precast structural concrete building components. The installation of windows, floors, plumbing and other fixtures is included in the precasting operation. The trend toward reducing the work on the site and transferring it to the factory, or covered-site workshop, is clear. With such methods, the building process at the site becomes simply a matter of assembling the factory made units.

Ten years ago the construction time for a large multi-storey European apartment house with a site-cast concrete frame and brick infilling was anywhere from eighteen months to two years. Today, using the new factory-based construction techniques, the same type of building can be completed in six months.

The labour situation in Europe presents a problem. There is virtually no unemployment, and in most of the countries there are far more job vacancies than there are men to fill them. The construction industry, which requires men to work under less favourable conditions than are prevalent in factory work, has found it difficult to recruit and attract men. Facing this acute labour shortage, attempts have been made to cut down the labour content in building, to transfer as much as possible of the work to factories, to develop the use of new materials and to cut production costs.

The lack of a stable market and the seasonal character of the construction industry are partly responsible for the high outlays of capital required for dwellings and for other structures. The major causes of the relatively high costs of housing are the lack of integration of the different phases of building and the uneven application of technological improvements and innovations in the factory and on the site. Thus, most of the remarkable but isolated improvements in the building industry in the 20th century have not reached the general consumer in the form of lower rents or lower monthly payments for his home and related services. The building and building materials industries are constantly under pressure to reorganize. In some countries this is being done with state aid, aiming at a higher output of better structures at lower cost. The first step in this process usually is the assembly or prefabrication of structures in shops. However, the costs of transporting the materials to the shop and the prefabricated components to the site are higher when this method of building is used. Reduction of weight and bulk is, therefore, a prerequisite for factory-built housing, which also implies a high degree of standardization of materials, accessories and structural elements as well as dimensional co-ordination of products and designs. The more interchangeable the structural elements are and the more their dimensions are co-ordinated, the greater the economy in their erection and the flexibility in their use.

Industrialization is a process of change, which involves the substitution of hand labour by machines, both on the site and in the factory. It involves also the use of new techniques and new materials, and the use of traditional materials in new ways. It involves, for its fullest exploitation, new methods of co-ordinating the building requirements of clients and new contractual and working relationships between clients, architects, builders and manufacturers. The main contribution which industrialized methods of building can make is to provide considerably more construction without substantially increasing the labour force, that is, provide greater productivity.

In keeping with the aims of the Department of Industry, the Materials Branch sponsored a technical mission to Europe to study industrialized building systems and techniques making use of prefabricated, precast concrete wall and floor elements in the construction of residential low rise and high rise buildings, institutional buildings, etc. The mission visited Sweden, Denmark, France, Italy and England.

COMMENTS ON INDUSTRIALIZED BUILDING

Much thought has been given to ways and means of bringing about a revolution in our methods of providing satisfactory housing for the great mass of our people. The object, of course, of all this thought is to find a method of bringing to bear on the problem the vast store of experience that has been gathered by industry, while evolving the mass production techniques so efficiently used in producing other necessities of our daily life. A very thorough study is constantly being made of progress to date in this field. The Department of Industry-sponsored Mission to Europe was for the purpose of studying the various techniques used in industrialized building and to see some of the results achieved by these techniques. Subsequent evaluation of all of the data obtained by visits to the engineering offices, the factories, the sites, and from discussions with the principals involved, lead one to the conclusion that industrialized building methods are possible, practical, economically sound, and allow for more buildings to be put in place using less time and considerably fewer skilled tradesmen. The result can be a building that is architecturally acceptable and provides the occupants with as good and, in some cases, much better living accommodation than that supplied by conventional building methods. For the most part, the development of the industrialized building systems studied in Europe incorporated the use of precast concrete structural components, either totally or in conjunction with poured-in-place floors. It would appear that precast concrete, because it can be moulded in so many ways with a wide variety of surface treatments, will play a very important part in the development of the industrialized approach to building. An even more significant contribution is that it can be simultaneously used, both structurally and architecturally, and also have cast within it practically all of the required services. Within its structural framework, it is possible to fit in a compatible manner almost all other building products. This allows for greater versatility in architectural expression.

There is ample evidence to indicate that much design time had been spent in the development of the various systems of building seen in Europe. This has naturally resulted in highly sophisticated methods of fitting various components together to achieve structural stability and weather tightness. The methods employed in the factories have also received a lot of attention and, for the most part, mechanization of the production has been achieved.

The equipment used in production of precast units is well designed, heavily built, and constructed to last many years. A guaranteed volume would probably be necessary to justify an investment of this type in Canada.

The investment and planning which went into most of the projects we visited was very detailed and required the outlay of considerable capital before the manufacture of components was started. Time and effort of this nature can only be expended on a negotiated project where "systems" building has been accepted as the right solution and arrangements made with a specific contractor to organize all work, including the manufacture of precast on a particular project.

One consistent weakness that did show up was the transporting and handling of the concrete mix. Some improvement could be made here. The handling of the units from the factory floor to the storage yard and subsequently to transportation units was very good. Most of the plants visited seemed to sacrifice quality for production and there was much time spent in fixing up and patching units prior to shipment. This seemed to nullify to some extent the savings achieved through mass production techniques. There was some evidence also, that more site supervision, or better trained erection crews were necessary. This was especially true in France, where the quality of the finished building was not as high as that in either Scandinavia or Italy.

Probably the most significant difference noted by the members of the Mission visiting the construction sites incorporating the use of factory produced components, was the few men employed at the site as against the large numbers normally found at the site of a conventionally constructed building. This served to emphasize the claim that more building can be produced with fewer tradesmen. It was difficult to factually prove a reduction in costs as compared to present North American methods of building, because there was no sound basis for comparison. However, it was indicated to us that 10% to 20% savings in costs over the use of conventional methods in Europe were being achieved.

There are over 400 industrialized system builders in Europe, of which only about 40 do the bulk of the work. The ten different systems we saw are among the oldest, most established and widely used.

One industrialized system builder summarized the concept of the system as follows. "Industrialized building implies:

(1) A high degree of mechanization

(2) Reduction of on-site labour

(3) Standardization of components and products

(4) Dimensional co-ordination and control

(5) Integration of building team - architect, engineer, fabricator, contractor, client

(6) More sophisticated use of management techniques

"The shortage of labour combined with the desperate need for housing led to the introduction of industrialized building. Industrialized building saves between one-third and one-half the number of man hours required by traditional building methods.

"Industrialized building is a concept of rationalized architecture embodying a philosophy of planning and design integrated with production and demand. The architect's role is primarily the utilization of space and balance between design and erection requirements. An architect using any system must accept the design disciplines of that system. He is a member of the building team, but not the leader."

It is extremely important in industrialized building to do a thorough job of planning from beginning to end. This includes all products and operations, since changes are extremely costly.

Completion dates are included when the contract for a project is signed. The foundation plan, number of storeys and time of erection per storey are all worked out at this time. Erection time for each building is broken down into time per floor. Precasting schedules are based on the continued use of the tower erection cranes which are the lifeblood of the project. All work is planned to keep these cranes in constant operation. Schedules for precasting work are furnished. The fabricating plant and all other schedules for finishing work are determined after the precast units are assembled.

Design loads are roughly comparable to ours. One system has been designed and tested to resist seismic loads of nine on the Richter scale. Some of these structures were the only buildings left standing after a recent earthquake in Russia. In most countries there are no building codes to meet. The structures are considered to be fire-safe. In buildings of over 7 to 9 storeys high an extra exit is required. Apartments up to 32 storeys high have been built so far, although the majority are in the 8 to 15 storey range.

Systems are relatively flexible even with standardized units. For example, one system has 30 types of wall panels and 50 different floor units to give an almost unlimited number of layouts. A typical apartment or flat of 900 to 1,000 square feet employs 20 units. Many different finishes can be used on the exterior walls of the building. They include plain, textured, rubbed, painted or tiled finishes. Interior finishes are usually paint or paper, but other types can be used. The main difference between systems is in joint design and construction, quality of workmanship, size and shape of components and methods of casting and erecting.

Average cost of a prefabricating plant, exclusive of land, capable of producing 2,000 to 2,500 flats per year, is between $1-3 million. Wages are about $2.50 to $3.50 per hour at the plant and $4 per hour at the site, including all social charges. A typical erection crew at the building site consists of about 10 people.

An approximate factory cost breakdown for industrialized building is 25 per cent labour, 20 per cent equipment, 40 per cent materials and 10 per cent overhead, including profit. Labour for the entire project represents about 15 per cent of the selling price of the building. This price is relatively independent of labour costs. Most plants feel they must produce at least 500 flats per year to break even. Many of them produce 1,000 to 2,000 flats per year.

Most industrialized building is for apartment buildings, but includes row housing, single family dwellings, offices, plants, schools, homes for the aged and dormitories. Apartments account for about 75 per cent of all industrialized building done to date.

To facilitate the growth and development of industrialized building in Europe, local government or quasi-public housing associations subsidized the industry. This was done by lending money to developer-builders for constructing fabricating plants. Loans of up to 95 per cent of the cost and at a rate of interest several per cent lower than the going market rate were made for this purpose. It was justified on the basis that industrialized building was a more efficient way of producing housing in a tight labour market and an expanding housing market.

As an example of the desperate housing situation, couples in Sweden have had to wait for up to 10 years for an apartment. Through industrialized building, this time has been reduced to between three and five years. In other countries the waiting period is nearer 1 to 2 years. Denmark presently builds 40,000 low cost flats per year and is aiming at 75,000 flats per year by 1975. In the Paris area there were 15 projects under construction in 1966, with over 5,000 flats in each project.

A further step by the government or housing associations to subsidize or at least encourage this type of construction was to contract for several thousand flats at one time. This had the effect of guaranteeing a market large enough to encourage those interested in industrialized building to borrow the money and invest in the plant and equipment with the knowledge they could earn it back. Cost of such a plant is usually amortized over a 2 to 5 year period. Subsequent production yielded a much greater profit and made the initial investment more attractive.

As mentioned previously, the primary advantage of industrialized building over traditional building is reduced on-site labour, better quality and increased production per man hour. In industrialized building, emphasis is shifted from a labour intensive to a capital intensive operation. Between 65 and 75 per cent of the total structural cost is at the plant. The initial economy of industrialized building is about equal to that of conventional construction. The economy increases with the volume of work. Material costs in industrialized building are reduced by decreases in waste. Mass buying is another economy. Earlier occupancy provides still another advantage.

Those organizations in Europe that have been doing industrialized building for several years have developed the know-how to adapt the system to a more competitive basis. Consequently, they are seeking outlets in other countries where they might use their skill and knowledge to advantage. Since North America is the only continent in the world where industrialized building has not been used to any extent yet, the various systems builders are looking at this market with considerable interest.

The cost of a franchise from one of these organizations usually runs in the neighbourhood of 2 to 3 per cent of the selling price of a project, not including land, but based on a minimum of 500 units per year. This is equal to about $80,000 per year. Consulting services are usually available on a negotiation basis.

Canada is one of the markets that the European systems builders are watching. While the housing situation here is not identical to that in Europe and elsewhere, there is enough similarity to warrant a close look at it. We do have an acute housing need, estimated to be as high as 60,000 low cost and low rent units per year. The need will be even greater in the years ahead, according to all estimates.

There has been a definite trend toward apartment living in Canada, which has been the chief market for industrialized building. However, as mentioned before, industrialized building can also be used for student housing, motel construction, housing for the elderly and urban renewal and development projects.

The members of the Technical Mission are of the opinion that industrialized building in Canada for the housing market will have to be developed along somewhat the same lines as in Europe. That is, there will have to be formed a group that will have the ability to acquire land, develop it, and finance production facilities, and take care of subsequent erection and completion of the buildings, along much the same lines as the conventional builders and developers are now doing. Therefore, it does not seem to be a field in which the manufacturer of prefabricated concrete components, using his present facilities, will effectively or economically operate. We feel industrialized building in Canada will be a long time reaching the degree which Europe has achieved to date, unless various levels of government participate, at least in the initial stages.

The whole approach to industrialized building could be speeded up, and it may be most desirable for it to be, by having those levels of government responsible for meeting the housing needs of the nation sponsor the formation of a consortium by providing them with a firm order for a sufficient number of housing units in one or more locations to justify the building and subsequent write-off of adequate plants and facilities. This may require subsidization in the form of higher costs per housing unit for the first development under such a scheme. It will be necessary also to obtain the co-operation of trade unions and the acceptance of the required techniques by the building code authorities. The members are of the opinion that once systems building has been successfully introduced, continuously controlled, and researched during the building stage, the real benefits will show up, and the advantages claimed for industrialized building will be justified.

CONCLUSIONS

There is no doubt that systems building or industrialization of the building industry is a necessity, particularly as it applies to housing and, more particularly, in the apartment building field.

Our visit to Europe showed that within the context of European construction, industrialization is more economical in terms of money and manpower, and building can be done at a much faster rate than with traditional methods. It is difficult to compare the conditions which exist in Europe with those in Canada at this time. We should look, therefore, at the contributing factors that make systems building in Europe so successful.

1) In all the countries visited, i.e. Sweden, Denmark, Italy, France and England, the waiting time for accommodation is from one to six years. These countries have not been able to keep pace with the growing needs of expanding population, slum clearance, and rebuilding after the Second World War.
2) The governments of these countries are taking a very active part in encouraging the building of large numbers of apartment complexes by indirectly or directly subsidizing either the builders or the rents, or by providing low interest loans.

3) Conventional skilled workers, i.e. masons, carpenters, plumbers, etc., are in short supply.

4) It was also apparent that traditional building in Europe lags far behind that in Canada in terms of technique, speed of construction, etc.

The above conditions have forced the Europeans to industrialize, and the resulting gap between traditional construction and industrialized construction is now perhaps 10% or 25% in both time and money.

Let us now examine the conditions as they exist in Canada. At the present time there would appear to be no shortage of accommodation for families in the $6,000 per year plus bracket. In Montreal, for instance, an apartment can be rented for between $100 and $125 per month. On the basis of 25% of income for accommodation, a family earning $6,000 per year can find suitable living quarters. The market in Canada would, therefore, appear to be for accommodation for families earning less than $6,000 per year.

The larger centres such as Toronto and Montreal will, in the not too distant future, be creating a market with their urban renewal programs. Most of the apartments in the $80 to $125 per month rent bracket are built by speculative builders as cheaply as possible and it is almost a foregone conclusion that within twenty years these apartments will be in a sorry state because the materials used are barely adequate. The tight money policy now in existence has, of course, slowed down this type of building and we may find that in a year or so accommodation will not be as easy to find as it is today.

A shortage of good skilled workers in Canada is slowly becoming a reality, and could be one of the major problems in construction in future years.

At the present time, while the Government has various programs of assistance available for research, they are not comparable to the assistance that can be obtained in Europe. If we compare the conditions in Canada against those in Europe, we find the following major differences:

1) The immediate need for accommodation is not critical in Canada, but is likely to become so at some future date.
2) The skill and availability of workers is deteriorating. This is comparable to the European problem.
3) The Government does not sponsor the building of accommodations to the extent that is done in Europe.

We must realize that an individual company, or group of companies embarking on a systems building program, is faced with a tremendous research program before it can hope to market a system that would provide accommodation to the low income groups and that it will be faced with a very large capital expenditure at the end of this research. There is no alternative but that all levels of government become fully involved financially with the complete development of industrialized building in Canada to determine whether accommodation can be provided by systems building without outside subsidy. If subsidy is found to be required, it can only come from Municipal, Provincial or Federal sources.

RECOMMENDATIONS

It is the opinion of the mission members that industrialized building should be carefully studied to see if it would be suitable to our needs and would produce acceptable housing at a lower cost and at a higher rate of productivity per man hour than construction methods now used for these purposes. To accomplish this the following recommendations are made by the mission members:

The Federal, Provincial and Municipal governments and local housing authorities must be sufficiently interested in the study to provide incentives and financial assistance to interest individuals or organizations in undertaking research and development work on the application of industrialized building in Canada. This might result in the adoption and use of systems already developed in Europe or it might result in the development of totally new systems.

As a first step in studying the whole question it is suggested that the Federal Government, in co-operation with industry, organize and sponsor a series of seminars on industrialized building across the country to inform interested people about the concepts and present the systems and techniques involved. These sessions could be followed by conferences in areas where a genuine interest has developed in order to discuss more specific plans and needs.

Governments should fully recognize the need for industrialized building. Having recognized this need, they must be prepared to become wholeheartedly involved in its development and initial research must be carried out into the types of accommodation required, for low income, middle income or upper income groups.

It is very obvious in Europe that one of the major reasons for success is in the consortium or systems approach to construction, i.e. the architect, engineer, manufacturer, lending institution and owner are working together as a team. This is a critical prerequisite for success and will have the effect of changing the role of the architect and engineer in the building industry.

Standards must be adopted, particularly in dimensional co-ordination, to eliminate the useless waste in all branches of the industry. A module should be established; this should be advertised and sold to the industry.

On our visit to Europe, we noted that many materials used would conflict with the existing building codes in Canada, such as plastic conduit for electrical wiring, minimum reinforcement, if any, in load bearing structures, etc. It would be necessary to fully investigate the traditional methods and materials used in Canada and examine each in detail, as well as to introduce new codes to meet the industrialized approach.

It would be desirable, when a Canadian system has been developed and the chances for economic success look good, to have public agencies sponsor large projects, perhaps in the 5,000 apartment range, over a five-year period which will allow the system to be fully proved, changed and developed during this time.

Assurance of this type of sponsorship would encourage companies to become involved with the basic programs required, knowing that the chances of success were reasonably good. We must bear in mind that because of the capital cost involved in systems building, the basic cost of the building must be perhaps 4% to 5% lower than that of traditional building in Canada today so that the capital cost can be amortized over a five or seven-year period.

The acceptance of a systems approach in Canada would require a fair amount of selling and it is recommended that the Department of Industry sponsor further technical missions for architects, engineers, etc. to Europe in order to acquaint them with the basic industrialized building systems and techniques. Seminars, conferences, etc. on industrialized building would also be required.

It would be necessary to obtain a special ruling or release from the appropriate unions to permit men in the factory and on the job site to do more than one class of work. This is essential to the efficient and economic operation of industrialized building.

The establishment of an independent body similar to the system of agréments operated in France by Le Centre Scientifique et Technique du Bâtiment (C.S.T.B.) or the Agréments Board set up by the Minister of Public Building and Works in England would be necessary. The principal objective would be to assess innovations in the building industry in respect of building materials, products, components and processes. The services offered would be to provide an assessment on the basis of examination, testing and other investigation. If the technical investigation produced conclusions favourable to the product, a certificate of approval would be issued.

The construction industry should not be used as a lever for self-balancing economic purposes.

In all these efforts it is recognized that industrialized building as practised in Europe may or may not be suitable for use in Canada. There may be better ways already in use which can be developed. The primary purpose of the entire exercise is to stimulate greater interest and activity in developing better, more economical ways of producing housing with less labour.

BYGGNADSFIRMAN OHLSSON & SKARNE AB

THE SKARNE SYSTEM

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Byggnadsfirman Ohlsson & Skarne AB, a leading Swedish contractor, has worked out two systems of construction: the light system and the heavy system. Both systems use prefabricated concrete elements. The main difference between them involves the requisite crane capacities.

In the light system, cranes with a capacity of 1.5 tons (normally centrally mounted tower cranes) are used for the erection of prefabricated wall units.

In the heavy system, cranes which can handle units with a weight of up to 12 tons are used. For buildings up to four or five storeys, gantry cranes are sufficient and for higher blocks, tower cranes on rails are used.

Skarne Light Construction System

The Skarne light system can be used for the construction of all types of housing. It has been employed in the construction of private houses, terrace houses, three-storey and multi-storey blocks of flats. The application of the Skarne light system to multi-storey buildings is described below.

The basement and the floor slab above the basement are, as a rule, built by conventional methods. Then follows the installation of the slip form and the Linden tower crane, which is permanently connected to this form. The slip form is used for the stairwell and the lift well core at the centre of the building. The stairwell core, which is rapidly concreted, serves as the most important static component of the building in the following state of its erection, and stabilizes the building in an extremely efficient manner.

The slip form is now raised at short intervals, at a rate of about 25 cm. per hour. A few days after the core has reached its full height, the Linden crane can be put in operation. The shuttering for the floor slabs is erected in the conventional way using standardized plywood form units. They are provided with slots into which the crane lowers the precast internal wall units for the storey situated below.

The storey-high concrete wall units are 10 cm. to 14 cm. thick and 1 m. wide. They project about 2 cm. above the floor slab form so that they may be thoroughly embedded in the concrete floor slab under construction.

After all internal and external walls have been erected, the floor slab is cast. It consists of a base course 17 cm. thick and a directly superimposed finishing course 3 cm. thick which is steel-trowelled.

All horizontal electrical conductors, as well as heating and sanitary pipes, are embedded in the floor slabs. The vertical electrical conductors are embedded in the pre-cast wall units. Special duct blocks are employed for the heating and sanitary pipes. As soon as the concrete is strong enough, the floor slab form is stripped and moved to the storey above. Then the whole procedure is repeated.

All internal walls are load-bearing and an embedded lifting stirrup which serves at the same time as transport reinforcement is anchored in the bottom surface of the wall panel. On the other hand, the wall panels with door openings (these panels are 2 m. wide) and the duct blocks (these are 30 cm. thick) are provided with two-way reinforcement. All these units are either precast in a temporary factory on the site or manufactured in a permanent factory. After assembly, the joints between the wall units are caulked. The wall surface is of such a high quality that it can be directly papered. The external walls can be built of Siporex lightweight concrete sandwich panels (7.5 cm. of Siporex + 8.5 cm. of expanded polystyrene + 7.5 cm. of Siporex).

These walls can also be constructed of room-sized curtain walling panels on timber studding or insulated concrete units with a ready-finished exterior surface consisting of exposed crushed marble aggregate, etc. In all these cases, the coefficient of heat transfer is extremely low, from 0.25 to 0.3.

In addition to the Linden crane, which need not be moved or raised during construction, the mechanical equipment comprises a hoist and on large sites a tower crane travelling on a track. A few Bantam mobile cranes serve the whole building site. The internal staircases are erected immediately after the completion of the stairwell core and are used during the entire period of construction. These are of course precast.

Skarne Heavy Construction System

Ohlsson and Skarne also use a heavy construction system of precast concrete construction for four-storey and multi-storey blocks of flats. This offers many advantages particularly from the point of view of a production engineer. The period of construction is shortened and both finishing and servicing are greatly simplified. This is due to careful design which is thought out in every detail with a view to making the cost of a dwelling acceptable to its future occupants.

The heavy construction system requires hoisting machinery which can take loads of up to 12 tons. For four-storey blocks of flats, gantry cranes are generally used and for blocks with a greater number of storeys, tower cranes running on tracks are used.

In both light and heavy construction the internal walls are load-bearing but the external walls are merely insulating.

An advantage of the heavy construction system is the reduction in the number of joints. The erection of the large units does not take any longer. Furthermore, these large units can be manufactured to the same tolerances as smaller units so that deviations from the nominal dimensions are very slight.

The principle of precast concrete construction is also consistently applied to the foundations. Thus, the single bases, foundation beams, and strip footings are precast and erected directly on the building site.

Each operation is subjected to a detailed time study. Construction work is organized so that time wasted on the site is reduced to a minimum.

The load-bearing components of the structural frame comprise site-assembled, room-sized, concrete wall units and internal wall units of lightweight concrete for enclosing clothes storage units and bathrooms. The external walls are frame walls which are built after the erection of the floor slab situated above.

A crane having a capacity of 10 metric tons is used for erection on the site. The concrete elements are manufactured in a factory at Handen which has a capacity of about 700 flats a year. The factory uses a vertical battery type of equipment for wall panels and floor slab castings.

They also prefabricate stairwells at the plant. The heaviest elements are the floor slabs which weigh up to 10.5 tons. Curing takes from 12 hours to 18 hours in the summer and 24 hours in the winter. Compressive strength of 3500 p.s.i. is obtained after 12 hours. The total investment of land, plant and equipment is approximately $1,200,000 and the amortization of the investment is based on a five to seven-year period.

The wall units are so large that two of them extend the whole width of the block. This width dispenses with many finishing operations since there are no joints in the rooms and no marks are left after panel joints have been formed. The plant staff consists of 30 men, — 26 labourers and 4 supervisors. The units are transported from the factory in supporting frames on 10-ton trucks and on trucks equipped with a hydraulic rotating platform.

The structural frame is erected storey by storey. The load-bearing internal walls and the floor slabs are erected first so that the building may be quickly roofed. In a four-storey block, the roof is put on after about three weeks. During this time, containers or pallets containing all the necessary material and equipment for kitchen and bathroom as well as doors, windows, window seats, wardrobes, radiators, etc., for one flat have been hoisted into each storey and placed on the floor slab before the erection of the floor slab situated above.

The timber studding of the external wall is constructed after the completion of the structural frame. The glazed and ready-painted windows are fitted into the studding at the same time. Then the exterior face of the studding is covered with hardboard which is applied from the scaffolding. The hardboard is carefully nailed and glued. This ensures complete weather-proofing. After that, finishing can be started at the same time as the construction of the face wall.

Electrical wiring can be installed as soon as the structural frame is completed. An ordinary electric incandescent lamp can therefore be suspended from the ceiling in each room to provide lighting for the finishing operations.

After papering or painting, the permanent fittings are screwed into position. Door frames with the doors in position are fitted after papering. Ready-painted skirtings and base boards are fitted at the same time as the kitchen joinery. The floor boards are coated with a thermo-plastic compound before delivery. Lacquered sheet-metal door frames are installed around the doors. Galvanized forged balcony railings, external aluminium window sills and other fittings require very little maintenance and at the same time reduce the amount of site work.

General Comments

1. License agreements are made for a 10 year period at a fee based on 3% of the production cost of the elements. All patents are registered.
2. The Planning Department of Ohlsson & Skarne is continually studying operations to determine how to make the systems more efficient.
3. Savings in time versus traditional construction is between 1/2 and 1/3 and a better finish and higher quality product is obtained.
4. If industrialized building systems are introduced in Canada, the building codes must be revised accordingly to allow for mass production of components.

General Information Concerning Byggnadsfirman Ohlsson & Skarne AB, Stockholm, Sweden.

Head Office: Sveavagen 153-155, Stockholm

Branches in Uppsala and Vasteras

Number of Employees: 310

Number of employed workers: 1,000

Foreign subsidiary companies: Skarne System Bau GmbH, Bietigheim, West Germany.

Part-ownership in foreign companies:

Hecht Skarne System Bau GmbH, Konstanz, West Germany

Francaise de Construction Planifiée (FCP), Nimes, France

Libyan Skarne Industrialized Building Company (LSIBCO), Tripoli, Libya.

Foreign licence holders:

Philipp Holzmann Ag, Hannover, West Germany

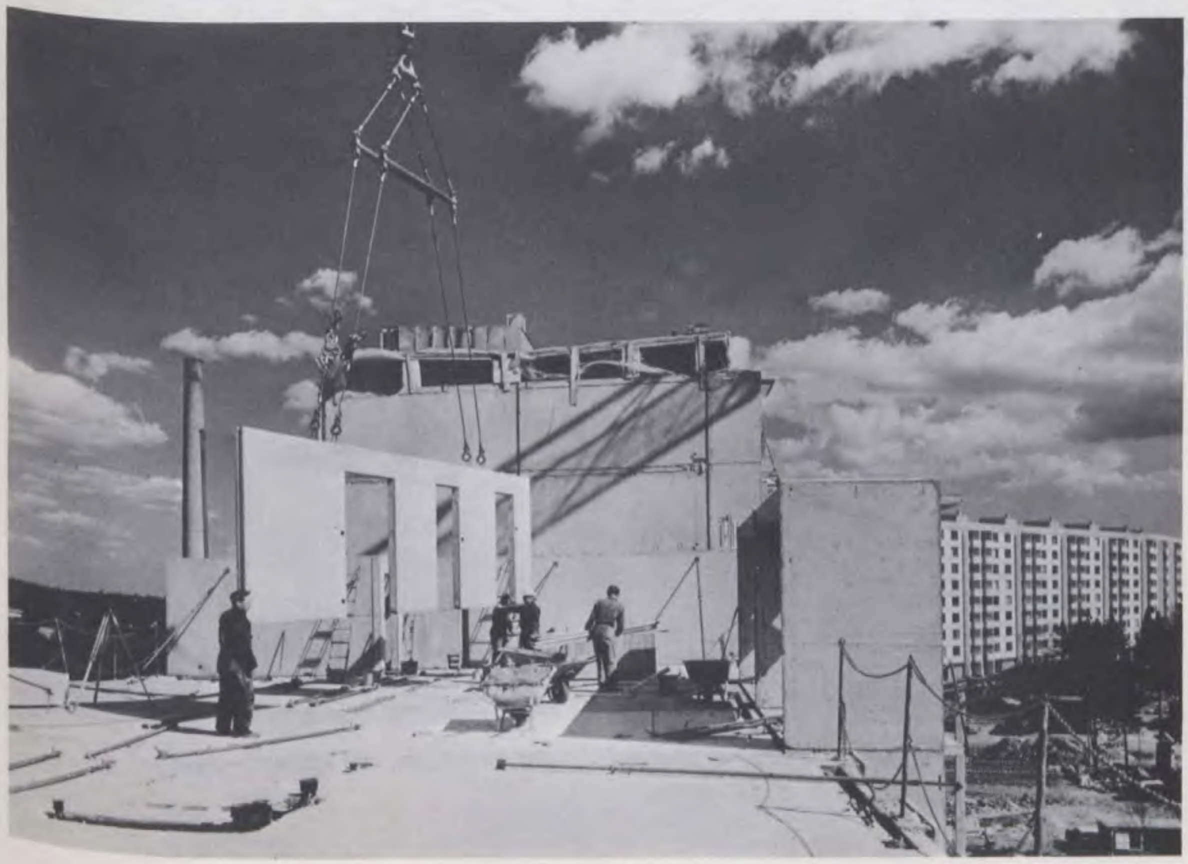
Crudens Ltd, Musselburgh, Scotland

Asuntoelementti OY, Helsinki, Finland

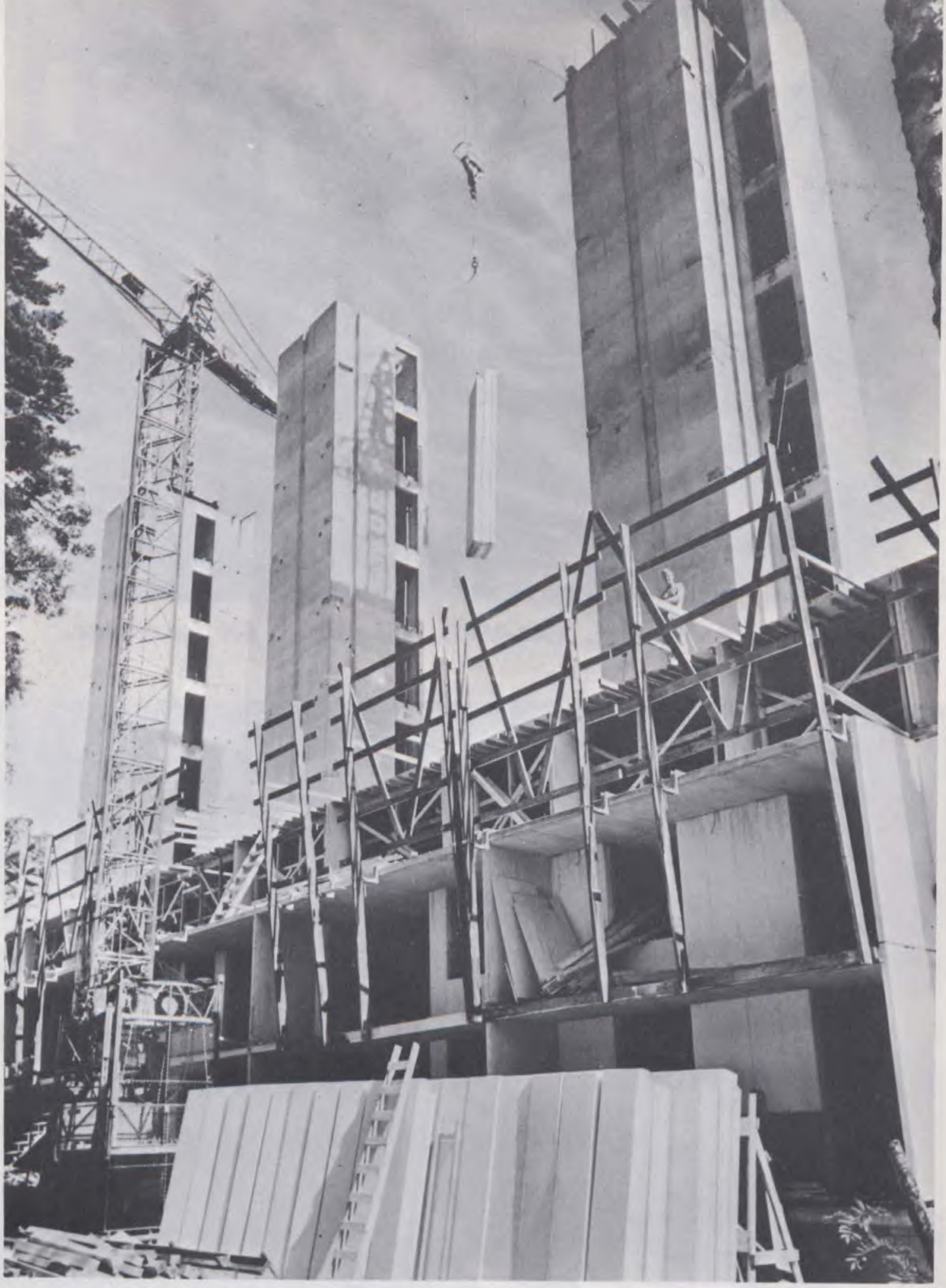
Coimpre, Turin, Italy

Kuwait Pre-Fabricated Building Co, Kuwait.

Bollmora site factory, 1961-1963. Capacity of 500 apartments.



Sharne heavy system - inner wall element weighing 6 tons.



Mörbyskogen, 1962 - Sharne light system, slipform-built staircase and lift core.

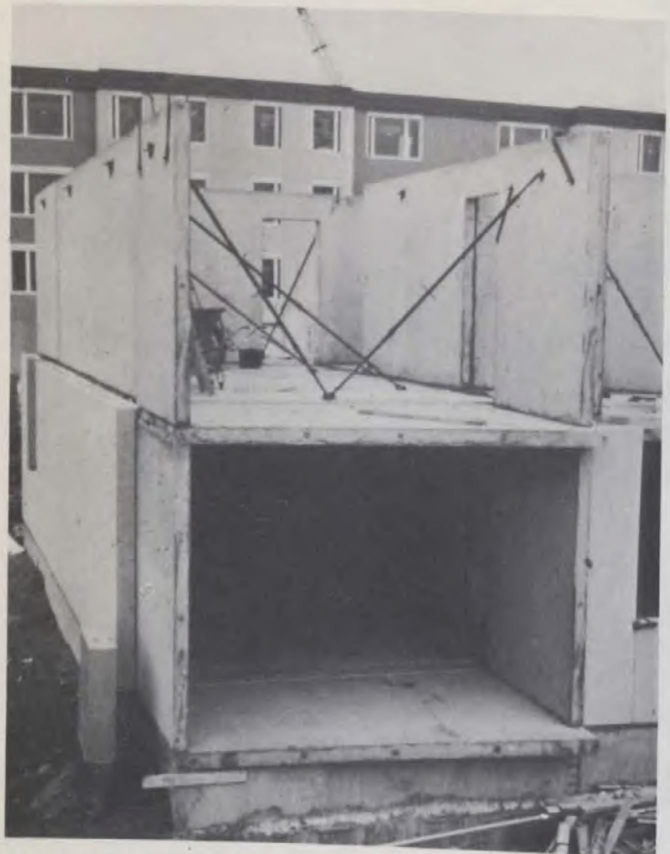
Näsbydal, 1959 - Sharne light system. 8 - 17 story blocks being erected

Special trucks equipped with hydraulic tilting platform.

Special trucks equipped with hydraulic tilting platform.

Precast circular stairs.

Precast circular stair installed.



Wall and floor elements and façade panels.

Standard kitchen in low rental apartment.

Low rental apartment at Soderby.

LARSEN & NIELSEN CONSTRUCTOR A/S

THE LARSEN & NIELSEN SYSTEM

Larsen & Nielsen Constructor A/S
11, Frederiksberg Bredegade
Copenhagen F
Denmark

LARSEN & NIELSEN

The engineering and contracting firm of Larsen & Nielsen Consultor A/S of Copenhagen is one of Denmark's leaders in developing modern construction based on prefabrication and use of precast and prestressed concrete elements.

In the Larsen and Nielsen system, the various building units are produced in factories and the units are then used for the erection of small houses, blocks of flats and factories. The panels and flooring slabs are cast as large as is possible, frequently being of whole room dimensions. The average weight of these elements is between 3-1/2 and 4-1/2 tons.

The sizes of the elements are limited by Danish law which prohibits the transport of an object wider than 8 ft. 2 in. on public roads. Thus the largest components made by the firm are the bathroom units which include the four walls of the bathroom, the bath tub, toilet, wash basin, piping, terrazzo flooring and painted and tiled walls. These units weigh about 8 tons.

Details of units manufactured

(a) Floor slabs are made from reinforced concrete and are 6 in. and 8 in. thick. The maximum span of these is 18 ft. while the maximum width is about 8 ft. The 6 inch floor slabs have cylindrical cores parallel to the span and the 8-inch floor slabs have oval cores.

(b) Load-bearing cross walls are made from concrete which is usually not reinforced except around the door openings. The thickness of these elements is 6 in. Timber door frames are cast-in during manufacture and are protected by plastic extrusions during transportation. Plastic piping for electrical wiring and switch boxes are also cast-in, in the factory.

(c) Two types of non-load-bearing partition walls are made. The first are concrete panels 2 1/2 in. thick again incorporating cast-in pipes for wiring, as is the case with the load-bearing panels. The others are light gypsum partitions made by a subcontractor in situ.

(d) Façade panels are sandwich elements which consist of an exterior skin of concrete with a ready-made finish, a layer of expanded polystyrene as the insulation layer and an internal layer of concrete. The external and internal concrete layers are connected to each other by galvanized steel or stainless steel wall ties. Wooden window frames are cast into the façade units and are glazed in the factory.

(e) Staircase flights and landings of reinforced concrete covered with either terrazzo or PVC flooring are delivered from the factory. The landings are supported by concrete brackets on non-load-bearing walls. Neoprene plates are inserted between the landings and the brackets. The flights are supported only by the landings and thus provide extremely effective sound insulation against the noise of footsteps.

Production

All the panels and slabs are produced in horizontal moulds. The rate of production is one element per mould per 24 hours. This is being achieved by single-shift work. At night the factory is heated in order to provide adequate strength to the concrete for stripping the panels and slabs. As various timber parts are incorporated in the moulds, steam curing is not considered advisable. After removal from the moulds the elements are stored in the open air for at least a fortnight. The flooring slabs are transported to the site in a horizontal position on trailers.

The façade and wall panels are not plastered as the surface of the concrete is smooth enough to permit direct painting or wall-papering. Kitchen fittings and other wall parts are made in ready painted units, and can be mounted directly. Doors are also mass-produced and are made accurately enough so that they can be fitted directly into the door frames which have been cast into the wall units without requiring any finishing work whatever.

It is possible to use a gable roof with the Larsen and Nielsen method but the firm recommends the erection of a flat roof which is constructed from standard flooring slabs covered by expanded polystyrene plates and roofing felt.

General design characteristics

The flooring slabs span in the longitudinal direction of the building. The vertical load is carried down to the foundations through the cross walls. The façade panels are suspended on brackets at the ends of the cross walls and façade joints are sealed with a neoprene strip instead of being grouted. This permits free movement due to shrinkage, thermal expansion and contraction. Stability against vertical forces (wind bracing) is created by the cross walls and by the heavy walls in a longitudinal direction in the centre of the building. The foundations and basements are, cast by conventional techniques.

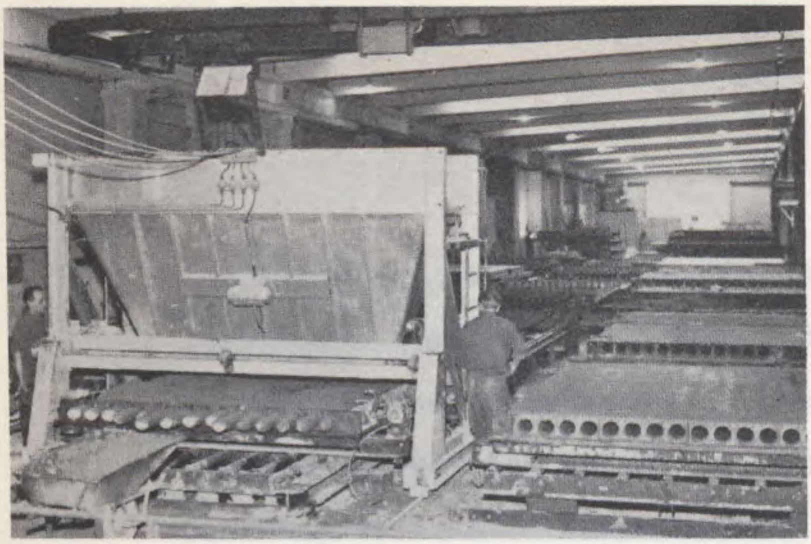
Mobile cranes are used for the erection of the blocks of flats. Such cranes erect between two and three flats per working day of eight hours. It has been estimated that about 400 drawings are necessary before a new scheme can be begun and that the initial capital outlay for building a factory is in the neighbourhood of $1,000,000. On the other hand, building erection with the Larsen and Nielsen system only requires half the labour force (both skilled and unskilled men) that is required using traditional building methods. The production of the Copenhagen factory is about 65,000 tons per annum, which corresponds to about 1,000 flats, while 35,000 tons of components are made for industrial schemes each year.

Factory building

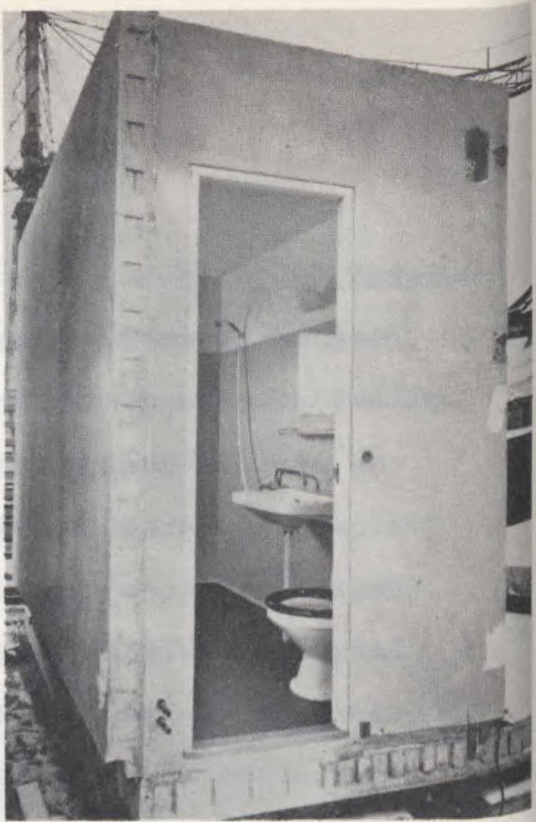
The method is also widely used for the erection of factories and other industrial premises. In this case, the construction is simplified by making the individual units as large as possible. The façade panels are made 6 ft. to 8 ft. in width and up to 30 ft. in height. Such panels are made either load-bearing or non-load-bearing. They can also be manufactured in thermally-insulated or non-insulated units. The roofing slabs also have widths between 6 ft. and 8 ft. and are made for spans up to 56 ft. The size of the roof slabs makes the provision of secondary beams and purlins unnecessary. A typical project of this type was the erection of a massive warehouse for the Danish brewery, "Tuborg". This building is 105 ft. high and has a storage capacity of 2.4 million gallons. Using prefabricated units the building was erected in one single year.

<u>General Comments</u>

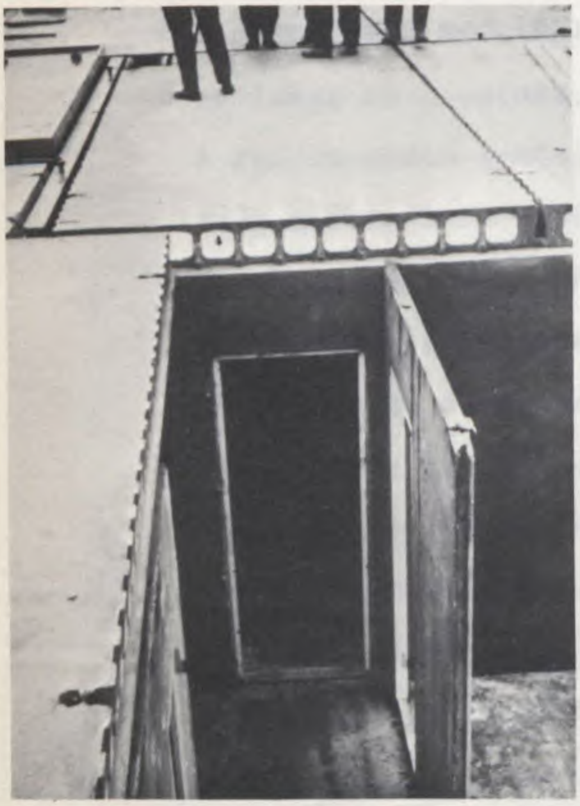
1. Licence given for 10 years at a fee of 3% of production cost of elements. These elements represent about 30% of the cost of the building. Therefore, the fee comes to about 1% of the cost of the building. All patents are registered.
2. Larsen & Nielsen have 15 licensees throughout the world
3. Larsen & Nielsen use 10 c.m. module
4. Production - conventional method - 2 flats per day
   - industrialized method - 8 flats per day
5. Time - conventional method - 1200 man hours per flat
   - industrialized method - 795 man hours per flat
6. Building team - erection team - 6 men
   filling team - 8 men
   finishing team - 7 men
7. Productivity at construction site
   Erection schedule well kept with constant delivery of adequate panels and other components to site and optimum use of well designed tower cranes.
8. Productivity of Plant - very good and panels are cast very accurately. Ventilation, mechanical and garbage chutes, ducts, panels and stairs are manufactured at plant. Highest possible degree of finish is done at plant.



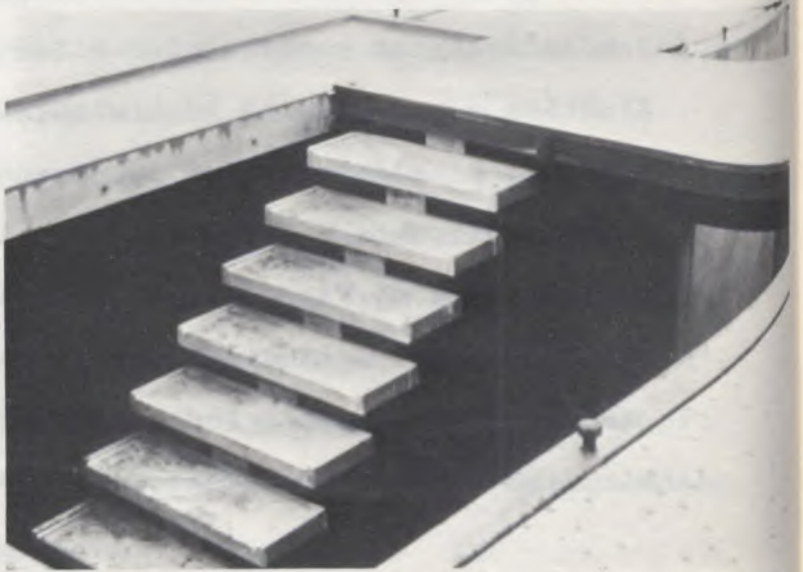
Production of floor slabs with pipe-shaped cavities. This department produces units for 6 apartments per day. In the foreground to the left is the machine for pulling out the cavity forming pipes.



Bathroom units are assembled in the factory complete with all installations. Door is fitted and remains locked during transportation and construction work on the building site.



Wall and floor elements.

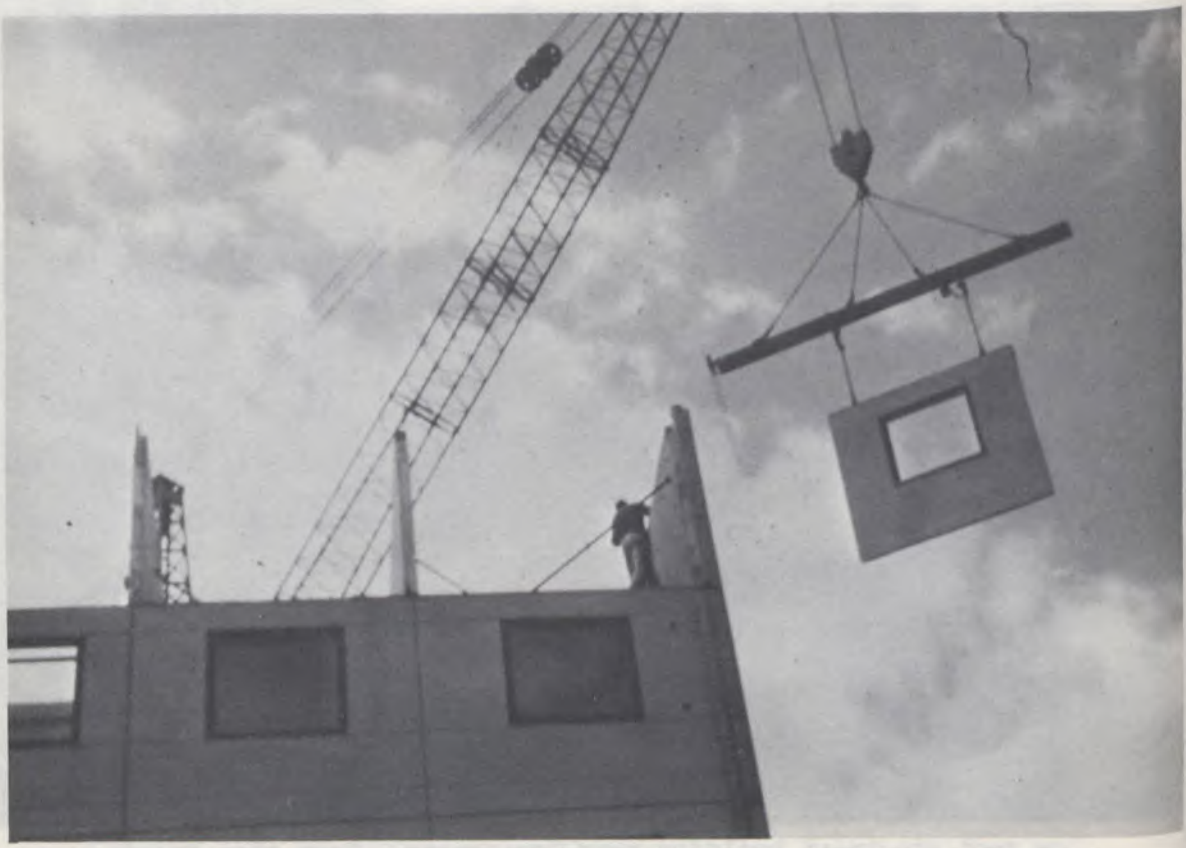


Precast stairs are installed as building goes up.

Construction site near Copenhagen showing assembled floor ready to receive wall elements. All fittings and equipment are placed in pre-selected areas.

Low rent apartment building near Copenhagen. Room size façade panels are of prefabricated wood elements covered with asbestos cement sheet on the outside and gypsum wall board on the inside.

Stairwell wall panel with cast in concrete brackets for stair landing.



Façade panel being lifted in position for assembly.

Securing façade panel.

Apartment building under construction in Copenhagen.

THE JESPERSEN SYSTEM

Modulbeton Ltd.
c/a A.Jespersen & Son Ltd.
18 Nyropsgade
Copenhagen 5, Denmark or
P.E. Malmstrom
Consulting Engineers
Jagtvej 223
Copenhagen, Denmark.

THE JESPERSEN SYSTEM

Modulbeton Ltd., with two concrete-element factories at Islevadalsvej and at Olstykke, is a subsidiary company of the contracting firm A. Jespersen & Son, Ltd., Copenhagen.

A. Jespersen & Son has been in business for over 60 years and has engaged in practically every type of building contract.

In 1956, the fabrication of precast concrete elements began at Islevadalsvej, where all types of precast concrete elements are now produced.

From the experience gained, in particular from the delivery of elements for 1600 flats in the period 1959-62, the company felt that element-construction was a major step towards the industrialization of housing construction but that 5-ton elements were too large. Many variants had to be produced in order to satisfy varying housing requirements. A good deal of the work had still to be done by hand, even though carried out in the factory. The company felt that elements could be standardized so that mechanization of production would be economical without involving excessive restrictions on the variety of flat layouts. These considerations resulted in the adoption of the Jespersen System and the establishing of a new factory at Olstykke for production of standard elements.

The Jespersen system was evolved in Denmark by the internationally known Danish consulting engineer, P.E. Malmstrom, who has considerable practical experience in industrialized building and is a pioneer and leading authority on precast concrete systems of construction. The aim has been to obtain the greatest possible freedom in planning layouts of flats, to attain maximum economy, and to reduce labour requirements for the production and erection of elements to the minimum. The system represents a major advance in the efforts to accelerate the industrialization of housing construction.

To increase productivity in building, to reduce man-hour requirements, or to produce flats more quickly, the Danish government decided to give financial assistance to certain large-scale housing projects which make full use of the element-construction method, thereby giving element-manufacturers an incentive to adopt a highly mechanized production process.

Modulbeton A/S supplied the elements for two of the projects visited by the Mission, the "Hedegaarden Project" and the "Gladsaxe Project", which total 3500 flats.

Ready-painted doors, door-frames, wardrobes, kitchen cupboards and façade-elements (including windows) are delivered by other highly mechanized factories in Denmark and Sweden at distances of up to 800 km. from the site.

The Element-Factory

The buildings comprise a mixing station, floor factory, wall factory, and office block. The mixing station, with its cement silos and aggregate stockpiles, is centrally located.

Concrete Production

The production and transport of concrete to the silos in the casting halls is semi-automatic.

The mixing is supervised from the control-room by means of the control panel. One man controls the entire process. The lights on the panel indicate the position of the aggregate lift, the quantities of cement and water, and the positions of the rail-trucks which automatically keep the factory silos filled.

The Floor Factory

The forms are propelled simultaneously from one position to the next. A form runs on a roller-track through the following positions on the production line:

1. The finished element is removed from the form and lifted by a vacuum-yoke to a block car. The element is inspected and number, date and quality mark are imprinted on it.
2. Cleaning of the form.
3. Oiling of the form, placing of the reinforcement mesh and adjustment of the form. They are welded, and are provided with plastic spacing-rings. There are only two types of mesh for each element-span.
4. Casting cycle (4 minutes). This takes place in the central part of the floor factory. The production capacity (number of elements per hour) is determined

by the time spent in this position. The following operations are carried out:

a) The tubes for forming the hollow cores are automatically inserted in the form.

b) The concrete is placed, vibrated, and smoothed off by machine under the control of a timer relay.

c) The tubes are automatically withdrawn.

d) The casting foreman advances the production line from the control panel after ensuring that the form is full, that the quality of the work is satisfactory, and that positions 1, 2 and 3 are ready.

4. Stages a) to d) take four minutes.
5. Cleaning of the holes in the end-faces of the forms.
6. Available for boring holes etc.

From position 6, the forms go into a stacking machine, which stacks a number of forms equal to the number which are delivered in the same period from the "de-stacking" machine. The latter delivers the forms (with the finished elements) to position 1. A stack of freshly cast elements rolls into the steam curing chamber at the same time that a stack of cured elements rolls out.

The Wall Factory

The elements are cast vertically in battery-forms, located on the lower floor of the factory. The various parts of the battery are moved by mechanical and hydraulic means.

A casting cycle consists of the following operations:

1. The cleaned, prepared forms are filled by a rotating casting machine.
2. Vibration is effected automatically by two rods hanging from a movable frame, and ceases automatically as soon as the form is filled; this ensures that all elements are compacted to the same degree.
3. A preliminary smoothing off of the top of the element takes place immediately after casting each element. A final smoothing and stopping takes place later, reducing the height tolerance to $\pm$ 2 mm.
4. After $2\frac{1}{2}$ hours of hardening the elements are removed from the forms and loaded on a block-car on the lower floor of the factory. The block-car can hold all the elements of a battery. The hollow steel partition plates are released and lifted back to the main floor. This is done by one man removing an element from the battery, while another deals with the partition plate thereby released. The plates are then cleaned and oiled and electrical fittings are mounted.

5. The fully loaded block-car is then run into the steam curing chamber, where it remains for 24 hours.

At present the factory has three batteries, for 120 cm, 180 cm, and 240 cm-wide wall elements respectively; all the elements are of 15 or 18 cm thickness. There is sufficient room and capacity for another battery.

The storage space for floor elements is served by two portal-cranes equipped with vacuum-yokes. Two men can carry out stacking and loading on rail-trucks.

The storage space for wall elements is provided with racks, and one man with the help of a portal-crane controlled from ground-level can deal with all transport, including loading.

The transport of both floor and wall elements from factory to site is effected by special trucks.

Production Capacity

The factory produces elements for 4-5 flats per shift. Total manpower per shift - 19 men.

The Elements

The elements are standardized in such a way that they can be used in many combinations, thereby making a variety of flat-layouts possible. The elements are, at the same time, well adapted for mechanized mass-production. 30 cm x 120 cm (1' x 4') grid has been used for dimensioning the floor and bearing-wall elements.

The layout of the partition walls is independent of the grid. The system of construction is bearing cross-walls and simply-supported floors.

The floor elements are all 120 cm (-4') wide and have spans ranging from 240 cm to 540 cm (-8' to 18') in multiples of 30 cm. The wall elements are 120 cm to 240 cm wide, the door units 240 cm wide.

According to the Danish Building Research Institute, these are the optimum dimensions for a simplified modular system based upon the provisions of the Danish Building regulations for a 30 cm x 30 cm grid. Freedom in layout planning is hereby combined with a limited number of different standard-units.

A systematic check on the dimensions was carried out during the last three months of 1962. It is possible to work to tolerances of $\pm$ 1 mm for wall-thickness and $\pm$ 2-3 mm for other dimensions.

The other components of the finished block are also standardized with design flexibility in view.

The Floor Elements

The normal floor-element, which is 18 cm thick and has seven longitudinal hollow cores and a "normal" reinforcement net, is designed for selfweight, flooring, 150 kg/m^2 partition walls and 150 kg/m^2 live load.

The floor-element with an area for recesses and openings with five longitudinal hollow cores and "heavy" reinforcement net is designed for the same loading as one, but on the assumption that two longitudinal bars will be cut through when an opening is made in the solid part of the slab.

The kitchen floor-element is a "standard type" of two based on a kitchen pipe and ventilation unit.

The façade floor-element is designed with six longitudinal hollow cores and "heavy" reinforcement net, with two deep vertical recesses on the upper surface, which permits two possible positions for carrying a radiator pipe through the element. The element is provided with light-weight concrete insulation along the front edge.

All four types can be cast in the same form, which has movable end-faces. Type four however requires a special edge-form, which has a fitting to hold the gasbeton insulation-blocks in place during casting.

The walls consist of two series of standard elements, of 120 cm. & 180 cm. width, of unreinforced concrete. Originally only one width, 120 cm, was contemplated, but as the heaviest floor-element weighs $2\frac{1}{2}$ tons, it is reasonable to allow the heaviest wall-element a width of 180 cm, which then weighs 1.7 tons in the 15 cm. thickness, and 2.0 tons in the 18 cm. thickness. On the basis of the relation between element-size and number of variants discussed above, there was some doubt concerning the 180 cm. width.

Analysis showed, that both widths involved only a small number of simple variants and not the "combined" special types (apart from the combined TV-outlet rosette element in the 180 cm. width), in order to satisfy all reasonable requirements in the various flat layouts.

The 120 cm. and 180 cm-wide wall elements comprise the standard units and variants with outlet rosette on one or both sides, with cooker outlet rosette on one or both sides, and with TV plug (in the 180 cm. walls combined with the outlet rosette). In practice, a few additional variants arise.

The standard door-elements are 240 cm. wide, and have a weight of two tons.

The Special Elements

The bathroom floor-element is not produced by a mechanized process.

This element contains the most complex cast-in fittings, and is manufactured as a special element according to the requirements of the particular project. The element normally includes all the fittings for the bathroom, kitchen and rubbish-chute units.

Balcony and access-balcony elements have also been produced as special elements until now, but as they vary only in span, it will eventually be possible to mechanize their production. Stairway and longitudinal bracing wall elements are "specials" as well as rubbish-chutes, ventilation-ducts, etc.

For the Ballerup Plan, 90% of the floor elements and 68% of the wall elements are manufactured at the Olstykke factory as "machine elements". The other elements are "specials".

The Joints

All the joints are based on the "traditional" Danish methods.

The Floor joint requires no formwork, and the chamfered edges of the elements enable differences of up to 2 mm or 3 mm. between the undersides of the slabs to be camouflaged.

The tolerance for element width is very small, and the edges must be straight and smooth.

The entire floor is assumed to act as a plate for the transfer of wind forces to the bearing cross-walls. For this purpose the edges of the slabs are toothed. The teeth act as shear-locks in the cast joint.

The finished floor consists of beechwood parquet boards mounted on bearers which rest on soft blocks (e.g. wood-fibre) on the concrete slab, the underside of which is painted.

The beech flooring is (with traditional wage-rates) the cheapest on the Danish market! This "floating floor" has excellent sound-insulation capacity, and provides a space very suitable for placing electrical wiring. A flooring involving less carpentry will be developed, in view of the probable future wage and price levels of an industrialized economy.

The wall joints likewise require no formwork, and the edges of the elements are also toothed, so that the entire wall acts as a plate for resisting the wind forces.

The joint between wall and floor. The load on the floor-slabs must be transferred to the wall on which they rest. The load from the wall above the joint must be carried downwards. Attention must be paid to production and erection tolerances.

The vertical forces in the walls cannot be carried through the floor slabs. As the floor slabs contain hollow cores, the narrow solid zones between them cannot take the forces from a fully loaded wall. In addition the floor slabs (to increase speed of erection) rest on a dry joint, so that the stress distribution will vary with small irregularities in the elements' surfaces. The vertical forces must be transmitted directly, i.e. through the cast in situ concrete in the joint, the cross-section of which is only slightly less than that of the wall. The slight reduction in sectional area due to the cams of the floor slabs in approximately counterbalanced by the reduction factor due to the slenderness ratio of the wall. The load is transmitted centrally and the stress distribution is known.

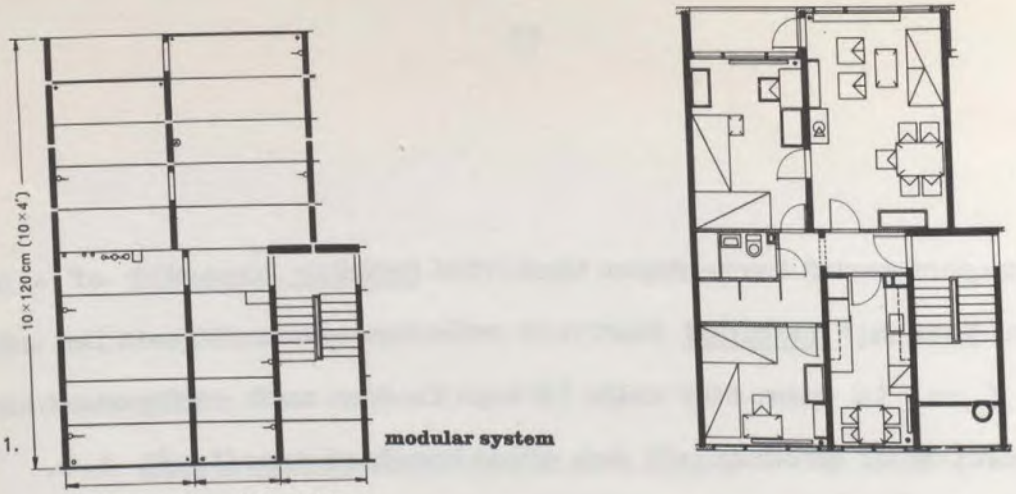
The forces in the floor slabs are transmitted by a row of cams, theoretically at 15 cm. intervals. In practice the slab does not rest on all the cams, and some are useless because of openings in the floor slab.

Many experiments have shown that the bearing capacity of a cam is ca. 3 tons, provided that the reinforcement is carried at least 5 cm. in over the wall (4 cm. in the most unfavourable combination of production and erection inaccuracies), i.e. carried through to the end of the cam. This method has been investigated theoretically, and has been used for practically all pre-fabricated housing construction in Denmark for the past 10 years. The end face of the form is quite simple and there is no projecting reinforcement.

Erection

Erection proceeds as follows: the floor elements are laid on the walls (the joint being dry); the joint reinforcement is placed in position; the façades are erected. In spite of the open joints, the building is then sufficiently closed to permit its being temporarily heated in winter, so that the joints can be cast. After the casting of joints on the newly placed floor, and the casting and vibration of the vertical wall joints, the mortar is washed from the under side of the floor.

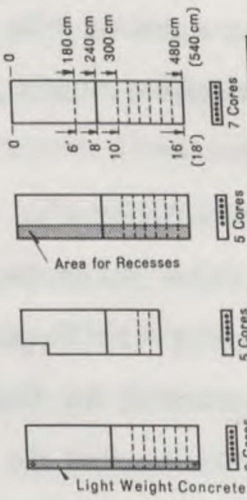
Fig. 1.



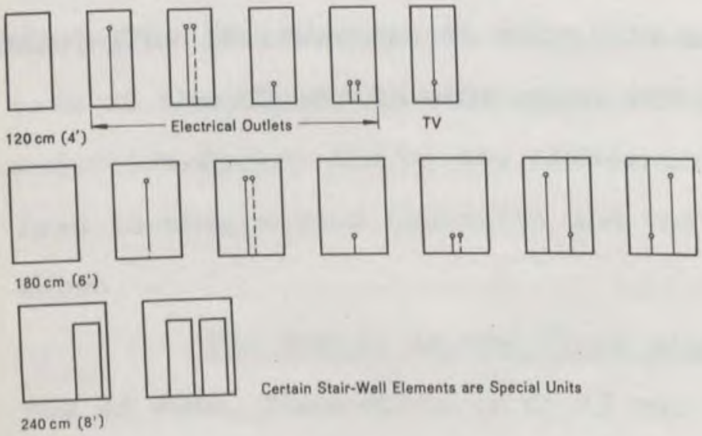
All Spans are Multiples of 30 cm (~1')

Modular system based on Danish building regulation that stipulates that a general 10 cm (4 inch) module must be used.

Floor elements



Type of Deck	Reinforcement	Number of Types
Normal	Normal	9
Recess	Heavy	Various
Kitchen	Heavy	4+4 Mirror Image
Facade	Heavy	9

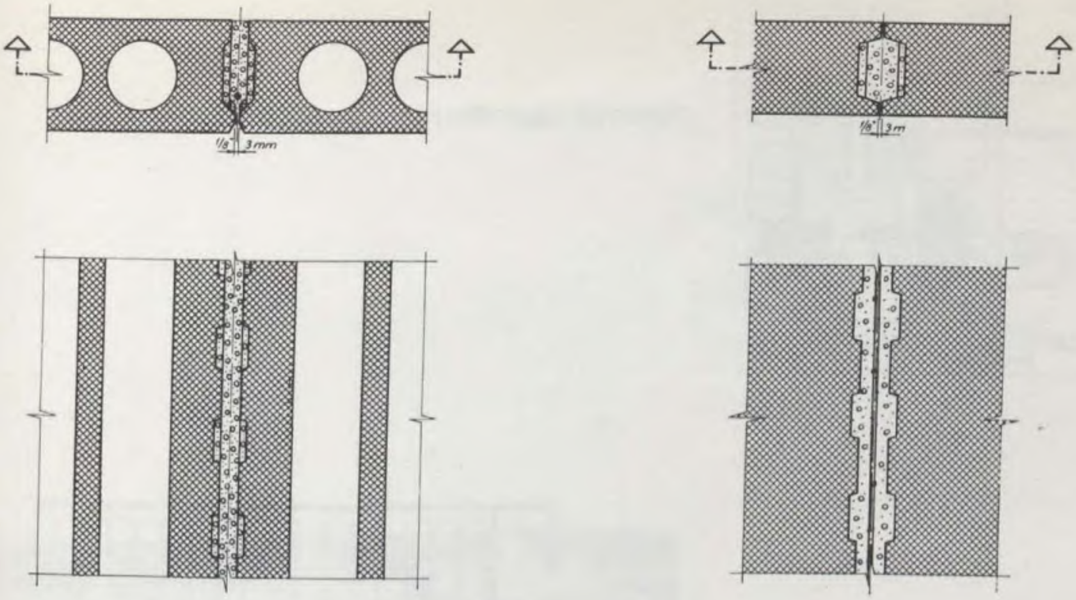


Wall elements.

The standard wall-elements shown have been utilized in the first two schemes. However, according to our experience the system will be slightly altered in the future:

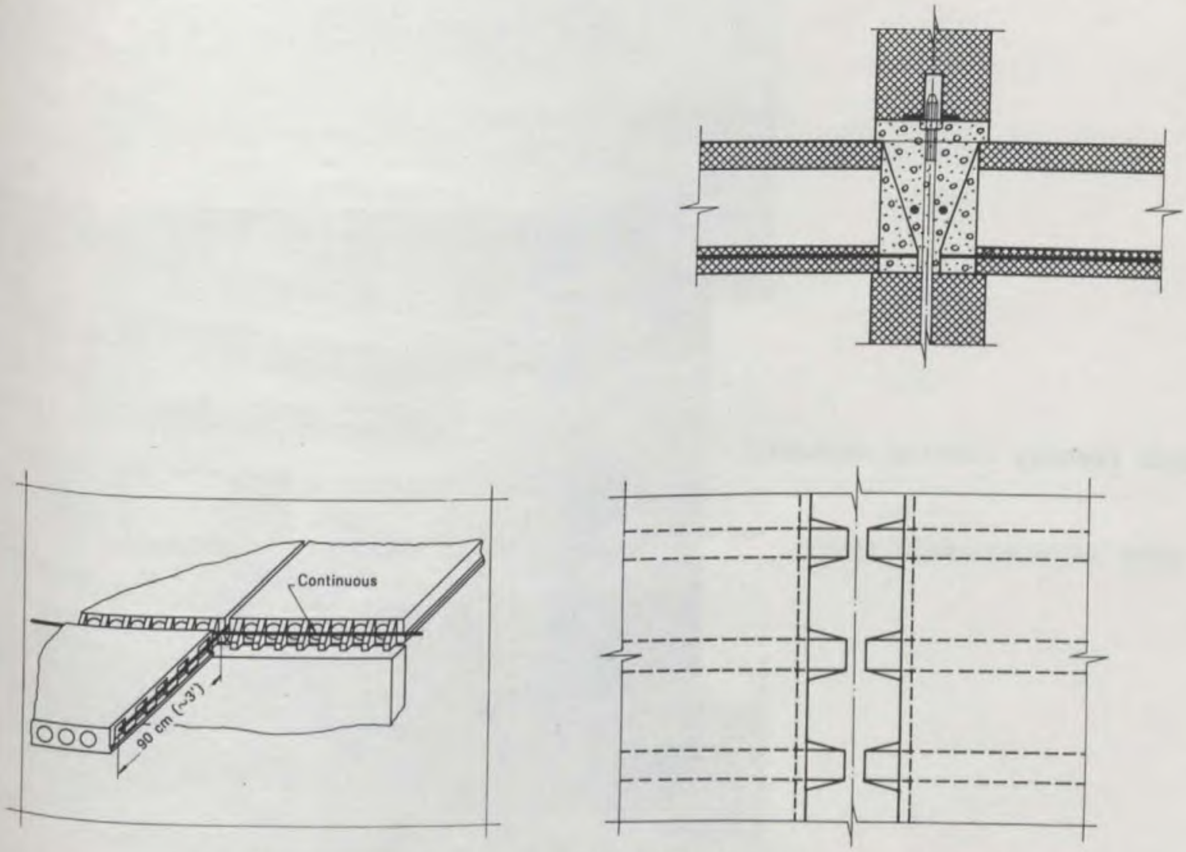
The 180 cm (6') elements will be substituted by 240 cm (8') elements including the same electrical services. The 120 cm (4') wide wall-elements will still be used as supplementary elements for flexibility.

Thus, wall-elements in future will be either 120 or 240 cm (4' or 8') wide giving simpler, faster and more economic planning, production and erection processes. The system's flexibility is hereby also maintained.



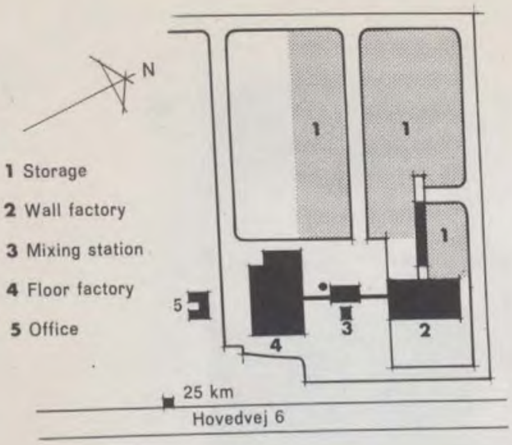
Floor joints and vertical wall joints.

15

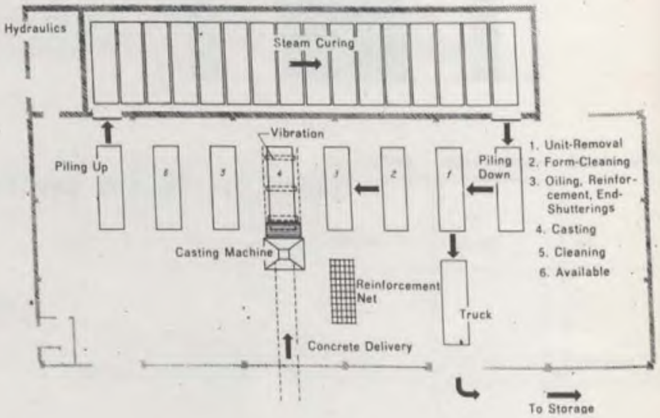


Reinforcement of floor wall joint and floor wall joint.

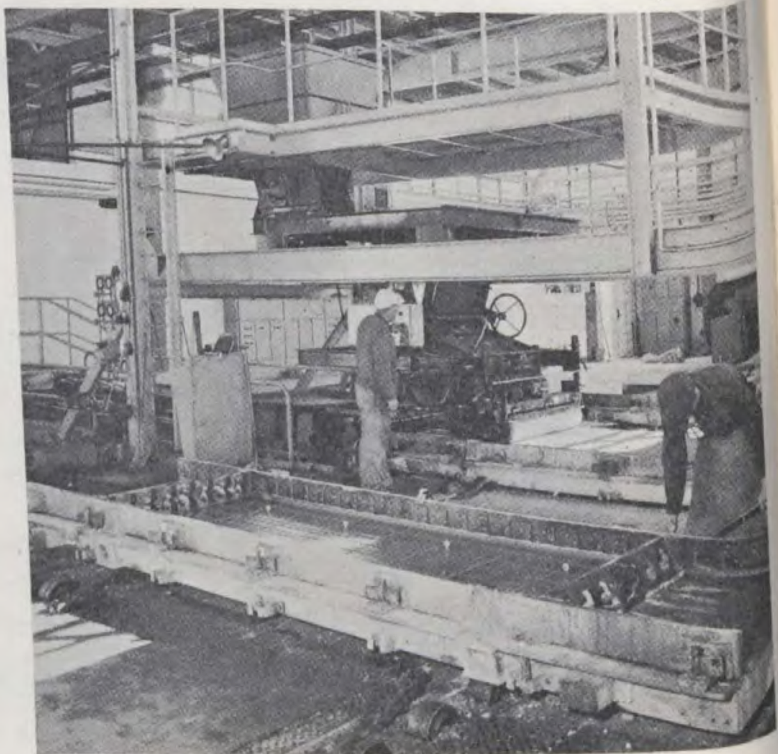
16



Factory layout

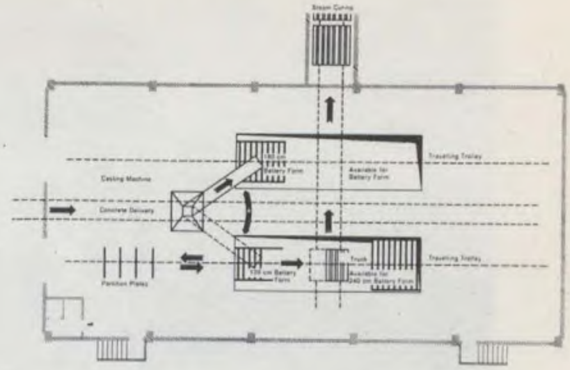


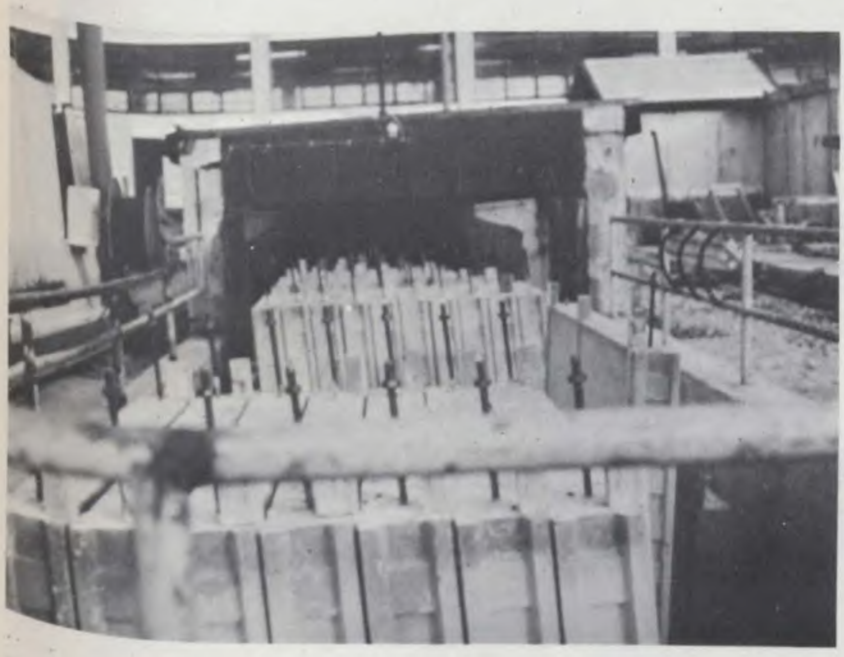
Floor element factory.



Floor element factory casting machine.

Wall element factory layout.





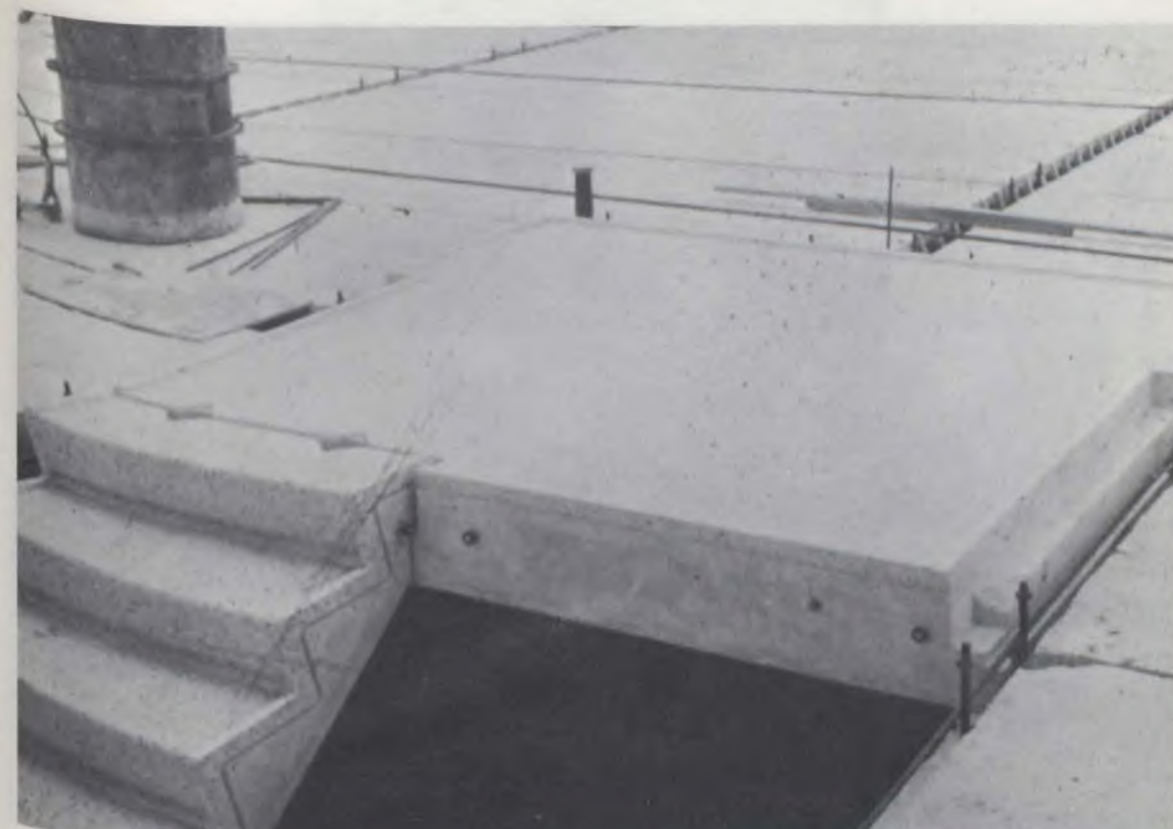
Loaded block car of wall elements leaving steam curing chamber.

Wall elements with door openings.

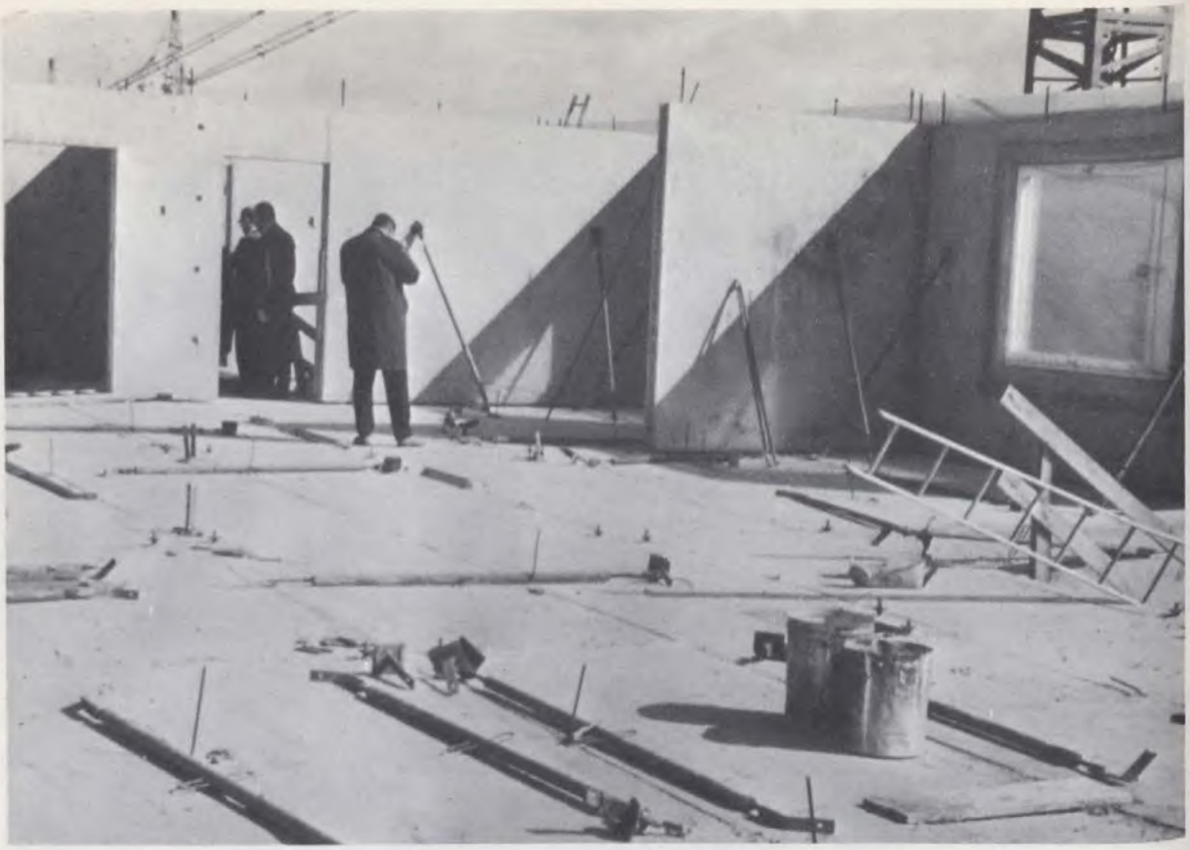
Floor elements.

Precast façade panels manufactured by
Swedish licencee of Jespersen system for
apartment project near Malmö.

Apartment project near Malmö.



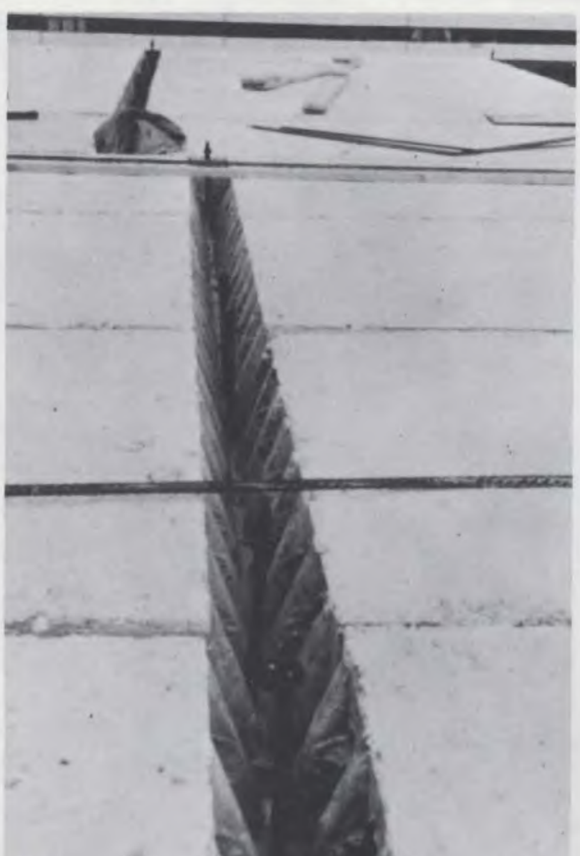
Apartment project near Malmö - showing stairs and floor elements installed.



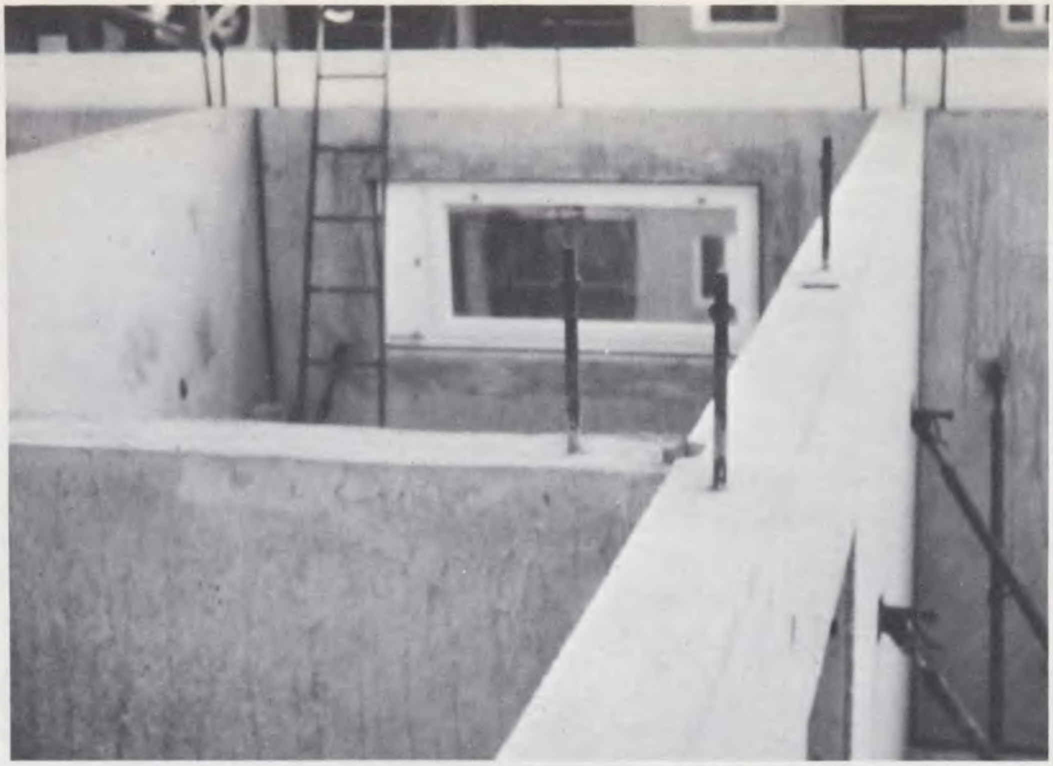
Apartment project near Malmö - showing wall and floor elements being erected.

Apartment project near Malmö - showing wall elements held in position by inclined props.

Apartment project near Malmö - showing how props are temporarily fastened to wall.



Apartment project near Malmö - showing floor elements installed.

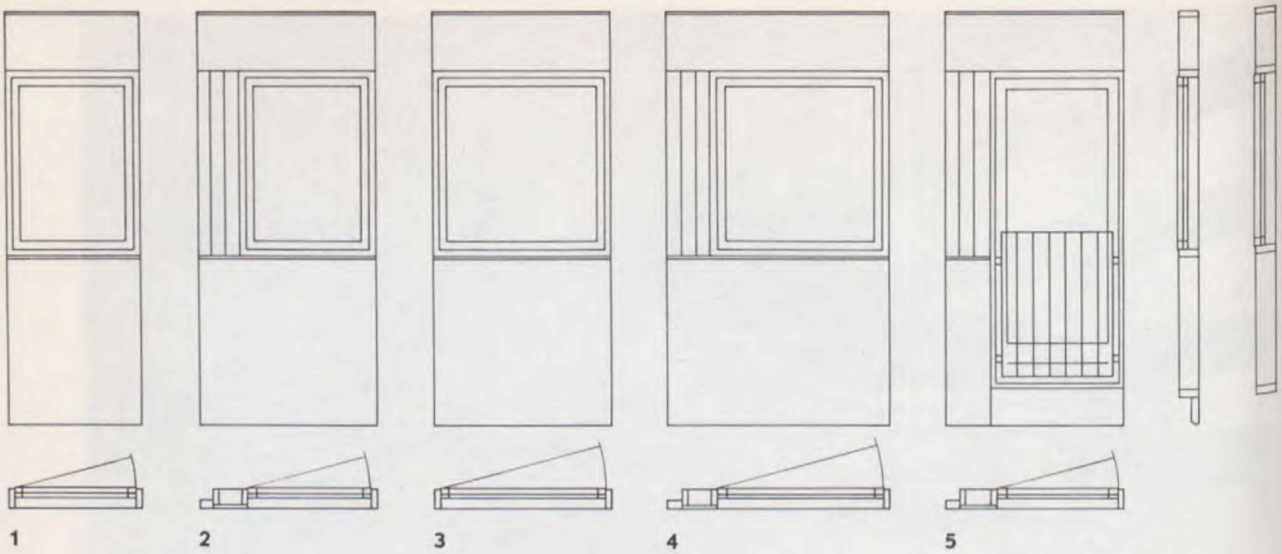


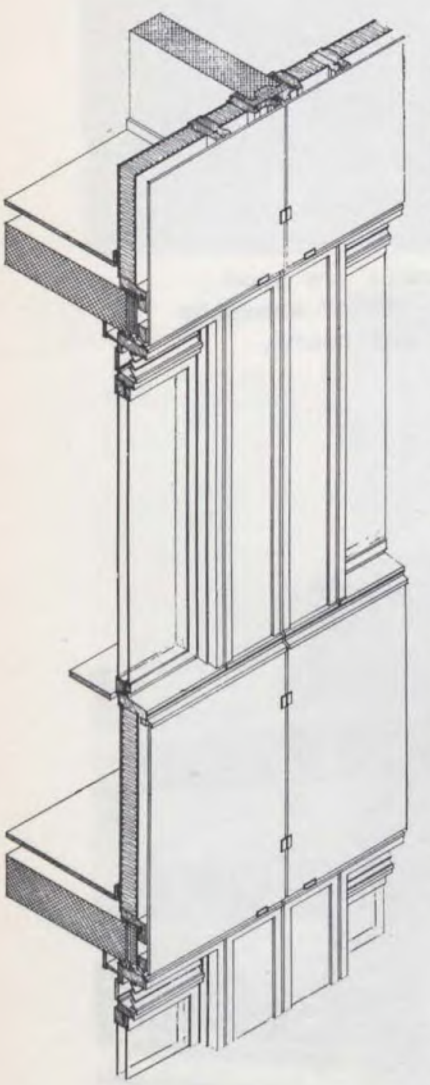
Apartment project near Malmö - showing partition walls erected.

Apartment project near Malmö - showing joint of partition wall element and façade elements.

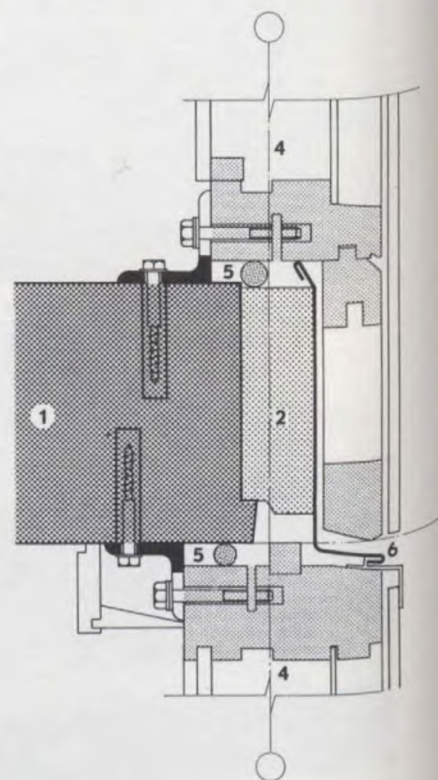
Construction site near Copenhagen. Façade panels are wood framed with sliding windows, the exterior face is of asbestos cement sheets and the interior face of gypsum wallboard.

Apartment building under construction. Material to finish interior of apartments in stored inside building prior to erecting the façades.



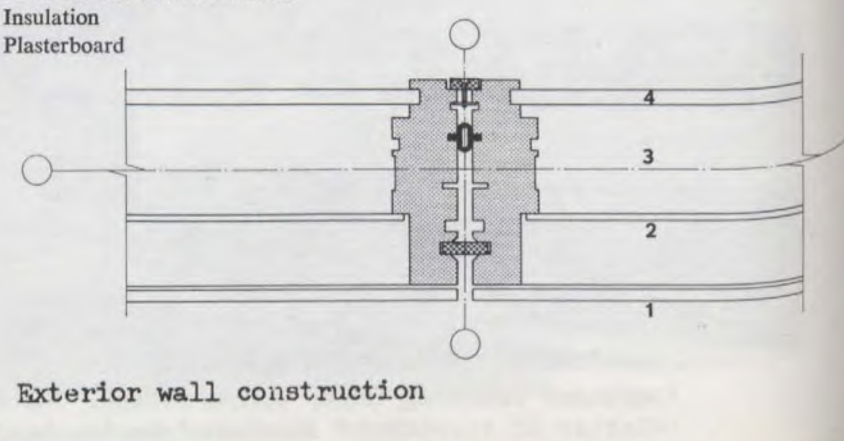


The 5 basic elements in the facade construction, scale 1:50.
The elements are produced in 3 widths: 90, 120 and 150 cm, thereby being applicable to any design, based on a structural planning module of 30 cm. The examples refer to the project "Hedegården", which is a continuation of the Ballerupplan, the structural principles being identical for the two projects. The elements are produced in a highly mechanized factory on the island of Funen and arrive pre-finished with windows, glass, in- and outside paint etc.



Vertical section through joint between exterior wall components and floor slab.
1 Floor slab
2 Lightweight concrete insulation cast on floor slab
4 Lightweight curtain walls
5 Jointing with plastic material
6 Zinc flashing

Horizontal joint between 2 lightweight exterior wall components, scale 1:5
1 Exterior cladding with asbestos-cement sheet
2 Fire resistent asbestos-cement
3 Insulation
4 Plasterboard



Exterior wall construction

THE GLADSAXE PROJECT

The Site

The site was provided by the Communes of Gladsaxe and of Copenhagen. The total area is about 700,000 m^2 of which approximately 40,000 m^2 will be built-up and approximately 160,000 m^2 used for roads, parking and terraces; the remaining approximately 500,000 m^2 is to be a public park.

The Commune

The project lies in Gladsaxe, which, with its 70,000 inhabitants, is the seventh largest Commune in Denmark. As security for the financing of the project, the Commune will underwrite part of the State-guaranteed third-priority loan. In addition, the Commune is subsidizing, to the extent of 15% of the cost, a certain number of flats reserved for families with low incomes. The Commune is the client for the schools.

Financing

The total cost of the project, excluding financing costs, is expected to be approximately 150,000,000 kr. The project is financed by credits and mortgage loans, together with a loan from Byggeriets Realkreditfond, amounting to 94% of the total cost. For the last-named loan, the State guarantees the amount between 65% and 94%. The remaining 6% is deposited by the tenants.

Types of flat

Of the 1921 flats in the project. 14,5% are 1-room, 14,5% 2-room, 35,7% 3-room, 25,9% 4-room and 9,4% 5-room, varying in size from 43,8 to 108,3 m^2 (approx. 470 to 1170 sq. ft.). Parking space has been planned on the basis of one car per flat. The shopping centre will have parking space for about 500 cars.

Technical details

The Gladsaxeplanen is an industrialized building project. Therefore, most components of the blocks of flats are produced as elements with a high degree of finish at mechanized factories, and are assembled on the site. This mechanized form of construction improves quality, reduces costs, and is independent of the weather.

Immediately after the war the average flat required 1750 man-hours. The figure today is about 1000 man-hours, divided roughly equally between factory and site. The man-hour requirement for skilled site workers has been reduced to one-third, an important point in favour of element-construction in the present period of labour shortage.

The structural elements are designed on a 30 x 120 cm module (1' x 4'). The floor-elements are simply supported at the cross-walls. Longitudinal bracing-walls provide stability in the direction parallel to the facade.

To ensure overall stability and to remove the possibility of crack-formation under high wind loading, the vertical joints in the cross-walls of the 9 and 16 storey blocks are prestressed by cables in the horizontal joints. The floor-elements are standard reinforced hollow-core slabs, 18 cm (7") thick, 120 cm (4') wide, the length a multiple of 30 cm (1'). The wall-elements are standard unreinforced solid units, 18 cm or 15 cm (7" or 6") thick, 120, 180 or 240 cm (4', 6' or 8') wide, and are of storey-height. 10% of the floor-units (bath, balcony and stairs) and 20% of the wall-units (elements with cantilever-support for balcony, gable, stairwell and longitudinal wall) are specially designed for this project.

The elements are erected at the rate of four flats per day.

The light wood-framed façades are delivered, ready-painted, complete with glass and 10 cm mineral-wool insulation, in sizes up to 5 m^2 (55 sq. ft.). The light-weight partition walls, which can be papered directly, are delivered with ready-cut grooves for electrical wiring.

Partition-wall units for each flat are packed together.

Pipework is delivered to the site ready to assemble, in packages containing pipes for three flats.

Kitchen cupboards, wardrobes and doors are delivered ready-painted.

Rentals and deposits

The provisional monthly rent and deposit for a 3-room flat have been fixed at 550 kr. and 4800 kr. respectively. (Approx. 80 and 700 US $).

Two categories of low-income family are recognized, for whom the above rental would be reduced to 490 and 354 kr. (approx. 70 and 50 US $).

Period of construction

Site-work started in December 1962, and erection of the first block began in September 1963. Occupation commenced in February 1964 and is expected to finish in 1966.

Attached is a plan layout and typical apartment layout of the Gladsaxe Project.

THE HEDEGAARDEN PROJECT

The Commune

The project lies in Ballerup, which, with its 35,000 inhabitants, is the fifth largest commune in suburban Copenhagen.

Financing

The total cost of the project, excluding financing costs, is expected to be approximately 117,000,000 kr.

Rentals and Deposits

The provisional monthly rent and deposit for a 3-room flat of 81 m^2 (875 sq. ft.) will be fixed at 615 kr. (excluding central heating) and 6700 kr. respectively. (Approximately 85 and 940 US $). For low-income families, the above rental will be reduced to 540 kr. (approximately 75 US $).

Types of Flat

Of the 1752 flats in the project, 11.5% are 2-room, 67,5% 3-room, 21% 4-room varying in size from 63 m^2 to 91 m^2 (approximately 680 sq. ft. to 980 sq. ft.) (gross area, excluding balconies). The blocks of flats are all 4-storey walk-up blocks. Parking space has been planned on the basis of one car per flat.

Technical Details

"Hedegaarden" is an industrialized building project, a continuation of the Ballerup plan. Most components of the blocks of flats are produced as elements with a high degree of finish at mechanized factories and are assembled on the site. This mechanized form of construction improves quality, reduces costs, and is independent of the weather.

Immediately after the war, the average flat required 1750 man-hours. The figure today is about 900 man-hours, divided roughly equally between factory and site. The man-hour requirement for skilled site workers has been reduced to one-fourth, an important point in favour of element construction in the present period of labour shortage.

The structural elements are designed on a 30 cm x 120 cm module (1' x 4'). The floor-elements are simply supported at the cross-walls. Longitudinal bracing-walls provide stability in the direction parallel to the façade.

The floor-elements are standard reinforced hollow core slabs, 18 cm (7") thick, 120 cm (4') wide, the length a multiple of 30 cm (1'). The wall-elements are standard unreinforced solid units, 15 cm (6") thick, 240 cm (or 120 cm) (8' or 4') wide, and are of storey-height. 18%

of the floor-units (bath, balcony and stairs) and 17% of the wall-units (gable and longitudinal wall) are specially designed for this project.

The elements are erected at the rate of five flats per day.

The light wood-framed façades are delivered, ready-painted, complete with glass and 10 cm mineral-wool insulation, in sizes up to 5 m^2 (55 sq. ft.). The light-weight partition walls, which can be papered directly, are delivered with ready-cut grooves for electrical wiring.

Partition wall units for each flat are packed together.

Pipework is delivered to the site ready to assemble, in packages containing pipes for two flats.

Kitchen cupboards, wardrobes and doors are delivered ready-painted.

Period of Construction

Site-work started in June 1964, and erection of the first block began in March 1965. Occupation commenced in September 1965 and is expected to be completed in 1967.

General Comments

1. Modulbeton is formed of the following companies:

The Jespersen Company	P. E. Malmstrom
Owns all the plants and is responsible for all production of components.	are the consulting engineers. They develop the philosophy and are responsible for all engineering, planning and site co-ordination.

2. Industrialized housing in Denmark is subsidized and hence has an advantage over traditional construction.
3. The Jespersen factory for standard units has a capacity of 12 flats per day, per 2 shifts of 32 men each. Plant produces 800 m2 sq. floor units and 500 m^2 sq. wall units. The annual capacity of the flat is 2500 apartments per annum. The plant is highly automated. The production at the plant is very high and the quality of the finished panels is very good. It requires 0.40 man hours per m^2 of product including foreman, maintenance staff, etc.
4. The site organization is well planned.
   Gladsaxe project is very impressive in its layout and the number and size of the buildings.
   Hedegaarden was also impressive in both layout and town planning.

5. Productivity at Construction site

Man hours per apartment of 85 m^2 or 920 sq. ft.

On site man hours required	Skilled	Special	Total
Traditional	1040	410	1450
Composite (trad. and I.B.)	730	310	1040
Industrialized Building	260	260	520
Jespersen systems	189.5	197.5	387

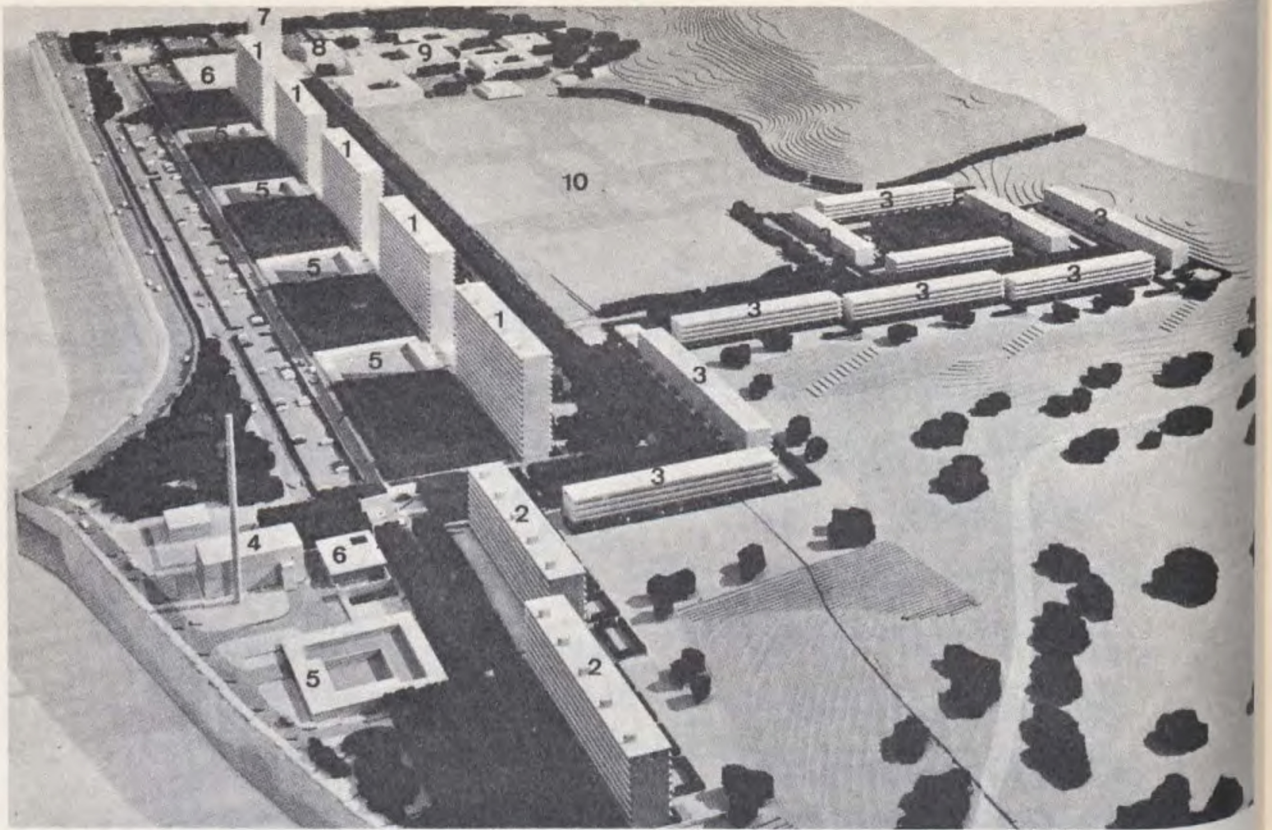
The average apartment is 85 m^2 or 920 sq. ft.

We visited the Jespersen licensee at Halsenberg in Sweden, the A.Betong Co.

The plant cost $2 million to build and is probably one of the best plants seen during our visit. Excellent plant layout and equipment.

We also visited the construction site where 435 apartments are being built.

License agreements are available subject to negotiations with the Modulbeton group.

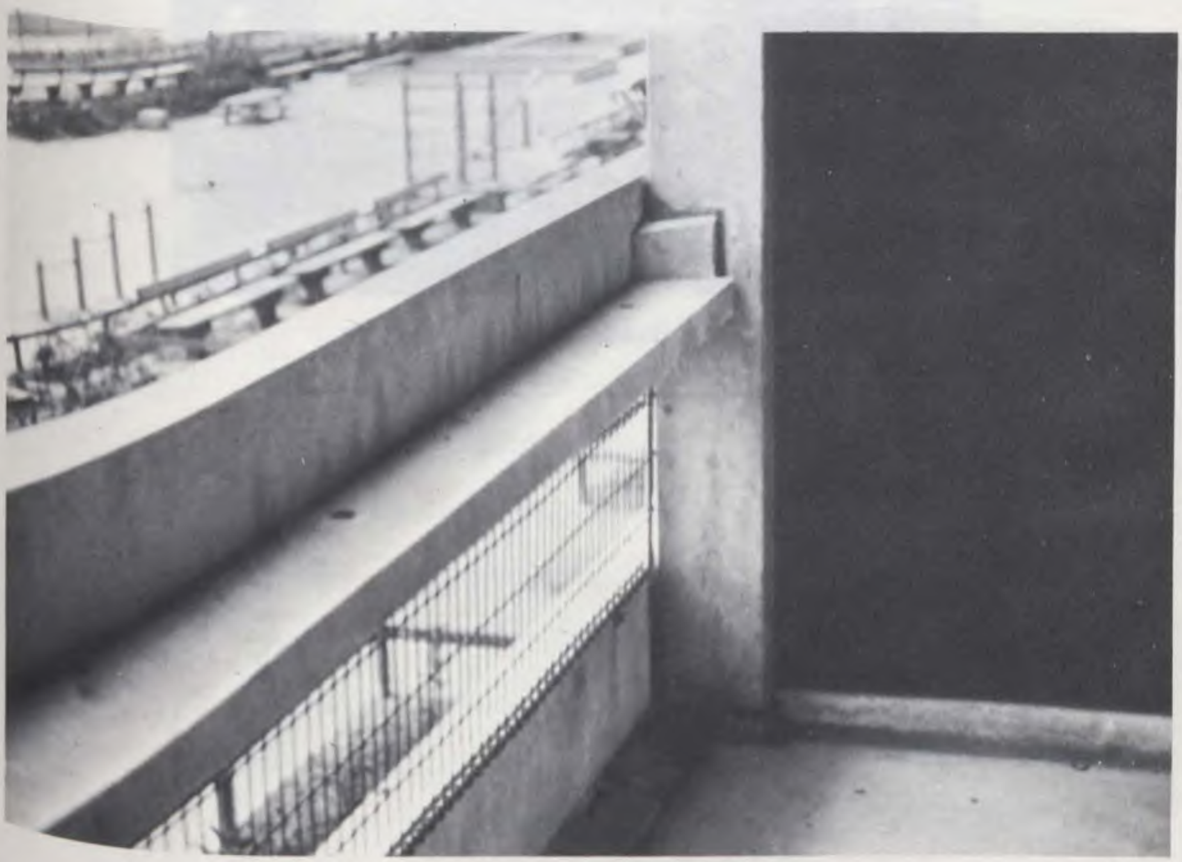


Model of Gladsaxe project

1 - 16-storey blocks.
2 - 9-storey blocks.
3 - 4-storey blocks.
4 - Central heating plant.
5 - Parking space and garage.
6 - Shopping centre.
7 - 9-storey building with offices, clinics, etc.
8 - Church.
9 - Schools.
10 - Playing fields.

Gladsaxe - The apartments were put into use as they were finished. The first tenant moved in 19 weeks after the start of erection and the last one 12 weeks later. Building time was 31 weeks from erection of the first components until the last tenant moved in.

Gladsaxe - Balcony façades of 16-storey block.



Gladsaxe - Detail of balcony construction.

Gladsaxe.

A.B. SKANSKA CEMENTGJUTERIET

THE HEART SYSTEM

Skanska Cementgjuteriet
Allbeton Division
Hjal Marekajen 3-5
Malmo 1
Sweden

Founded in 1887, Skanska Cementgjuteriet has long been one of the leaders among European construction firms. Since the company has always been associated with Swedish cement-manufacturing interests, it has been especially prominent in the development of all types of concrete construction.

The company operates 40 concrete plants and produces 97% of all cement in Sweden (80m bbls.)

From the manufacture of concrete products, its activities have been progressively expanded to cover the whole field of building and civil engineering. Over a long period, contracts have included major highway and airport projects, bridges, harbour works, power plants, all types of housing and industrial buildings, as well as storage structures. Applying mechanization to a high degree, Skanska Cementgjuteriet has also pioneered some remarkable techniques and new methods of construction.

Until after the Second World War, the company's operations were largely confined to Scandinavia. Today they execute contracts all over the world. In 1965 the company's dollar volume of business amounted to over $300,000,000 and it employed 17,500 persons.

While the company is accustomed to all the various types of contracts prevalent in building and civil engineering work, its contracts tend to include the design and engineering as well as the construction.

"turn-key" type of contract, all the necessary financial and personnel resources are available enabling them to carry out complete projects extending from the preliminary surveys and design to the handing over of a finished installation.

THE HEART SYSTEM

Skanska Cementgjuteriet developed the large scale production of a unit called the "Hjarat" or "Heart". It is a prefabricated unit comprising the oil-fired central heating installation, toilet, bathroom and kitchen and includes the plumbing and electrical installations.

The accompanying photographs and diagrams show the layout and production of the units. Experience has shown that the "heart" unit lowers building costs. Mass production of a single unit is obviously cheaper than carrying out all operations on the site as is the traditional method in this country. Building codes and bylaws in Canada would be a very serious obstacle to such a prefabricated unit. Sweden shows, however, that it can be done.

The "heart unit" consists of bathroom, toilet, boiler room and part of the kitchen with all the necessary equipment. The bathroom contains a bath and hand basin. The toilet contains the lavatory, a hand basin and a bidet. In the boiler room there is the oil-fired boiler, with all controls, the electric control panel and auxiliaries. The kitchen section has a sink unit, wall cupboards, electric stove and a kitchen fan. The electric light fittings have bulbs ready screwed in and, as a special gimmick, even rolls of toilet paper are fitted in the toilet paper holders.

The "heart" is supplied with all surfaces completely finished. Floors, walls and ceiling are of concrete. The dimensions of the unit are 7ft. 4in. by 14ft. 2in.

Manufacture takes place on special production tracks: there are three parallel production tracks, one storage track and one assembly track, five in all. These are connected by two transverse connection tracks, one at each end of the production tracks. These connect the production tracks with the storage tracks. Each production track has nine working stations, each corresponding to a day's work. All the items to be incorporated are delivered in a prefabricated form to the factory. Timber fittings, boilers, burners, etc., arrive by truck in special containers and are placed upon a storage space, thereby avoiding costs of handling. The units themselves are on wheeled trolleys which pass along the production tracks. After eight days of production a "heart" unit is ready to be transported via the transverse track to the storage track. From this it can be loaded upon a trailer and be transported to the building site. The production trolley is then wheeled along the other transverse track back to the production track.

Manufacture: The units are manufactured in a factory in Eslov which is in the Skane district of Southern Sweden, by methods which are very similar to those used in the automotive industry.

The basis of the production method is a number of separate production tracks, equipped with rails. The "Hearts" themselves are made on top of special trolleys which are capable of moving along these production tracks.

Production Line: The trolleys pass along nine different production stations.

Station 1. - The floor slab is cast of reinforced concrete. The casting is made upside down. In this way it is possible to obtain a suitable fall towards the floor drain in the centre of the bathroom floor and also to get a perfectly smooth floor which requires no further treatment. Electric heating is installed in the shuttering to speed up the setting. Floor drain, heating coils, cold water pipes, piping for boiler, fixing nipples, etc., are all cast into the flooring slab.

Station 2. - The flooring slab, which has set by now, is turned over by a traverse. The steel shuttering for walls and ceiling is placed on the floor slab. The nipples required for fixing the electrical control panel, bathroom mirror and cabinet, bath, shower, hand basins, towel bars, windows, doors, wall cupboards and electrical installations are attached to the shuttering. There are approximately 200 of these fixing nipples, and the position of each is determined by means of holes bored into the shuttering. Electric conduits and junction boxes are also cast in. The casting of the walls and ceiling takes place on station 2 and the trolley is then wheeled to:

Station 3. - Where the form moulds are removed.

Station 4. - Wiring is laid into the metal conduits. A four-colour scheme is employed.

Station 5. - The concrete sufaces are first filled and then primed by spraying a special cement mix on to them.

Station 6. - The unit is now surface treated. The first coat of paint is sprayed on, the finishing coat is applied by hand.

Station 7. - The boiler is installed and all piping is connected. Floor coverings are fitted. Door frames are installed.

Station 8. - Sanitary installations such as bath, w.c., wash basins, fixtures are installed. Electric control panel is fitted.

Station 9. - The prefabricated stainless sink, base, and wall cabinets are attached in the kitchen, followed by the installation and connection of the electric stove. Ventilators and gratings are installed and doors to bathroom and boiler room are fitted. Socket outlets are fitted. Electric light fittings are installed and bulbs are inserted. Electric installations are tested as is the hot and cold water supply. A test run is carried out on the oil burner, followed by final finishing and inspection.

Storage: The finished unit wrapped in plastic is unloaded on a special storage siding awaiting delivery to the site and the trolley returned to station 1.

Production is limited by the time required for the concrete to set; consequently the weekly production per track is six units. Each production track employs 12 men. Due to the fact that the work is repetitive, these men need not be specially skilled.

All the items which are to be installed into the units are delivered in a prefabricated state from either subsidiary factories or sub-contractors. All pipes and conduits are ready bent and threaded. All woodwork is ready finished and all linoleum cut to shape. The different components to be fitted are stored conveniently near the appropriate assembly station and are transported to it by auxiliary lifting systems.

The price of a "heart" unit is approximately 14,000 Swedish Kroner or $3,000 Canadian. This price includes the cost of installation in the house to be erected but not the transport, which is about $20. per 100 miles.

General information

Plant cost	- Approximately $2.5 million
Plant capacity	- 5 complete units 1 day
	25 " " 1 week
Plant employees	- 70 employees
Rate of pay	- $2.50 to $3.00 per hour

Man hours required to produce Heart unit

(1)	traditional method	1100 man hours
(2)	Heart system	120 man hours
	Time saving	980 man hours

Volume of business $2 million per annum

Franchise cost is 350 Kr. ($70) per unit

Their "heart" production factory employs some of the most advanced techniques of industrialization.

The productivity at the "heart" factory is very high as units move on a production line basis and tight schedules are met.

Workmanship in the various trades is excellent.

Erection of "The Heart Unit" - The method of erection is as follows: The foundations are completed so that the "heart" may rest on a specially designed support. The unit is transported to the building site by truck and lifted into position by means of the crane. The electricity supply, water and sewer connections are connected and the rest of the house built round the unit from any desired materials, brick, gas concrete, stone and so on, according to the special desires of the architect in charge. Even though the relative positions of kitchen, bathroom and boiler room are fixed, it is possible to build any number of houses, using the "heart" unit, which differ from each other considerably.

The "corpus" (body) method: The development of the "heart" has led to the production of special body units, which are intended to be incorporated with the "heart" units to form complete houses.

These "corpus" units are made of concrete in a factory in room-size units using the moving belt principle in the same way as in the manufacture of the "heart" units.

Each production track is sub-divided into six production stations. In the first three stations the floor, walls, and ceiling are cast. Surface finishes are applied in stations 4 and 5, while auxiliary components are incorporated in station 6.

The units are transported from the factory to the building site either on top of special trailers or, in the case of long distances, by rail. Each "corpus" unit is supported on four concrete blocks, placed underneath the four corners of the unit. Special adjustable supports are used to enable the unit to be levelled accurately. The foundations consist of a layer of concrete, a sheet of polyethylene foil followed by a thin layer of gravel and no less than 8 in. of mineral wool as thermal insulation. The floor proper is of concrete, 4 in. thick, and includes the hot water heating tubes, which are cast in at the factory. External walls are of 4 in. thick concrete, insulated on the outside by 4 in. of mineral wool and followed by the facing materials, which may be of concrete facing slabs, brickwork, timber, asbestos,cement, etc.

Room dividing walls are made from twin leaves of concrete each $2\frac{1}{2}$ in. thick with an air space of $\frac{3}{4}$ in. between them. This has been found to improve the sound insulation enormously and is suggested for cases where multi-family houses are to be constructed by this method.

As is customary in Sweden, the ceilings of the building are of solid concrete construction, with a thickness of 4 in. followed by a very thick layer of glass-fibre insulation (about 8 in.). The roof is prefabricated in six sections and holes for pipes and chimneys are provided.

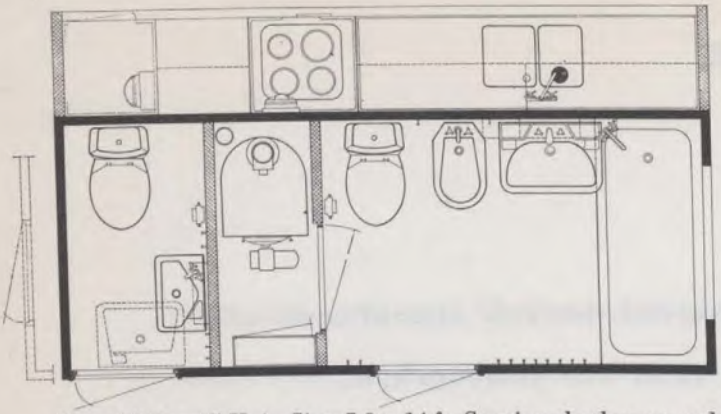
An experimental house was built in Eslov in Southern Sweden which consists of 10 "corpus" units and has a floor area of about 1,000 sq. ft. excluding the wash-house, storage and boiler room. The building was started at 6 a.m. on August 29, 1961, and at 7:30 p.m. on the same day the entire house was roofed-in. The finishing operations took another three days and on the evening of September 1, 1961, the house was ready for occupation. It should be mentioned that work and time planning were carried out assuming normal working speeds and conditions.

The attractive and quite non-prefab appearance of the finished houses can be seen from the photograph.

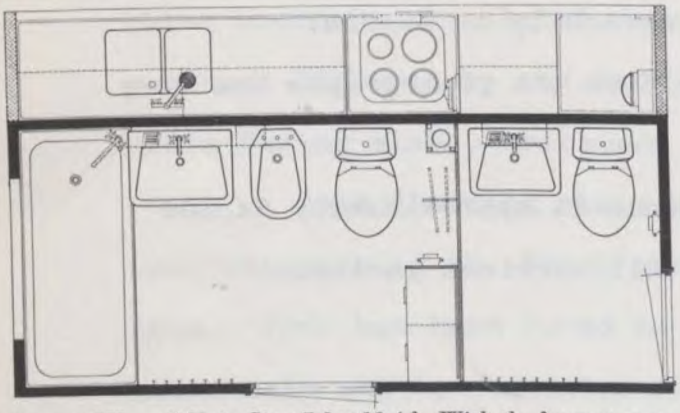
The Corpus system is being used in the construction of student residences at Lund University in Sweden.

The residences as seen from the photographs are very practical and attractive.

The cost of each residence is approximately $4,800 and the rent is $400 per annum, all services included.



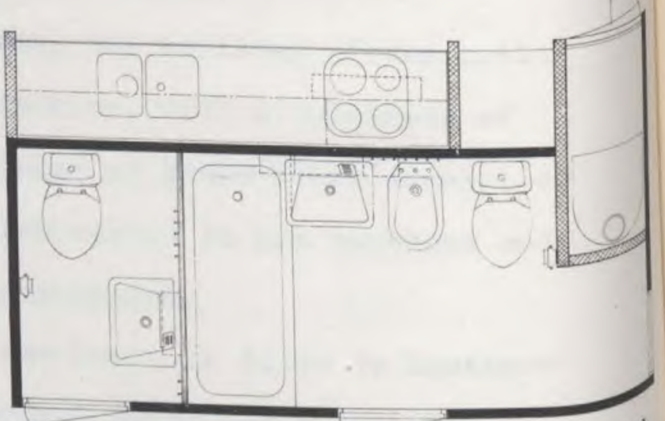
Type 4 "Heart" Unit. Size: 7.9 × 14 ft. Spacious bathroom and fully equipped kitchen wall with washing machine and drier.



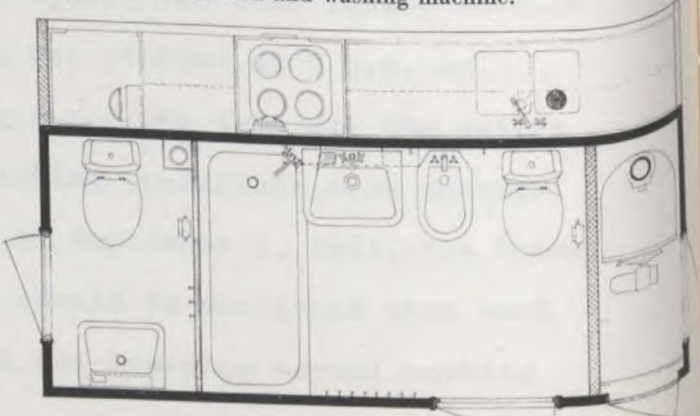
Type 7 "Heart" Unit. Size: 7.9 × 13.4 ft. With the furnace compartment supplied as a separate unit, extra space is gained for toilet and bathroom, enabling dressing table to be fitted too.

Heart unit - variety of arrangements to suit individual needs.

Heart unit - variety of arrangements to suit individual needs.

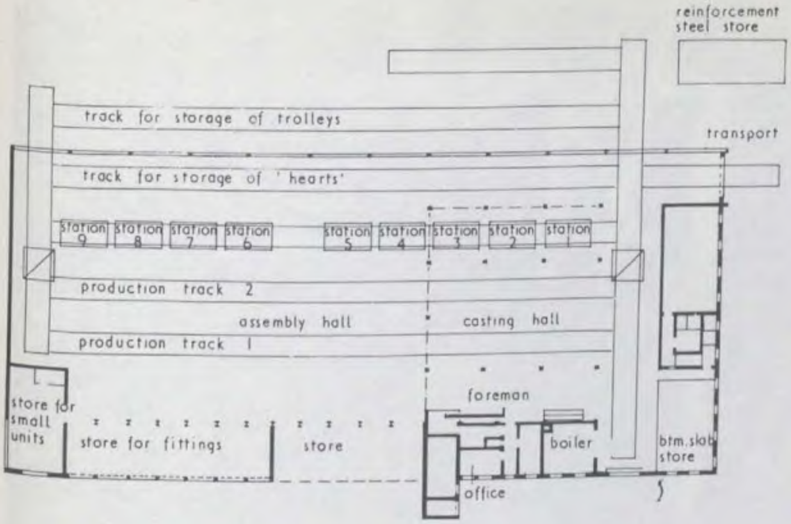


Type 8 "Heart" Unit. Size: 7.9 × 14 ft. Long kitchen sink, a spacious bathroom and washing machine.



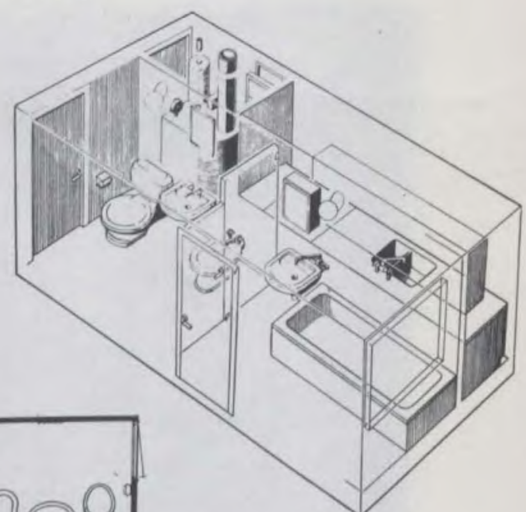
Type 10 "Heart" Unit. Size: 7.9 × 14 ft. Spacious bathroom and fully equipped kitchen wall with washing machine and drier.

Layout of the 'heart' casting yard

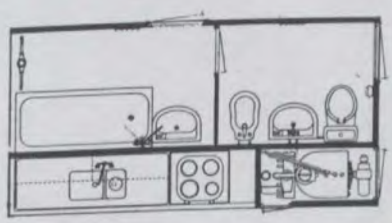


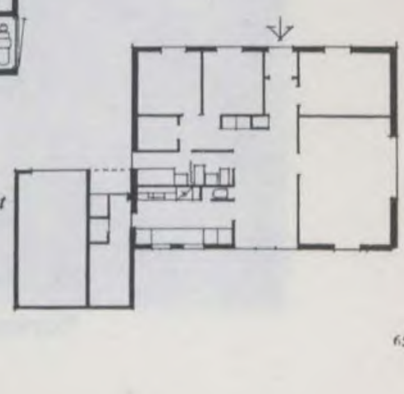
Layout of the Heart unit casting and assembly factory at Eslöv.

Completed interior of a 'heart' house



Isometric view showing the compact arrangements.

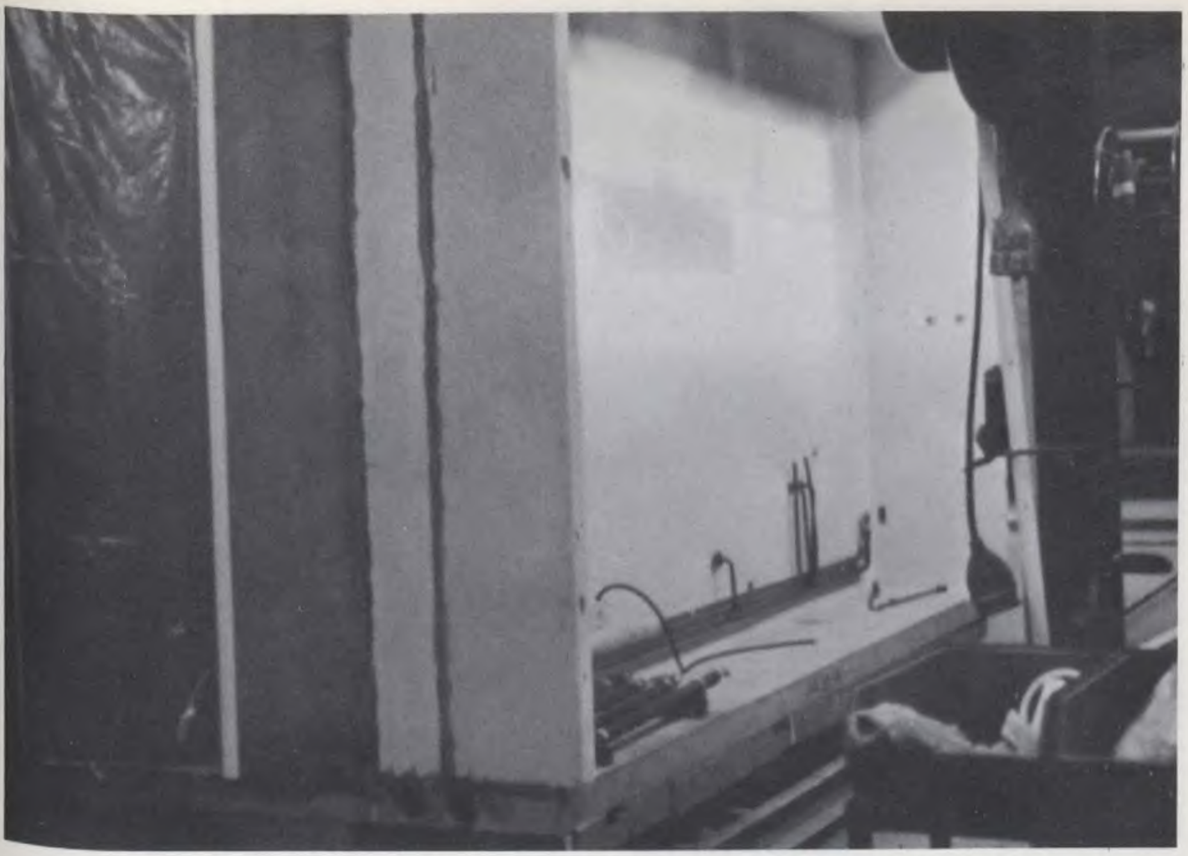




The isometric and plan show the compact arrangement of fitments in the 'heart' unit. Everything requiring plumbing is included in an area of 7ft 4in by 14ft 2in. Right, plan of a typical 'heart' house

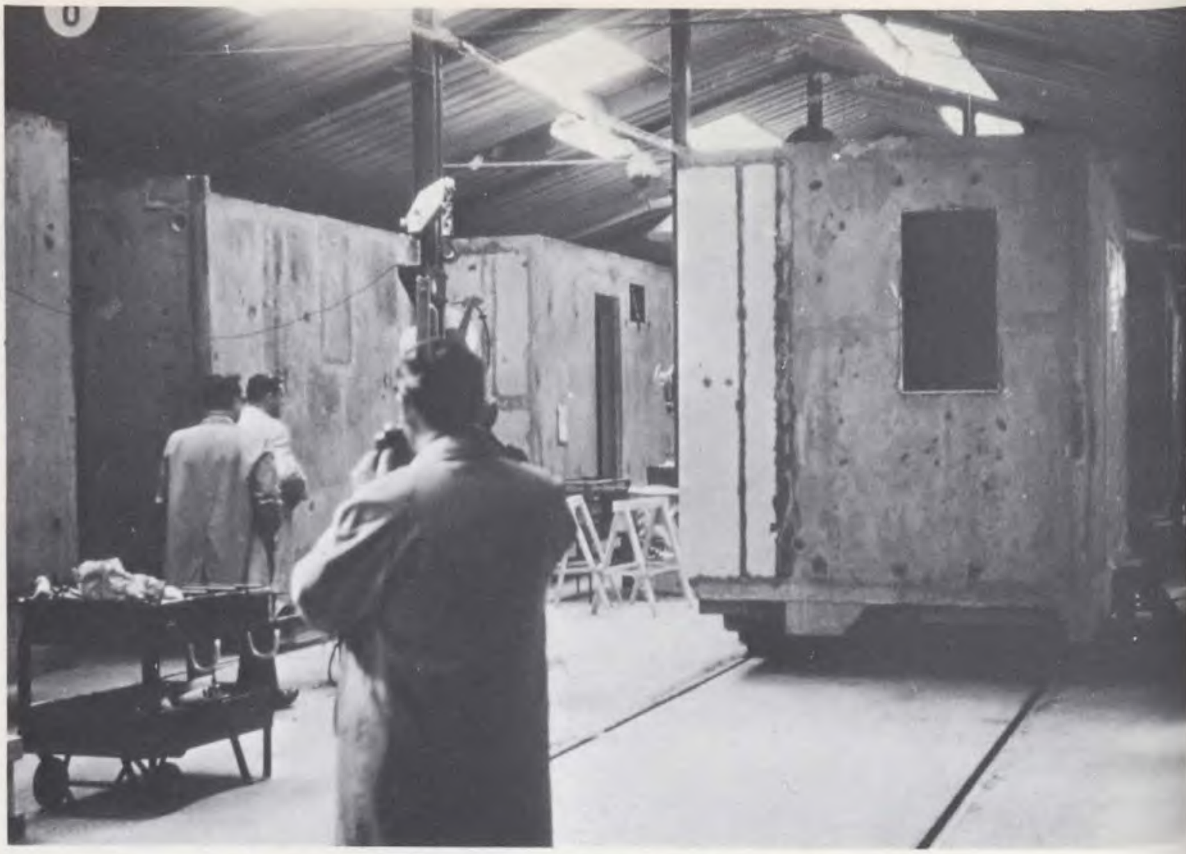
Precasting mould assembly.

Workman executing minor repairs prior to painting.

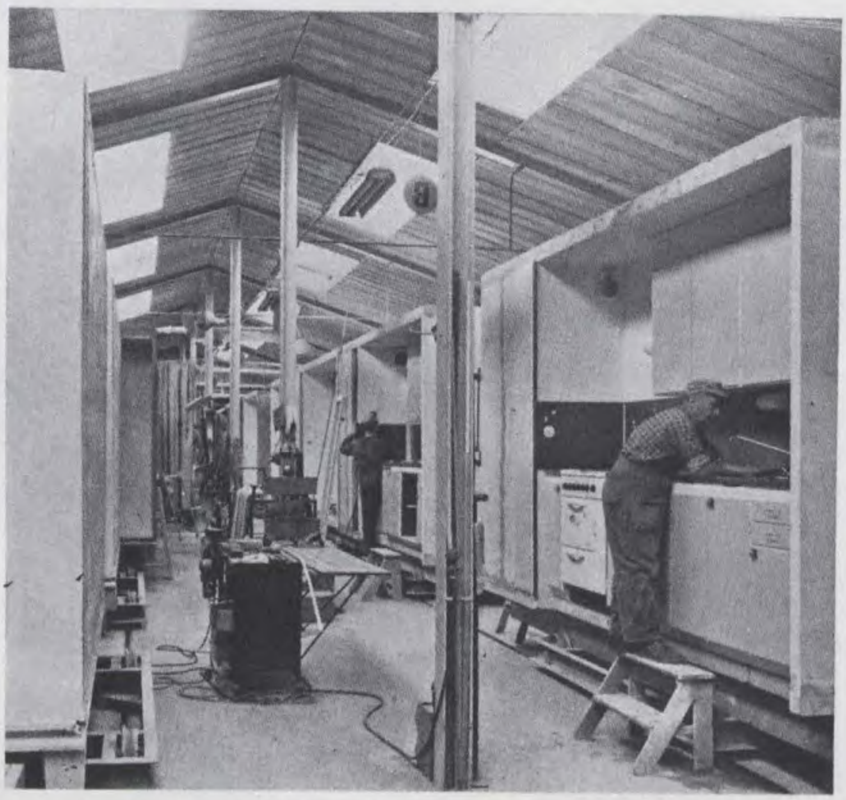


Hot and cold water pipe and waste water pipe being installed.

Completed Heart unit.

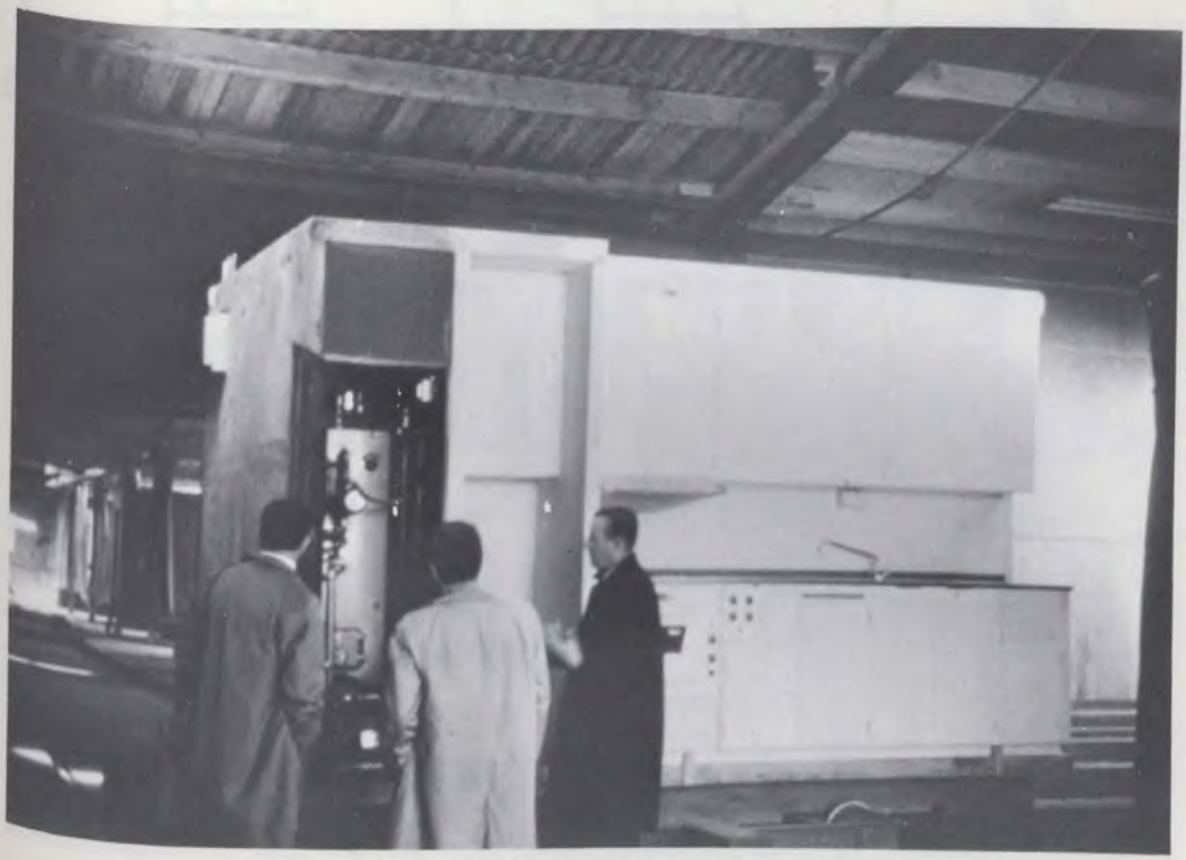


Heart units in position "8" of assembly line.

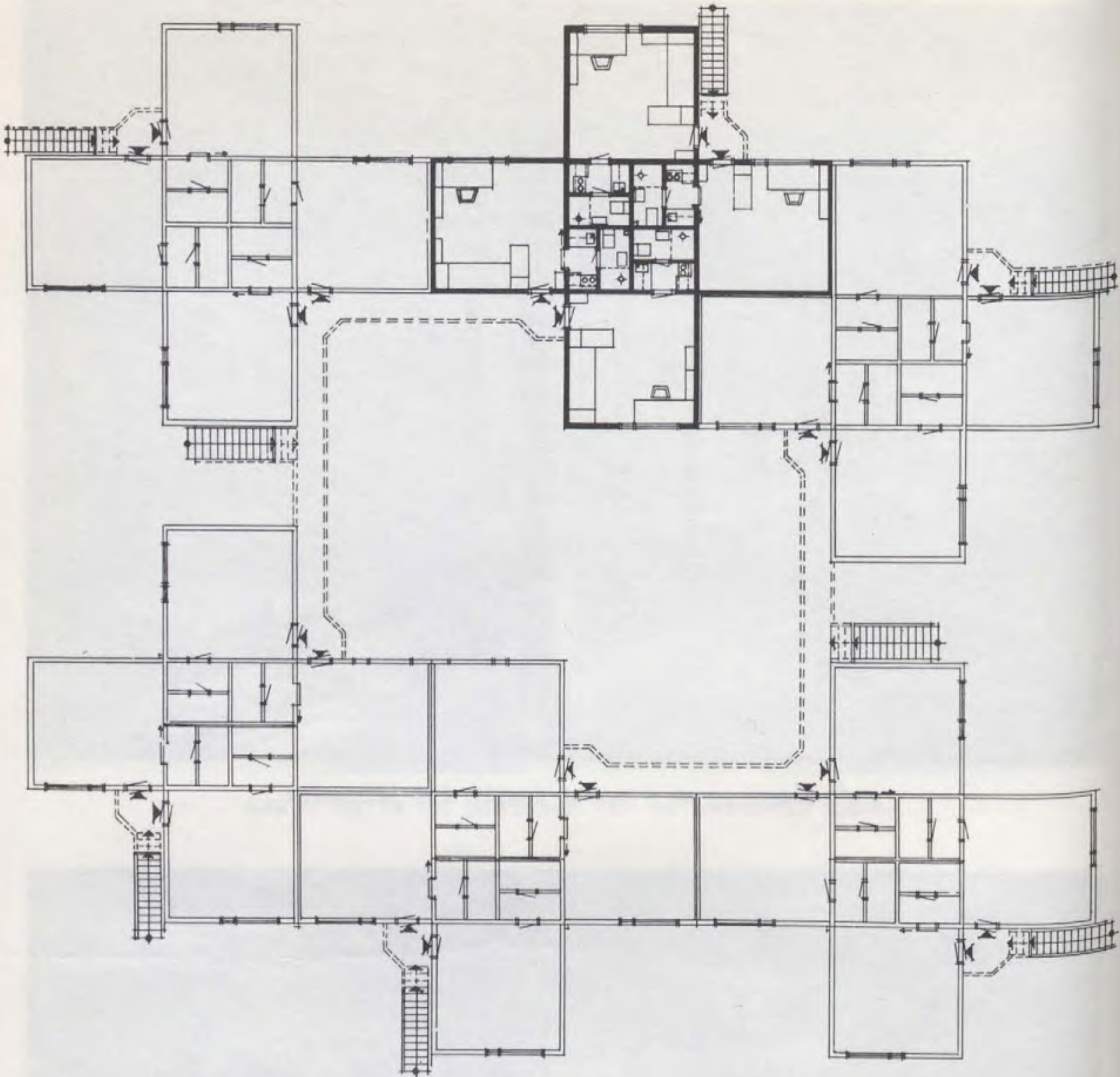


Heart units moving down assembly line.

Storage area - units ready for shipment.

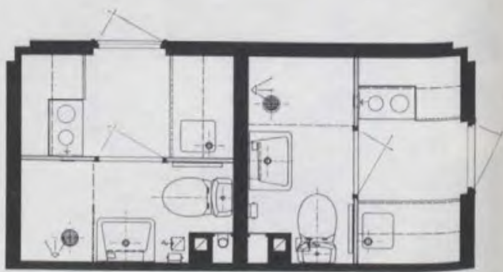


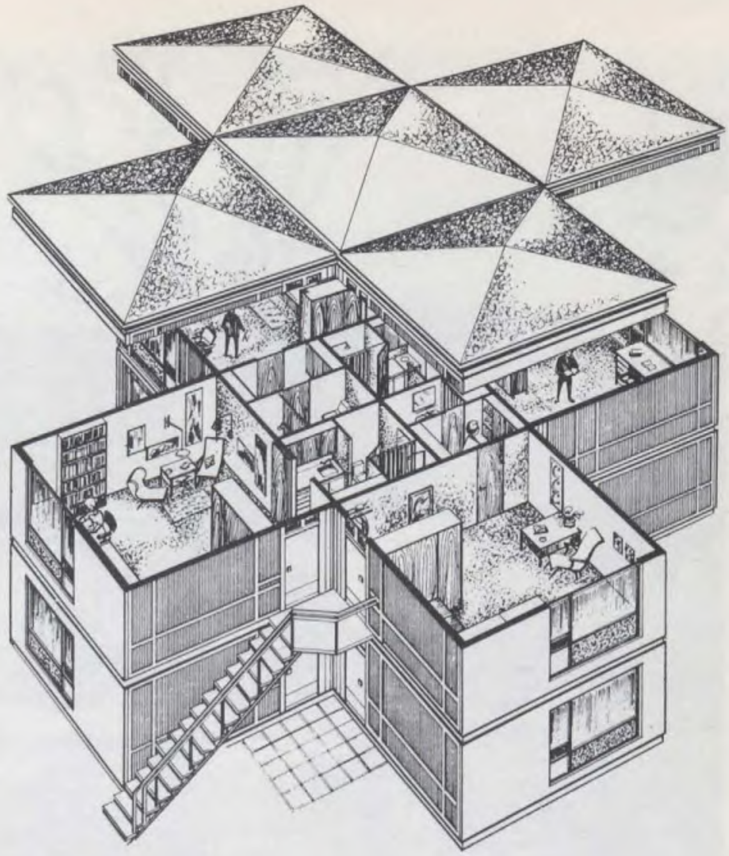
Inspection of Heart units.



Students residence floor layout using Corpus unit.

Corpus unit plan.





Isometric view of students residence using Corpus unit.

Corpus unit installed.

Students Residence at Lundz.

Inside view of student room.

Inside view of student room.

LA SOCIETE TRACOBA

THE TRACOBA #1 SYSTEM

TRACOBA
c/o The Omnium Technique Group (OTH)
254 rue de Bercy
Paris 13, France

TRACOBA

La société TRACOBA is a society of consulting engineers formed to assist in the planning of industrialized factories to produce precast elements for multi-storey apartment buildings.

It is a wholly owned subsidiary of l'Omnium Technique OTH, 18 boulevard de la Bastille, Paris 12e, France, one of the largest consulting engineering firms of France engaged in construction and design of dwellings, hospitals, schools, factories, laboratories, public works, etc.

The Tracoba prefabrication system uses load-bearing cross-walls and non-load-bearing façade slabs.

The internal load-bearing walls are made in panels up to 22 ft. in length. Both transverse and longitudinal walls are made this way. The external walls are non-load-bearing throughout, which has the advantage of giving the architect complete freedom of design. External walls can be designed with large picture windows, loggias or balconies without affecting the structure of the building. The system has been applied to date in the construction of blocks of flats up to 23 storeys.

Wall and flooring units

The simple floor and wall units are usually manufactured in a casting bay adjacent to the actual building while the more complex façade and other units are made in a covered temporary site factory, as close to the buildings as possible. The load-bearing internal walls as close to the buildings as possible. The load-bearing internal walls are cast from reinforced concrete, generally about 6 in. in thickness. The electric conduits, heating pipes and plumbing are incorporated during the precasting and the surfaces finished to an extent that no plastering is necessary. The wall units are handled by the site crane using reinforcement steel loops which emerge from the tops of the units.

The flooring slabs are specially designed with four lugs at the sides. These are specially reinforced to bear the weight of the units. The flooring slabs are set down upon the wall units at these four points. This leaves considerable free space at the sides which can then be filled with high-density concrete which is compacted by means of concrete vibrators.

This method of jointing has a considerable advantage over other methods, in that a first-class solid wall-to-floor connection exists, together with sufficiently wide space between the units, to enable efficient casting of high-density vibrated concrete. This forms a better monolithic joint than the use of thin smears of cement mortar. The reinforcement projects into the joint from the edges of the different units and forms a really efficient structural connection.

Another advantage of this method, is that the filling-in of the joints with concrete can be carried out after further storeys of the building have been assembled, which helps considerably under bad weather conditions.

The only shuttering required is thin lathes of timber which are held from underneath into the corners between the internal walls and the soffit. Once the concrete has set, the corners are made good, air holes in the walls are filled up and the internal walls can be finished, either by wallpapering or painting.

In addition to the load-bearing internal walls, which form the longitudinal transverse frame work of the building, there are also a number of non-load-bearing precast partition walls. In France, these partition walls are made from "Gypsolith" units. All door frames are cast into the concrete units, as are the lugs and fittings for sanitary connections. Staircase and lift shaft units are also precast. Lifts are installed into position during the actual erection of the structures.

Façade walls

These are made in special moulds which can be pivoted through 80 degrees in the temporary factory, adjacent to the building site. The mould surface is cleaned and layers of facing materials, which may be ceramic or mosaic glass tiles or any other suitable facing material, are placed into the moulds. Ventilators, window frames, and other items which are to be incorporated in the façade are inserted. A thin layer of mortar is laid to joint the tiles or mosaic, followed by a layer of reinforced concrete. A layer of gas concrete follows, or alternatively, a layer of expanded polystyrene is used as the thermally insulating material.

The internal concrete leaf is cast on top of the expanded polystyrene or gas concrete and the units are made monolithic by the cross-connection of the reinforcement network. The supporting connections are cast into the inner wall leaf at the same time as the inner reinforcement is laid. These are metal blades which project from the ends of the units.

The general dimensions of the profile of façade walls areas follows: outside lining of tiles, mosaic or alternatively, exposed aggregates; 3 in. of reinforced concrete; $1\frac{3}{4}$ in. of expanded polystyrene or $4\frac{1}{2}$ in. of gas concrete; 2 in. of reinforced concrete. As in the case of the other walls, the internal surface is smooth enough not to require plastering.

The façade panels are assembled by allowing the metal blades to rest upon steel stirrups which are cast into the appropriate ends of external walls. The two are then welded together with electric arc welding equipment. The panels are waterproofed by means of weather strips which are stuck to the units while they are in the storage area. Layers of expanded polystyrene are placed into the gaps between adjoining façade panels to provide adequate insulation at the joints. Next an internal shuttering is erected at the joints and corners. The gaps are filled with high-density concrete which is vibrated and compacted to form a firm joint. At wall/floor connections a sheet of expanded polystyrene is inserted which acts as a thermal insulation at this point and also as a permanent shuttering. Concrete is placed into this space as well and is compacted by the concrete vibrators.

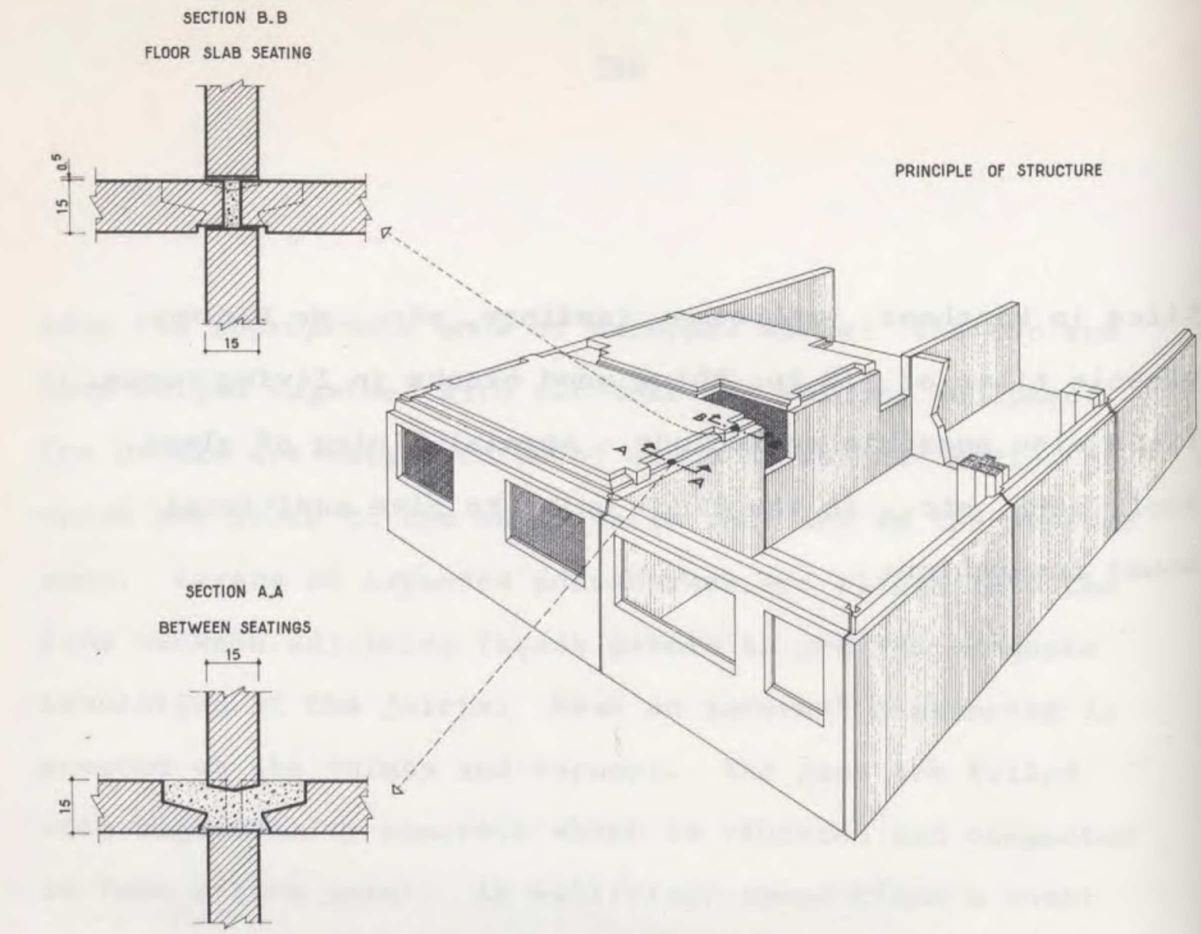
<u>Finishing details</u>

In France, the most usual form of heating employed is that of district heating using hot water from a central boiler-house. But any form of heating such as underfloor electric or gas space heating can be incorporated. Electric conduits are cast in the units but the wiring is carried out as a finishing operation.

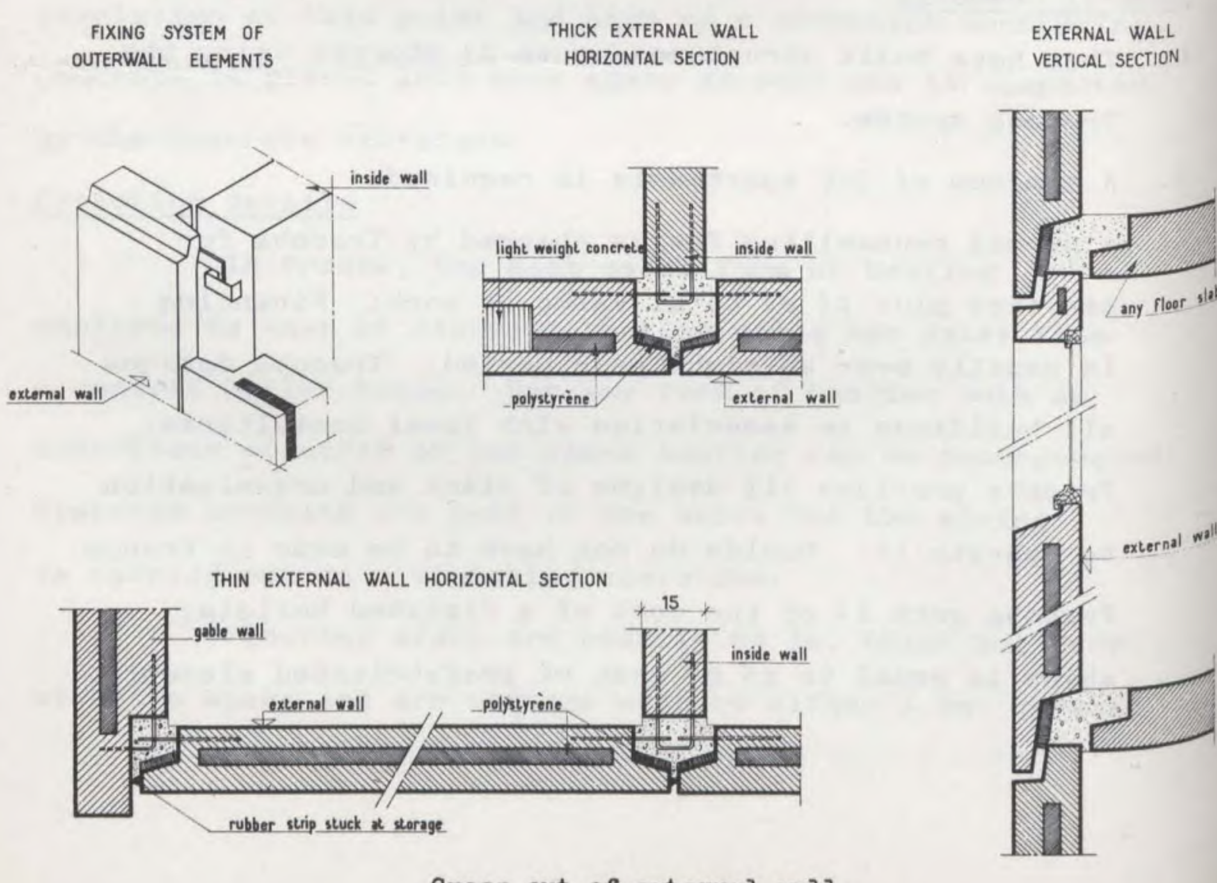
Flooring slabs are usually $6\frac{1}{2}$ in. thick but vary with the spans and are covered over by either 2 in. ceramic tiles in kitchens, bathrooms, landings, etc., or thermoplastic tiles of 3/8 in. thick wood blocks in living rooms. It is also possible to include a special lining of glass wool, cork, etc., in the floor units to give additional sound insulation.

General Comments

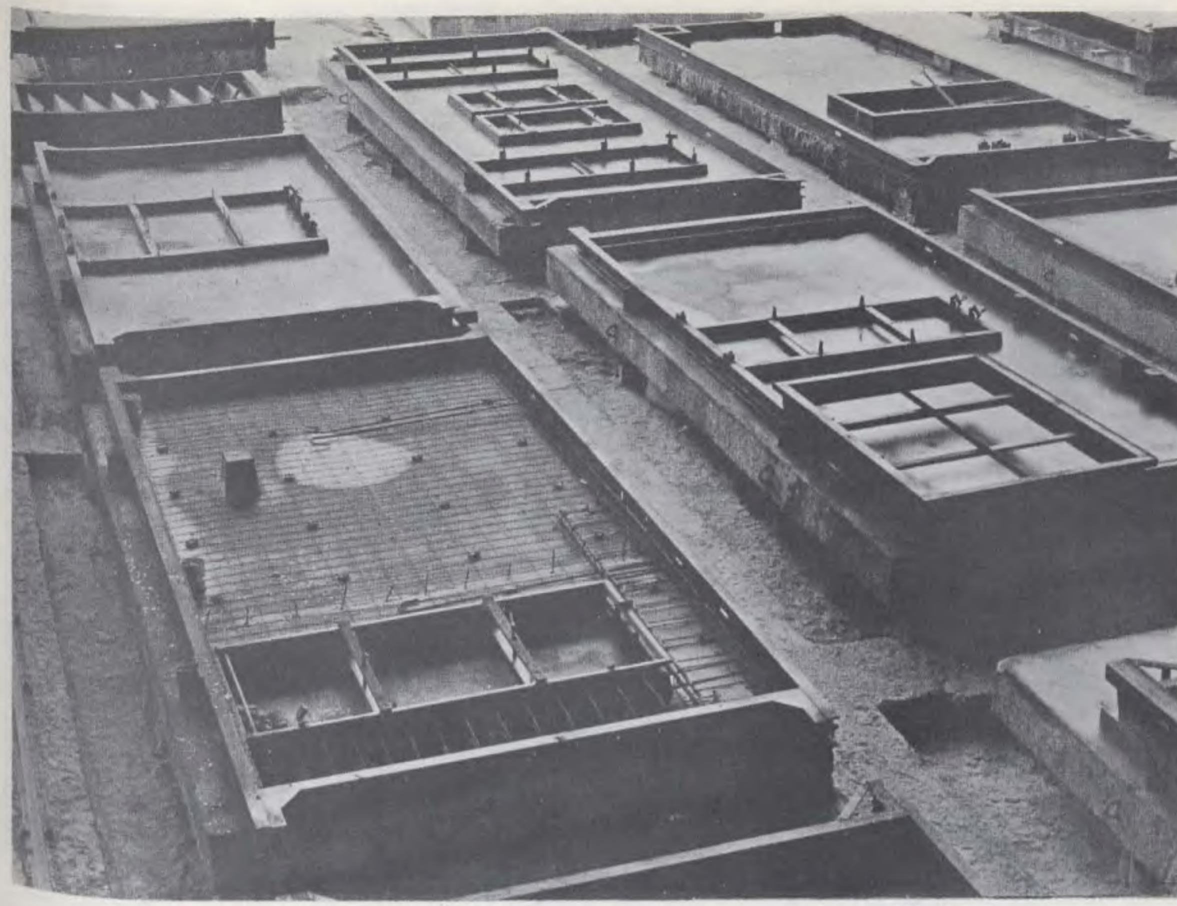
1. They have built structures up to 23 storeys using the Tracoba system.
2. A minimum of 500 apartments is required.
3. A normal counselling fee is charged by Tracoba for services plus 2% of total value of work. Financing is usually over an eight year period. Tracoba designs all buildings in association with local consultants. Tracoba provides all designs of plant and organization to operate it. Moulds do not have to be made in France. Tracoba gets 2% of the cost of a finished building which is equal to 4% of cost of prefabricated elements.



Perspective of assembled precast units and cross cut of inside wall.

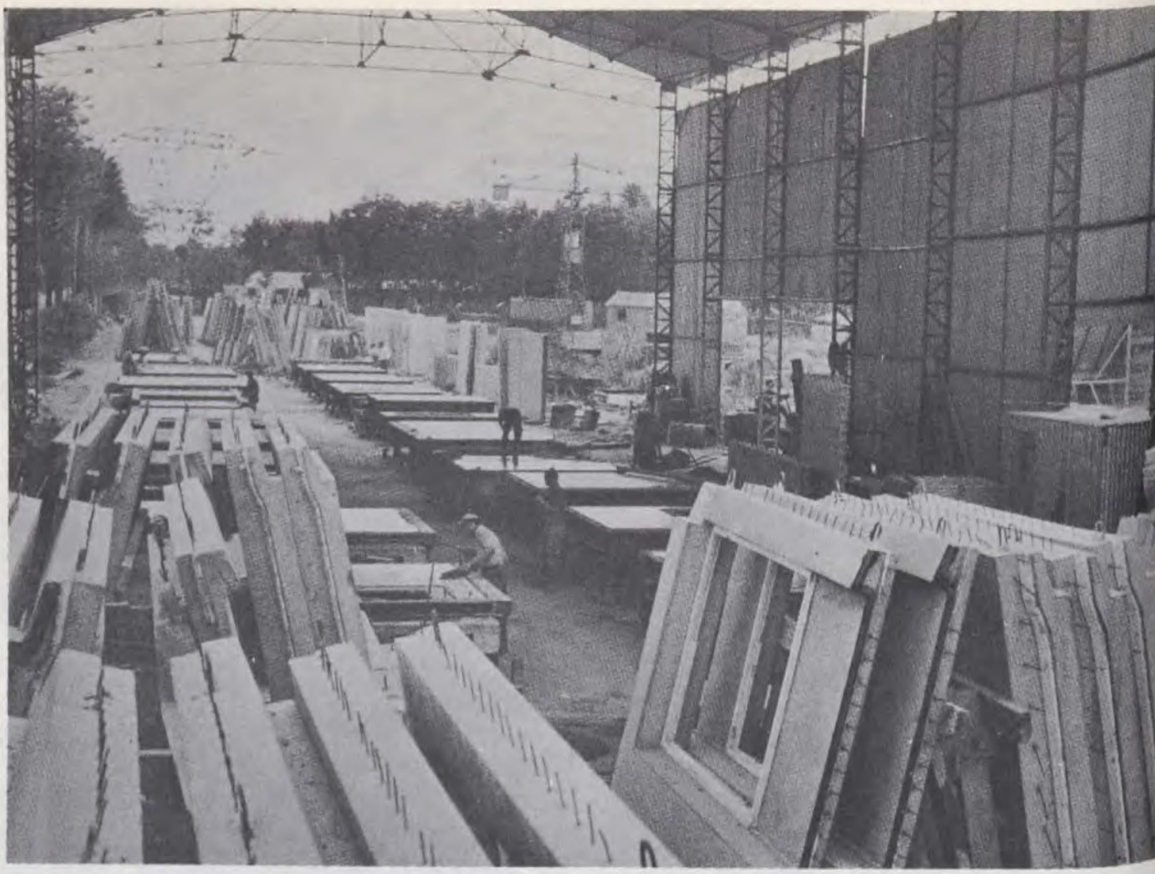


Cross cut of external wall.

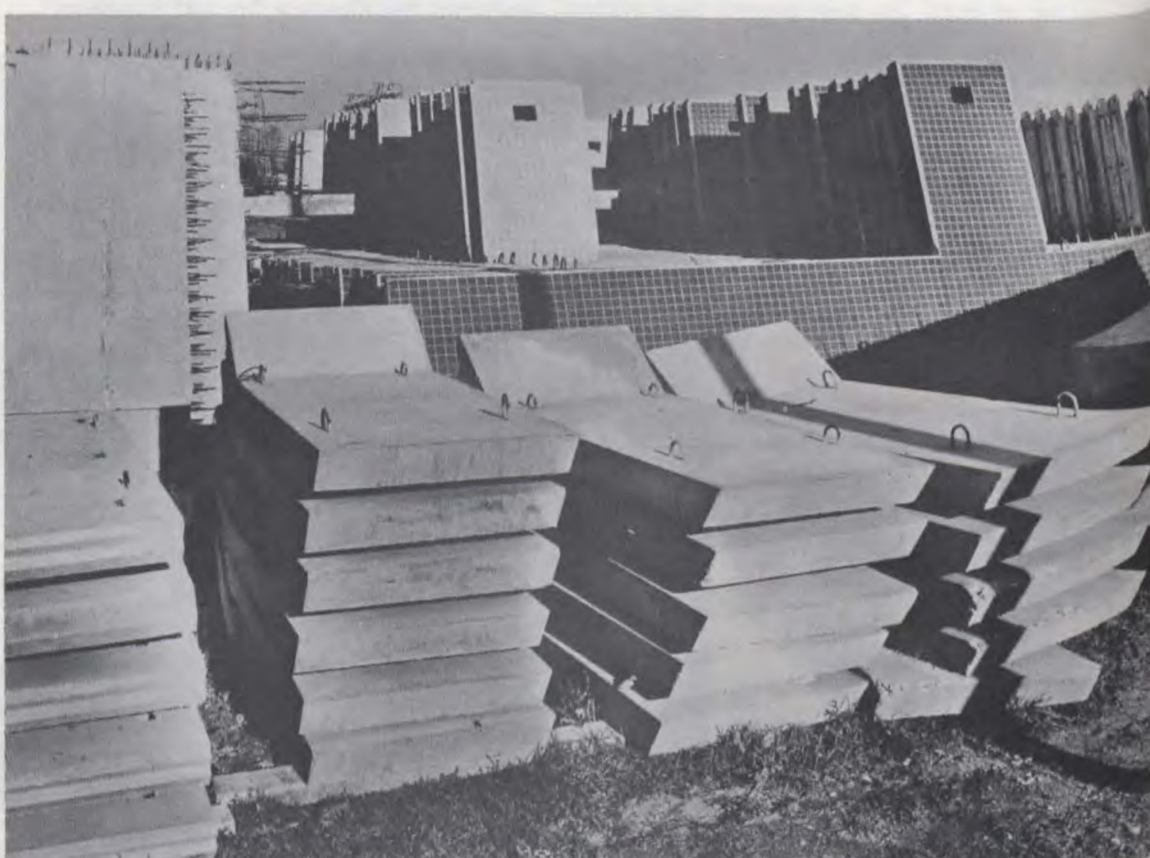


Precasting moulds.

Prefabricated unit being removed from mould.



Precasting factory with a capacity of one apartment per day at Thais near Paris.



Finished elements in storage area.

Meaux project (1860 low rent apartments)

2648 low rent apartment project at Vigneux. The highest building is 23 stories high.

2" x 2" ceramic tiles on façade panels.

CONSTRUCTION EDMOND COIGNET

THE COIGNET SYSTEM

Construction Edmond Coignet
11 avenue Myron T. Herrick
Paris 8e, France

THE COIGNET SYSTEM

The Coignet system is based on load-bearing external walls fitted with balconies with intermediate bearing walls.

The building components are produced by the most highly mechanized and complex process in Europe and involve a heavy investment in production facilities. The Mission visited the factory at Aulnai-sous-Bois.

In the Coignet system, buildings are divided into a given number of large structural units, each adaptable to a maximum number of uses, and cast separately in their final form.

The units, which are mass produced, are designed to be suitable for industrialized production. Their dimensions are as large as the permitted means of transport allow, and in this way the number of units per dwelling is reduced, as are the costs of manufacture, transport, and erection which are dependent on the number of operations to be carried out.

The units are manufactured mechanically to very exact dimensions and to their final state. Once placed in position, they form the finished building. The unit is placed exactly as it emerges from the factory; it will require no rendering, no drilling of holes, no connections, no masonry cladding - only horizontal jointing (longitudinal and transverse), and vertical jointing from top to bottom, to make the whole structure monolithic and give it the necessary stability. This jointing is carried out in, 'in situ' concrete, placed between the grooved edges of the panels, and is invisible both externally and internally; no formwork is necessary.

The units contain most of the necessary finishes: door and window frames, and ducting for all services - heating, electricity, flues, ventilation, and dust-chutes. They incorporate threaded metal fittings to which the majority of the household and sanitary equipment is eventually fixed.

Façades

The façades consist of storey-height panels, the length of one or more rooms; some panels, cast in one piece, are 7 m. long and weigh up to nine tons.

They consist of two leaves of concrete separated by a layer of expanded polystyrene, joined together by galvanized steel ties. When they act as curtain walling, the two leaves are each 4 cm. thick; when they act as a load-bearing wall the leaves generally have thicknesses of 19 cm. and 4 cm. In temperate climates the expanded polystyrene is 2 cm. thick; a load-bearing wall panel made up in this way has a thermal coefficient K equal to approximately

0.96 thermal units per square metre per hour per degree centigrade. In colder climates, the thickness of polystyrene is increased to 4 cm., which provides a coefficient K equal to 0.69.

In the side of each panel is a trapezoidal groove which, when placed against that in the adjacent panel, forms a closed channel in which the vertical jointing concrete is cast. The base of each panel has splayed rebates which form the horizontal joint, and two projections which enable the panels to be positioned automatically. The top is also rebated to correspond with the bottom of the panel above, and is profiled in such a way that when the floor panel is placed in position, it forms a channel in which the horizontal jointing is cast. There are four projecting steel rings, two for lifting and two for fixing during erection; all four help to provide wall-floor continuity.

The joinery, in either wood or metal, is cast in, as are the blind boxes and the various ducts. The external facing is machine-finished; it can consist of either a layer of facing concrete, using specially chosen aggregate exposed by sand-blasting, or smooth concrete ready for painting, or ceramic or glass mosaic or tiles. The internal finish is obtained with a mechanical float, which gives an absolutely smooth surface which can be painted directly.

Cappings

The substructure of the buildings is constructed on traditional lines and masonry walls, even when well built, have at the best a tolerance of about 1 cm. The superstructure must have a maximum tolerance of 1 mm. Precast concrete cappings are therefore used to join these very diverse elements. These are hollow units of small depth, having the same top and side profiles as the façade panels and a flat base. They are carefully positioned by wedging them on the masonry, in this way the whole superstructure can be erected with the necessary precision. The voids in the cappings are filled with concrete to provide continuity of support, while at the same time, longitudinal jointing at right angles to the first floor panel is provided.

Floor

The floors consist of reinforced concrete panels; one or more are used to cover the surface, but none are larger than 25 sq.m. Of solid reinforced concrete, and never less than 14 cm. thick, they form both the floor surface of one storey and the ceiling of the storey below. The floor is mechanically finished with parquet, tiling, granolithic, or simply smooth concrete ready to receive a plastic coating. The concrete ceiling is cast perfectly smooth, ready for painting. Most often, hot-water pipes are incorporated for floor heating. Reinforcements project from the edges of the floor panels to tie with the in situ jointing concrete.

Flat roofs

These are similar to the floors, but are cast with a slight fall (1 per cent). On the site, they are given a covering of insulating material, followed by a water-proofing layer of the independent multi-layer type, and finally a layer of chippings.

Internal walls

These are formed of concrete 14 cm. thick and storey height. The internal walls are cast sufficiently smooth to be painted direct. In the top edge is a V-shaped groove to take the in situ jointing concrete (transverse or longitudinal).

At the tops of the panels are projections for positioning, on which the panels above rest.

Partitions

The partition panels are cast storey height. On plan, their shape is varied - L-shaped, U-shaped, Z-shaped, according to their use. They are generally 6 cm. thick and reinforced with welded metal mesh.

Staircase

The staircase units include the flight and sometimes the landing; they have a tiled or granolithic finish or are simply given a plastic coating.

Flues and ventilation ducts

The flue and ventilation blocks are storey height. Designed on the unit system they include, in the case of the flues, an internal lining of asbestos-cement.

Equipment

The different types of units are cast in concrete, in steel moulds, specially designed to heat the concrete to approximately 80° C and to permit the units to be automatically removed when completed.

The mould is horizontal during manufacture of the unit. It pivots on its base up to the vertical to allow for de-moulding. This is carried out after hardening of the concrete, which takes place after two hours' heating.

All movements of the mould - i.e. lowering and raising the cover, opening the side walls, pivoting the upper walls, and pivoting the mould itself- are done by hydraulic jacks, worked by an electrical system which automatically ensures the sequence of operations by simple press-button action.

The units are removed by a gantry crane which transports them to a storage area where the curing and shrinkage are completed.

The moulds, which are made of machined steel, with a tolerance of manufacture of about 1 mm., are designed with the side walls removable, so that they can be used for different sized panels. Thus the same façade mould can produce units varying in length from 1 m. to 7 m.

The external frame supports are fixed by means of a magnetic system which enables them to be immediately removed, so that any frame system can be incorporated at a moment's notice.

This makes it possible to construct buildings of different types. However, it must not be forgotten that the whole interest of these industrialized systems lies in mass production, and their advantages increase with the number of identical units that can be made.

The machines are provided with all necessary equipment for the exact placing of the various services.

Factories

The factories for the manufacture of dwellings, which contain this machinery, comprise a central mixing plant, with silos for aggregates and cement, hoists, pneumatic transport, weigh-batchers, mixers, etc.; a control cabin, managed by one operator, which automatically controls all the handling of material, the batching of the concrete, its manufacture, and its distribution to the moulds; a storage area for storing the completed units, which is served by the same gantry cranes as the manufacturing area; a reinforcement workshop, where reinforcing steel is cut and bent; machinery for preparing the joinery, polystyrene sheets, tiles, etc.

Erection

Erection of the units is carried out by means of a tower crane with a capacity of 140 T/m.

A precisely calculated working time table determines the make-up, the order, and the time of arrival of the trailers. The units are removed from them by the crane, and placed directly in their final position.

The foundations of the building are constructed by traditional methods, depending on the nature of the soil. On these foundations, an exactly levelled seating is established by means of cappings, on which erection proceeds quickly and easily, without any subsequent measuring or levelling. The very small tolerances in the dimensions of the units enable them to be exactly positioned as they arrive on the site.

During erection, the vertical panels are held in position by means of a system of adjustable telescopic struts, which form a protective parapet and are attached to the floor by anchorages incorporated in the slab during manufacture.

All these erection details are equally applicable to the construction of single- or two-storey houses and to twenty-storey blocks of flats.

Finishing work

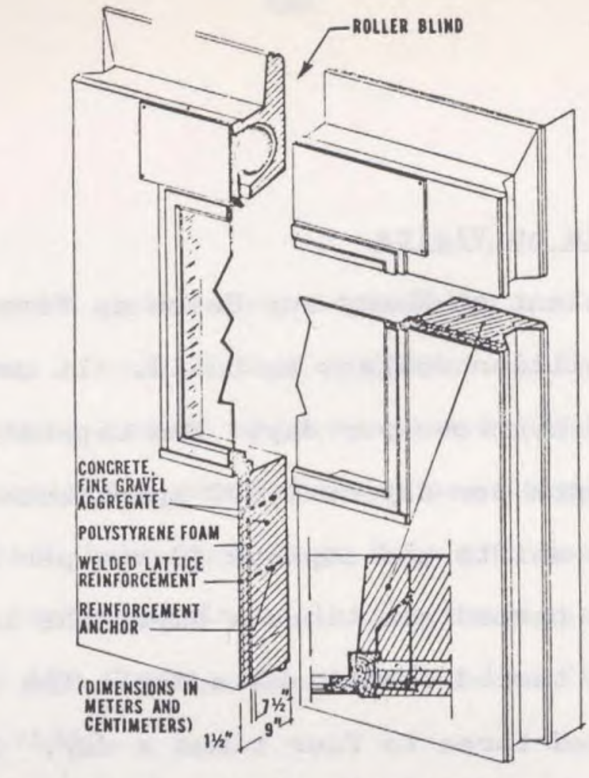
Important gains in productivity are obtained in the finishing trades. Most of the equipment is incorporated during manufacture, and it only remains to place the floor covering (if required), complete the painting, and connect up the services which have been cast into the concrete.

The electrical installation consists of inserting the wiring into the ducts, and screwing the fittings into the sockets provided.

The installation of household and sanitary equipment is reduced to screws and nuts. Thanks to the precision of the building units, placing a piece of equipment requires no measurement or previous preparation, cutting, shaping, welding, or packing.

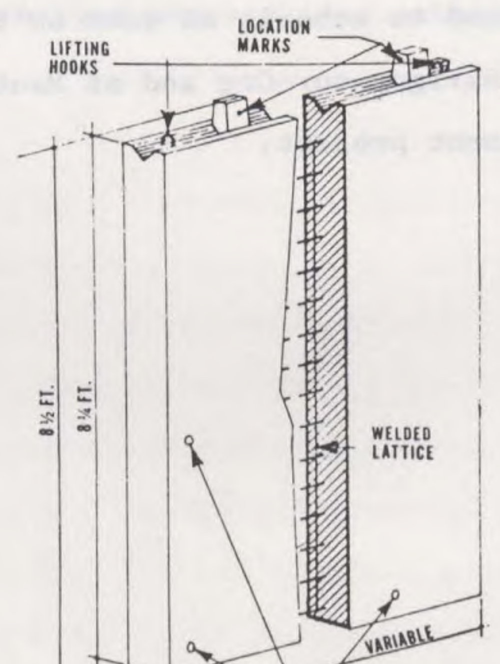
General Comments on Visits

The plant at Rosny-sur-Seine is five-years old and cost over one million dollars to build. It uses approximately 250 cu. yds. of concrete per day. The capacity of the plant is four apartments per day or 1,000 apartments per annum. It operates on two shifts and employs 40 men per shift. The floor mould is turned six times a day. The interior partition moulds are turned five times a day. The exterior panel moulds are turned three to four times a day. It obtains a concrete strength of 3,500 psi. The largest element weighs ten tons and the largest floor slab measures about 15 feet by 20 feet. The system adapts itself to multi-storey apartment buildings and to schools as seen on the projects visited at Champaigny, Savigny-sur-Org and at Mantes la Jolie with its 7,000 apartment project.



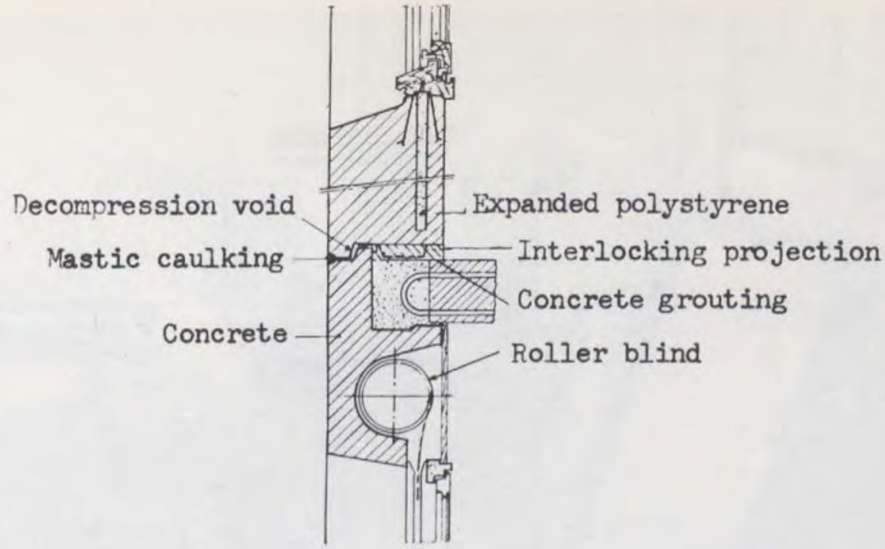
Typical facade panel (not to scale) made by Coignet

Typical façade panel.

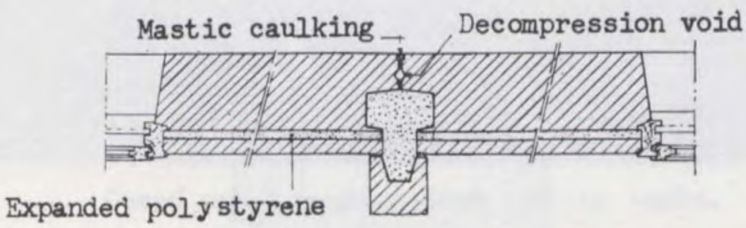


Partition wall element

Partition wall element.

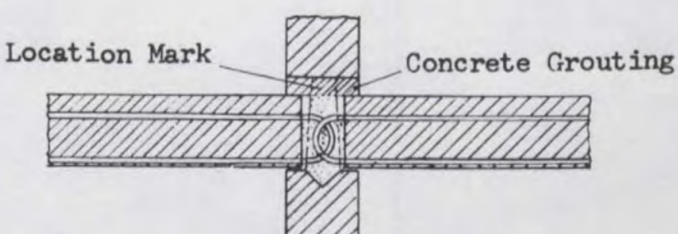


Vertical section through façade wall.

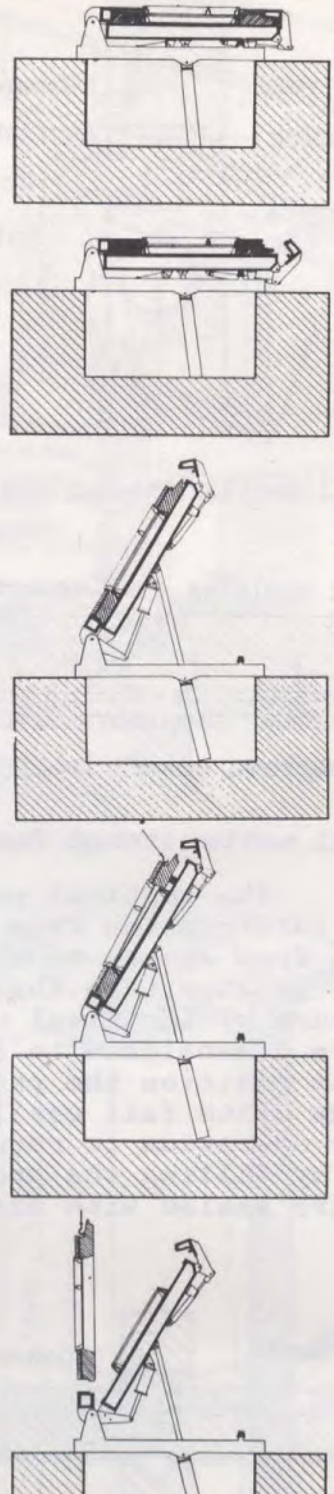


Horizontal section through façade wall.

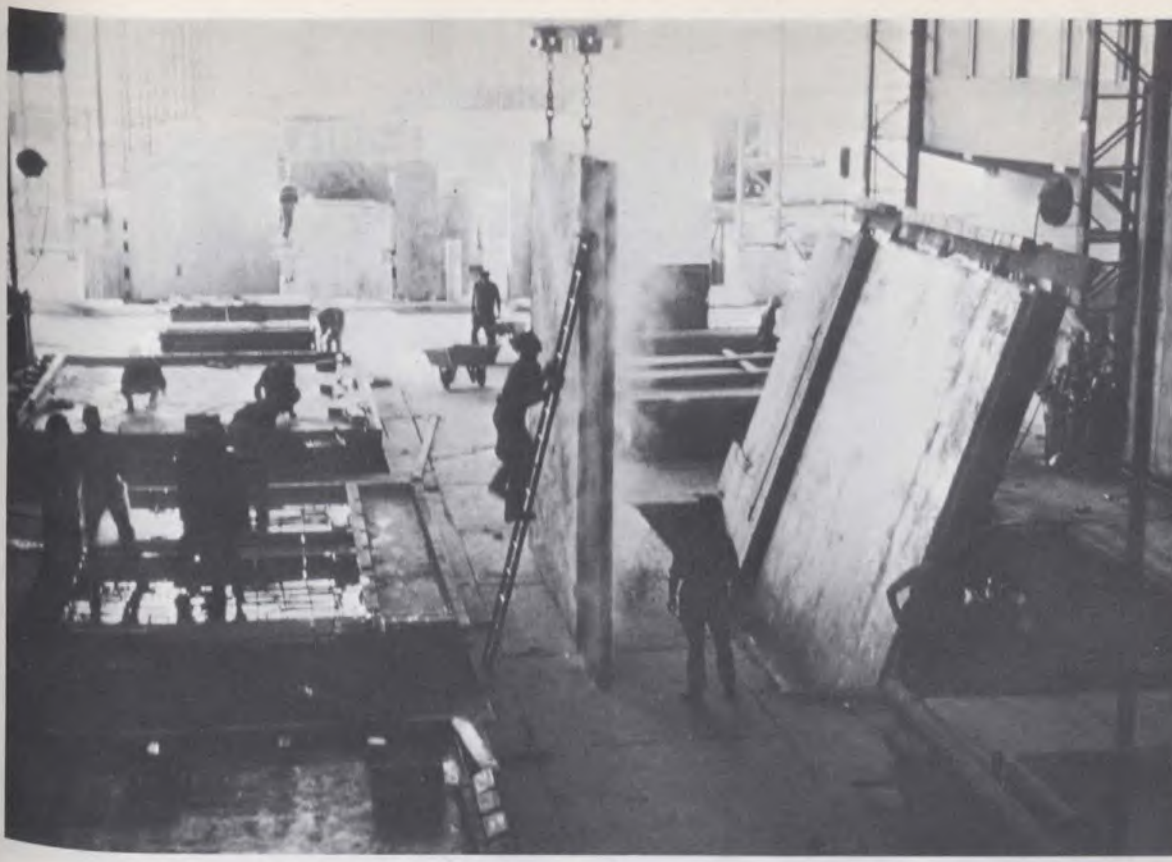
The vertical panels rest one on top of the other without interruption from the floor slab - the only movement is thus from storey to storey - and this movement is, moreover, no greater than that arising from the tolerance of manufacture of identical units, cast in the same moulds, which are dimensioned to a millimetre. The interlocking projections position the panel, on plan, with an accuracy of 1 mm. The units fall easily and precisely into place, and no further operation is required. The vertical jointing is effected by filling the grooves with concrete. The external joints are sealed with mastic to ensure watertightness.



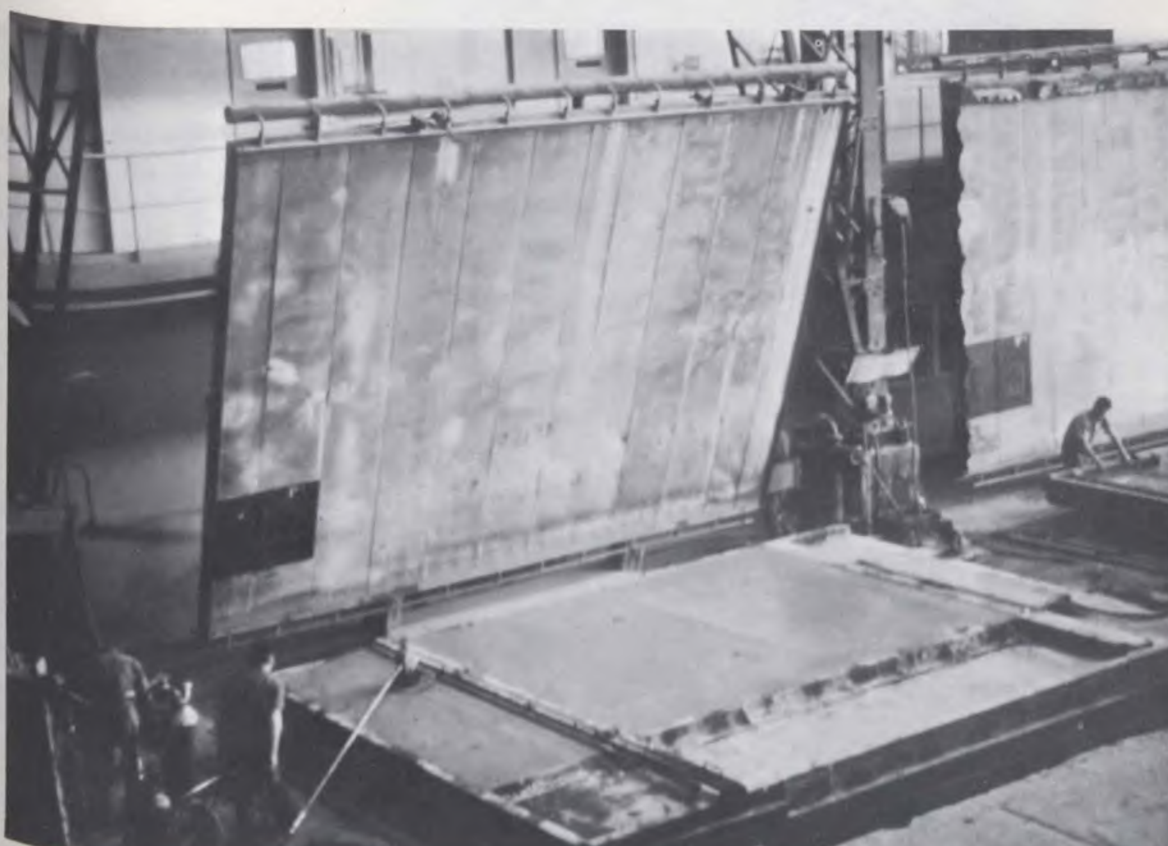
Vertical section through cross wall. The super-imposed units are trued one on the other in the same way, with the same small tolerance, by means of positioning nibs cast in the panels during manufacture, and which support the upper unit until it is made load-bearing by the in situ concrete filling.



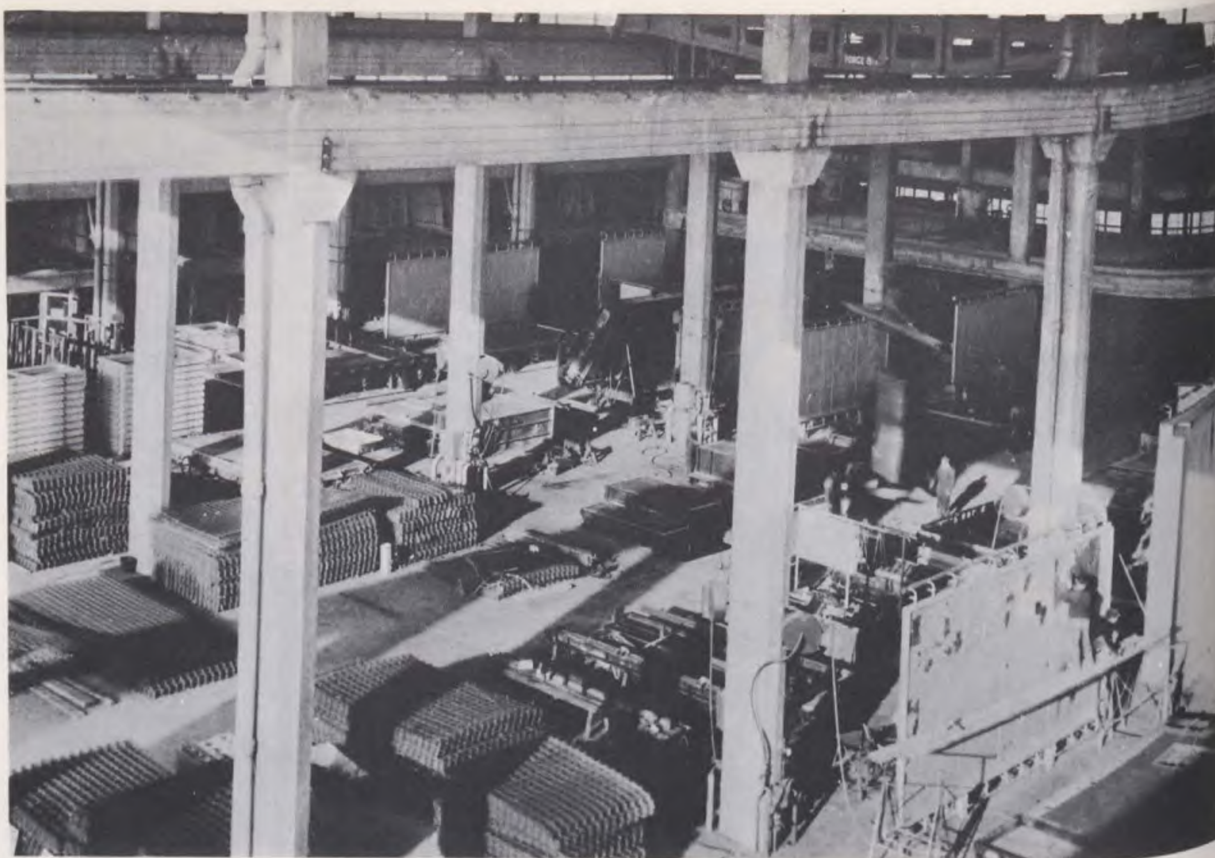
Stages in casting a Coignet wall unit.



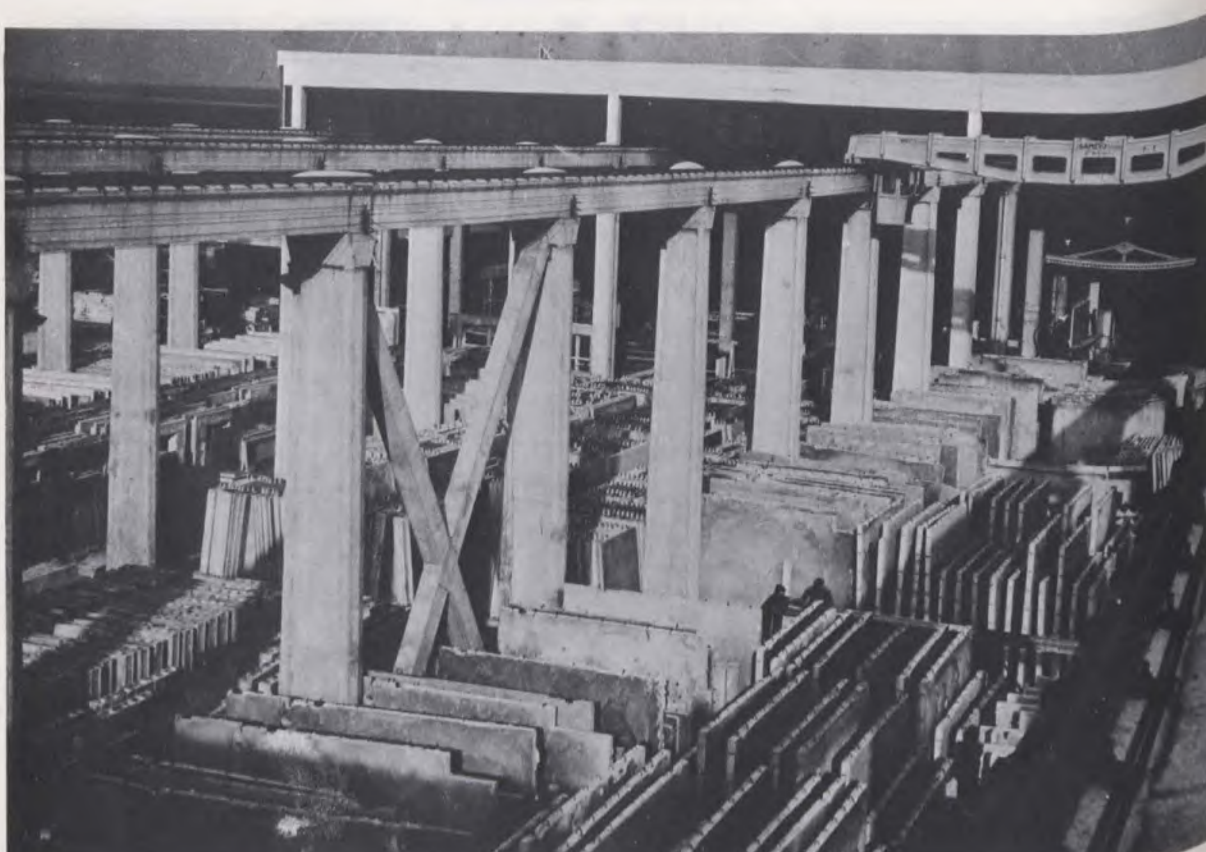
Cured panel removed from casting table.



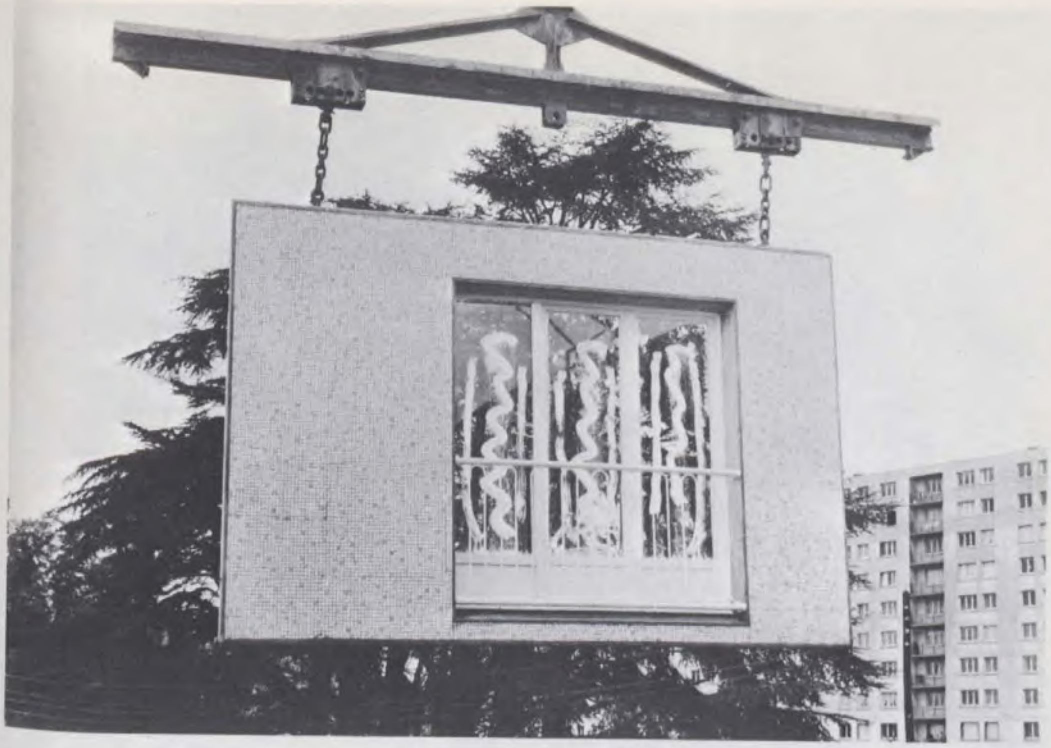
Casting table with hood lifted.



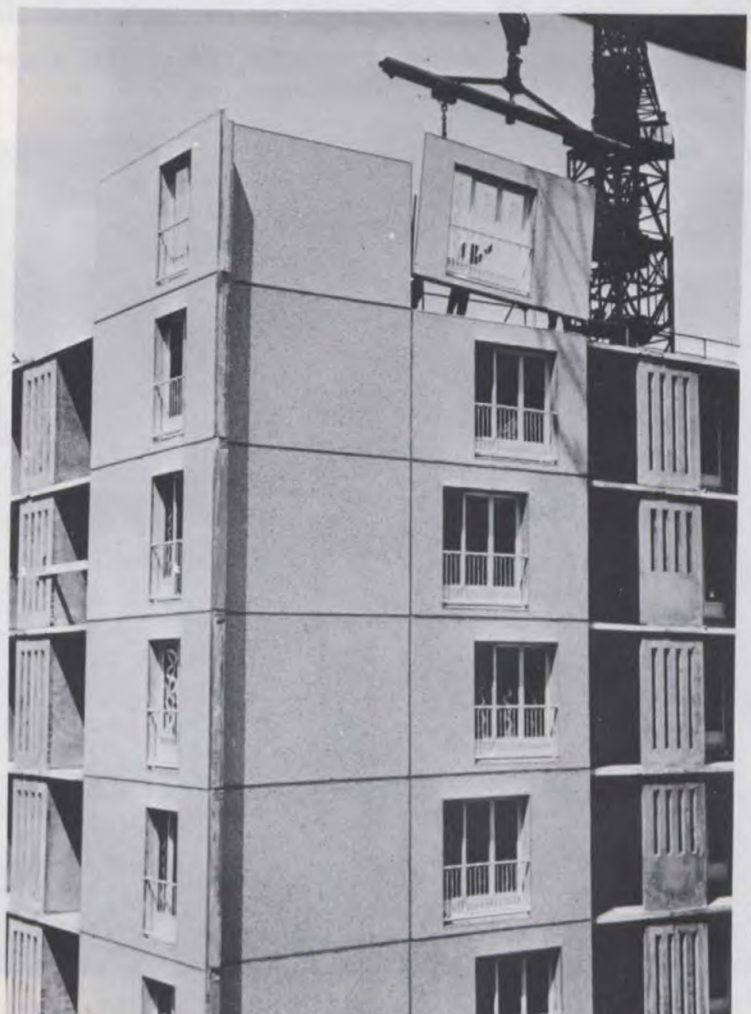
Inside view of factory.



Storage area.



Façade panel.



Assembly of element.

Savigny-sur-Orge project - 900 apartments.

Blanc-Mesnil project - 1016 apartments.

Large project under construction near Paris.

Low rent apartment building - high quality concrete panels.

21 storey low rent apartment.

SOCIÉTÉ RAYMOND CAMUS & CIE

THE CAMUS SYSTEM

Société Raymond Camus & Cie
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CAMUS SYSTEM

The Camus system was first developed and patented in 1949. For the first three years temporary factories were employed to perfect techniques. Since 1952 the number of Camus factories has steadily increased and today a total of over 100,000 dwellings have been erected in various countries throughout the world. Many of these factories are jointly owned by Camus and contractors or industrialists.

A total of 22,000 dwellings are produced annually by Camus factories now in operation. From this total 7,000 are from factories which are Camus subsidiaries and 15,000 from factories producing under licence arrangements. The value of work carried out is in excess of $150,000,000 per annum.

The Camus company is the pioneer of the industrialization of building by the factory production of large concrete panels incorporating the majority of the elements for the building. With the Camus system, thermal insulation, tiling, doors, windows, ducts and flues, etc., are incorporated into the units during the factory process. The units are finished to such an extent that little more is required on site than the mounting and connection of these units, only approximately 25 of which are required to make one complete dwelling.

The advantages of the systems are:

(a) A very high proportion of the work is carried out in the factory where it is easier to organize and supervise efficiently.

(b) Continual employment of the labour force as opposed to the floating labour force of the conventional building industry. The fact that operations can be exactly sequenced in the factory results in higher productivity.

(c) The elimination of the waiting time of one trade upon another.

(d) Lost time due to unfavourable weather is almost completely eliminated.

(e) Less wastage of materials.

(f) Fuller utilization of the plant.

(g) Better social conditions for the labour force.

All these advantages result in higher productivity per man hours worked and the time taken for completion of dwellings is reduced by at least half.

The Camus system has been designed to give the maximum degree of flexibility to architects not only in the variety of plastic expression but also in the range of external finishes that are possible. The different types of dwelling units which have been constructed in the system include: single storey patio types, two storey houses, and blocks of flats from 3 storeys to 23 storeys in height.

The essential basis of the Camus system is the transfer of the maximum amount of the work usually carried out on site to the more congenial and sheltered atmosphere of the factory, where it can be more carefully controlled and organized to produce both better standards in terms of finished results, and greater productivity with less wastage of materials and man-hours.

The system consists of the manufacture of large room-size panels made of precast concrete in the factory and incorporating the majority of the building components. Doors, windows, thermal insulation, internal and external finishes, services, ducts, ventilation flues, holes and conduit runs, for various services, are all cast into the units at the factory. Public staircases of open riser or solid riser design together with landings are also produced in the factory, complete with a wide variety of surface finishes such as tiles, granolithic, mosaic and including all holes for fixing handrails, guardrails, etc.

Units are manufactured to the largest possible size, compatible with the limitations of transportation and site erection equipment. Floor panels, for example, 270 sq. ft. in area, are cast in one piece. External wall panel partitions and internal load-bearing walls are cast in storey height panels with maximum lengths of twenty one feet.

Factory design is based upon a careful survey of the economic and social conditions of the country in which it will operate, the number of dwelling units it will be required to produce per year and the variety of dwelling types it will have to produce. Furthermore, the degree of mechanization incorporated, must be directly related to the labour conditions and the wage rates prevailing in the country concerned if the maximum overall economy is to be achieved. Different circumstances therefore, demand different factory solutions and, consequently, no standard factory layout is used with the Camus system.

The Mission visited the factory at Montesson on the northern outskirts of Paris. This factory has an output of 2,000 dwellings per annum and has produced a total of 25,000 dwellings in and around Paris since it was completed in 1956. It is capable of producing five entirely different types of dwellings at the same time.

In this factory the central mixer plant is located at one end of the axis way running through the factory. Casting bays alternating with workshops and stores are arranged symmetrically on either side. The stores and workshops have an additional floor overhead connected by galleries running over the central axis way. On this upper storey, the reinforcement is manufactured. For panels which require several concrete mixes or are of a complex nature, such as external wall panels, horizontal casting tables are used. Each casting bay has four or five of these horizontal tables manned by a team of six operators.

To reduce capital costs, casting tables at the Montesson factory are of simple design and since this factory has to produce a wide variety of types with very frequent changes of design, moulds have been designed to enable them to be easily adjusted. The tables can produce units of up to 22' long and 10' wide. The horizontal casting tables are served with concrete from the central mixing plant by hopper trolleys.

Except in the case of exposed aggregate external finishes, panels are cast face down. Where square tile finish is used, it is laid on the face of thé table. These tiles are attached by water soluble glue to brown paper sheets which are subsequently washed off in the temporary stock yard. After the tiles have been laid, they are covered with a thin layer of mortar. For exposed aggregate facing, panels are cast face up.

A layer of concrete is then poured over the tiles and a light reinforcement mat is laid and covered with concrete to form the outer leaf of the external wall unit.

The polystyrene insulation is next laid on this outer leaf, followed by further concrete and reinforcement to form the inner leaf of the sandwich construction.

The reinforcements of the inner and outer leaves are tied together during the casting process to make a monolithic construction and doors and other components are incorporated at the appropriate stage.

A mechanically operated float is used to make the surface of the panels smooth requiring no plastering on site.

At the Montesson factory, curing is carried out by placing an insulated hood over the mould by means of the overhead travelling crane with which each casting bay is equipped. Both the hoods and the casting tables have heating coils incorporated.

By the time the casting team has completed the casting of the four to five panels in the working bay, the curing of the first panel is completed and the demoulding cycle can proceed.

This consists of removing the curing hood turning the table to the vertical position and then lifting the panel clear with the overhead crane and taking it out to the external temporary stocking yard.

When the panels have thoroughly cooled the paper is soaked and stripped from the tile or mosaic facing. The panels are inspected and approved for transfer to the stock yard, to await delivery to the site.

Panels which are not of multiple layer construction are cast in vertical battery moulds producing up to 12 units at a time. Partitions, for example, complete with electrical conduit runs, socket outlet boxes, and door frames are cast in this way.

Battery moulds are filled with concrete by forced feed pipes, direct from the central mixing plant. Heat curing is again employed, but since heat is produced naturally by the mass of concrete during its nitial set, this is only applied to the periphery of the battery in order to maintain an even rate of curing between panels on the outside and those in the middle of the battery.

For those units for which they can be used, battery moulds save valuable factory floor space and also effect considerable savings in mould and labour costs.

<u>Planning and Control</u>

During the planning stage, a punch card record is produced for each panel recording all the relevant information for that panel:

The type and code number of the panel, the number of the casting bay in which it will be cast, the date on which it will be cast, the position it will occupy in the building, the number of the transport vehicle which will take it to the site and its order of loading on the transport vehicle.

The punch cards are subsequently fed through an electronic computer to produce transportation production, and erection schedules. The computer is also used to calculate costs, carry out work studies, etc.

By providing precise information on site requirements, it allows the transportation vehicle to be loaded with the panels placed exactly in the order required for unloading. They can then be lifted directly from the vehicle into their final place in the building. Similarly the arrival of the vehicle on site is timed to coincide with the completion of the unloading of the previous vehicle. In this way, waiting time of the vehicle is obviated.

The vehicles and trailers used for transportation are capable of taking loads up to 20 tons. The vehicle does not remain on site while the panels in the trailer are being unloaded and placed in position, but picks up the empty trailer and returns to the factory for a further load.

Erection of panels

Work on-site consists of two parts, the erection of the units and the work required to complete the dwellings for occupation. The erection of the panel units consists of lifting them into place by crane and placing them either on to mortar beds or on to spot bearers, depending on the height of the building being constructed. After checking for alignment and verticality, panel units are then held in position temporarily by specially designed adjustable props. These are connected either to female threads or holes incorporated in the panels during manufacture. The reinforcement left projecting from the panels during manufacture is then bonded and the joints poured with concrete and compacted by poker vibration. The site erection schedule is planned to allow time for these joints to set thoroughly before the work on the next floor begins.

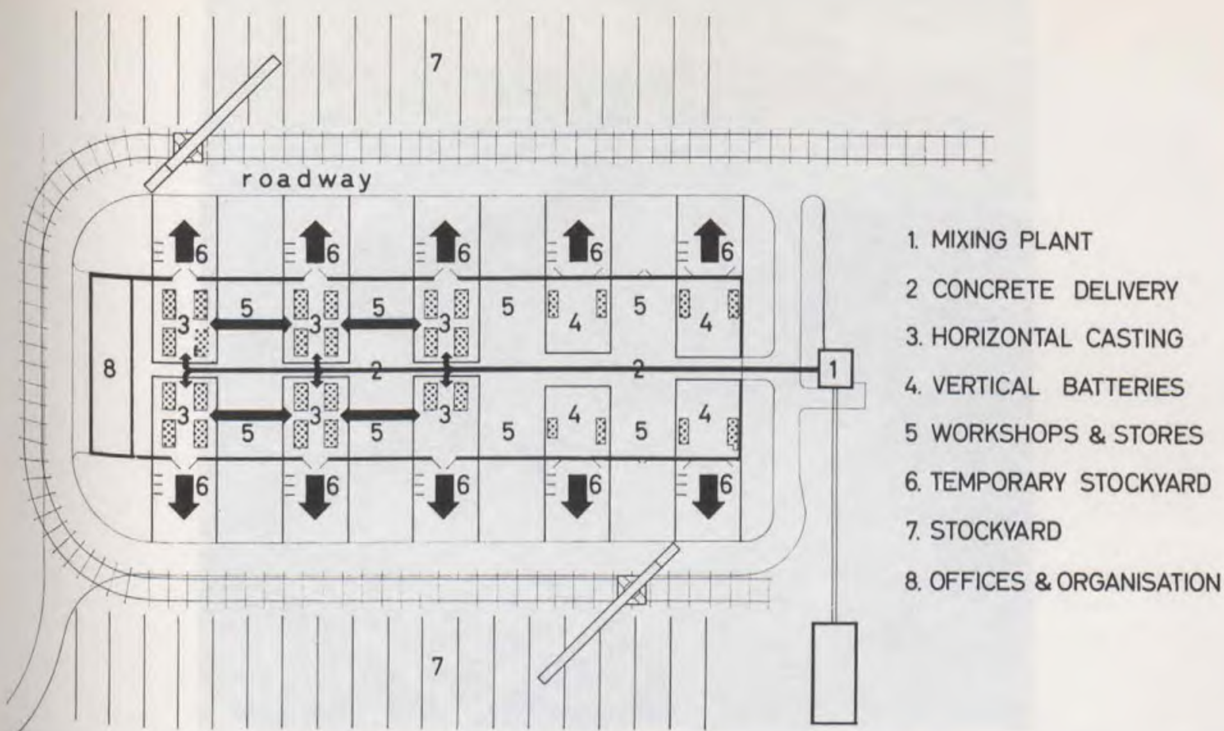
General Comments

1. The Raymond Camus et Compagnie organization is the oldest in its field of industrialized building.
2. The system provides one of the best connections between elements whether cross walls, floor slabs or outside panels.
3. The Camus Research Centre (Centre de Recherches pour le développement de l'Industrialisation de la Construction C.R.I.C.) carries out research into all the aspects of industrialized building, such as weathering, strength, quality, material testing, cost analysis, etc. It is concerned not only with the technical aspect of building but also with the methods of production and of increasing productivity in the factory and on the construction site.
4. The Mission visited the SHAPE housing project built on the outskirts of Paris in 1951 to house Allied Forces Headquarters. The panels have large exposed aggregate, show very little deterioration, and the architecture of the building is still quite acceptable today.
5. The Mission visited the Grand Jardin project, where a Travertine marble was used on façade panels. This project is considered to be a luxury apartment project and it showed that more expensive buildings can also

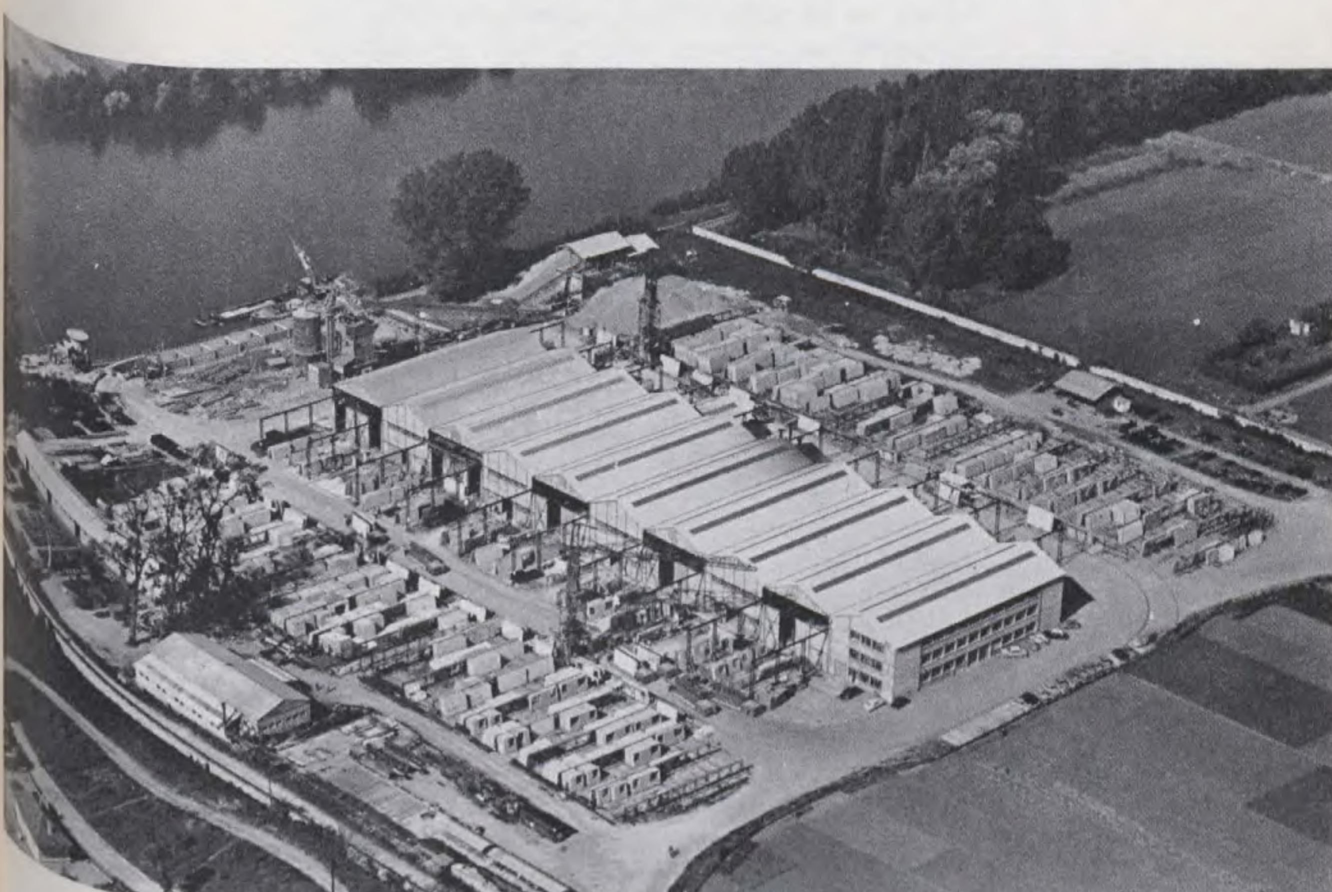
be factory produced. The buildings were of very high quality and the layout of the apartments was excellent.

6. The Mission also visited the Grand Village project, a very attractive housing project composed of individual homes and row housing. The type of construction would be acceptable to Canadians.

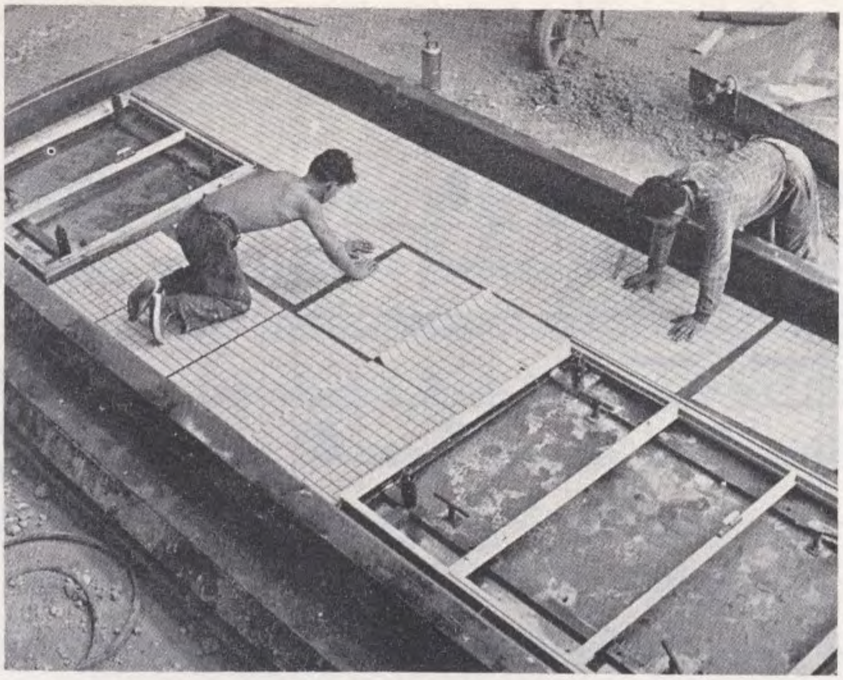
7. The franchise to manufacture in Canada under the Camus system is available. Conditions would have to be discussed with officers of the organization.



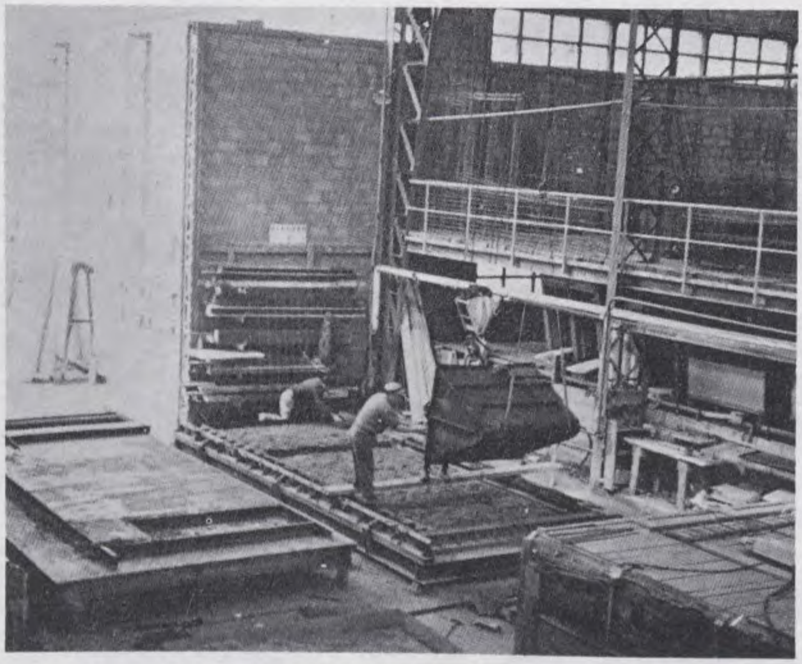
Plan of factory at Montesson near Paris.



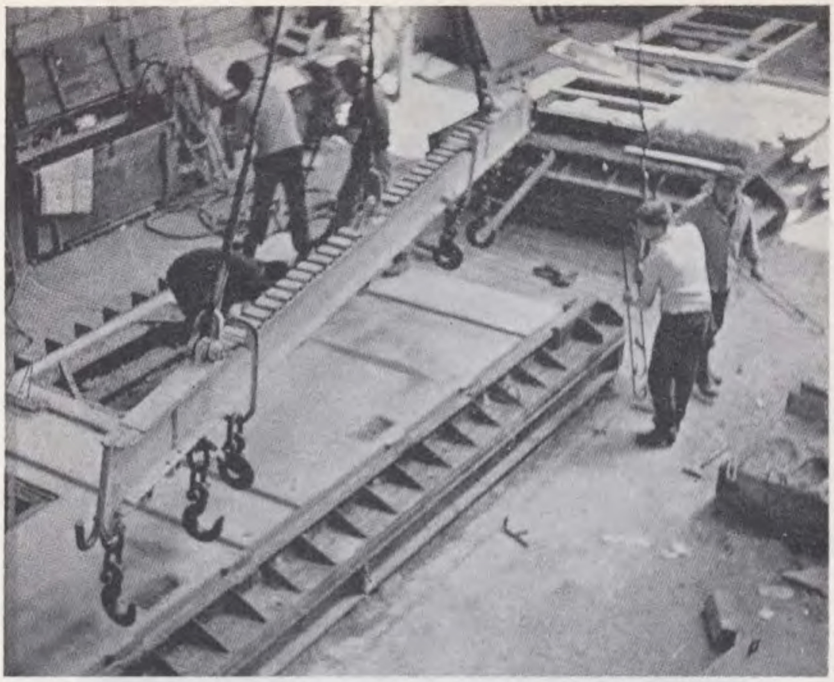
Aerial view of factory.



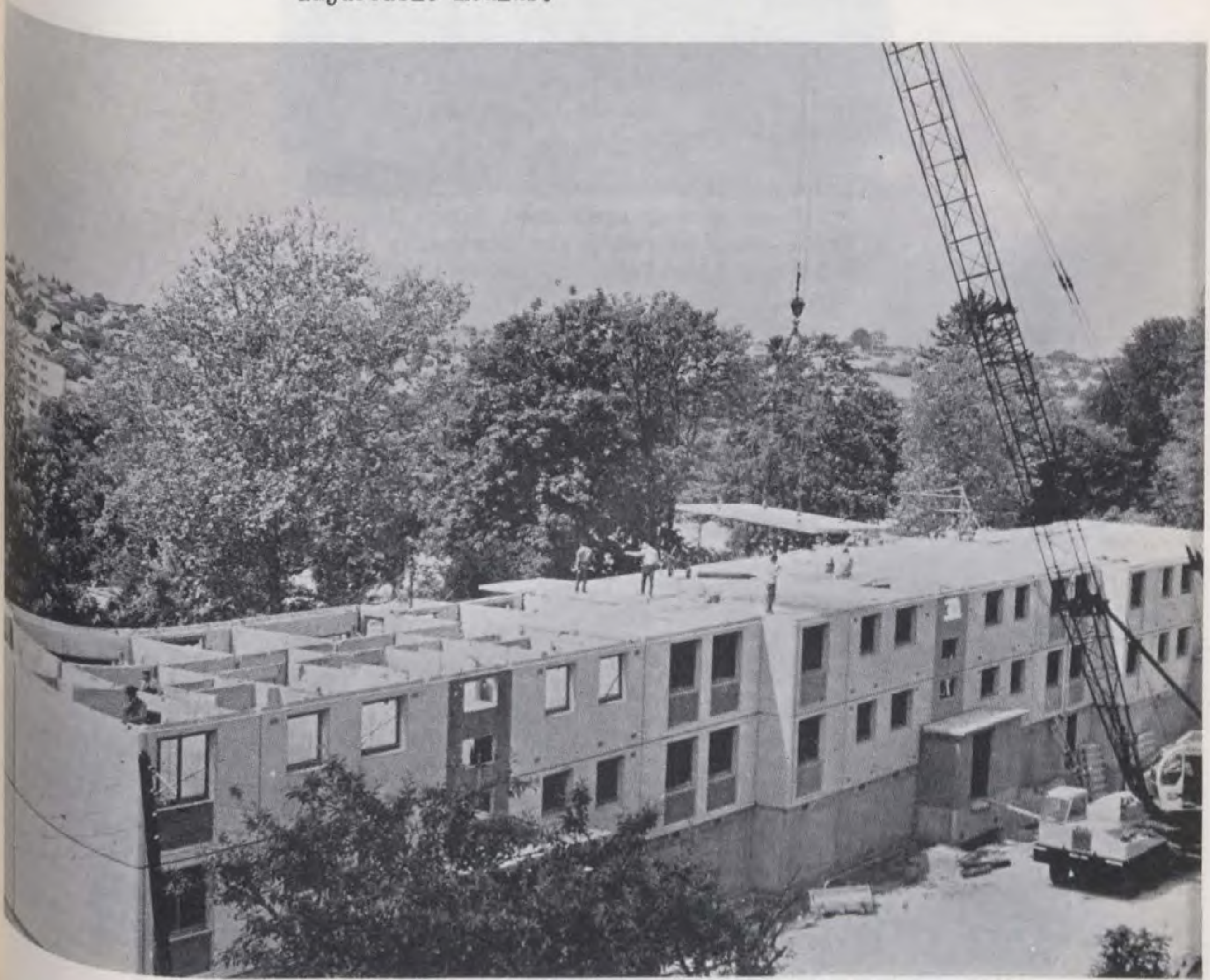
Workmen applying exterior finish. Many alternative external finishes are used such as ceramic tiles, glass mosaics, exposed aggregate, stone, etc. Moulds are designed to be adjustable.



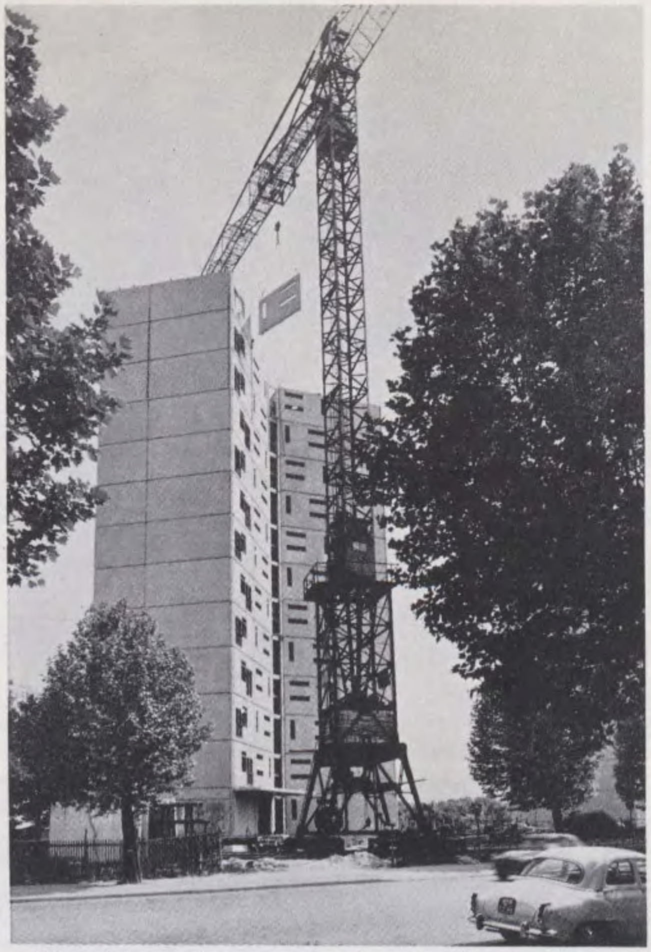
Mechanical vibration ensures good quality concrete. The surface of the panel is of such high standard that plastering is eliminated. Heat accelerates the curing of concrete and the turnover of the moulds.



Panels of any size can be designed on the adjustable moulds.



Elements being placed in position.



Thirteen storey apartment block in Paris erected ready for occupancy in half the time taken by conventional methods.

SHAPE HQ near Paris - built 20 years ago. The quality and condition of the building is still excellent.

16 storey low rent apartment building in Paris.

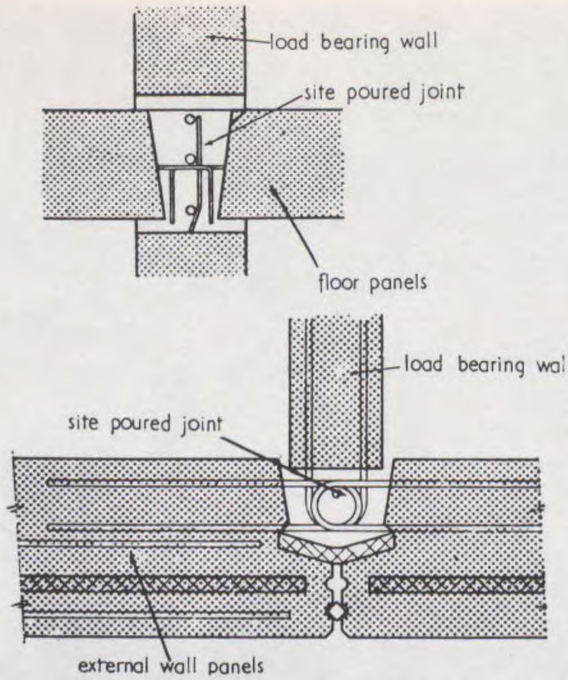
Medium rent apartment project.

Luxury apartment near Paris. Travertine was used as facing material on panels.

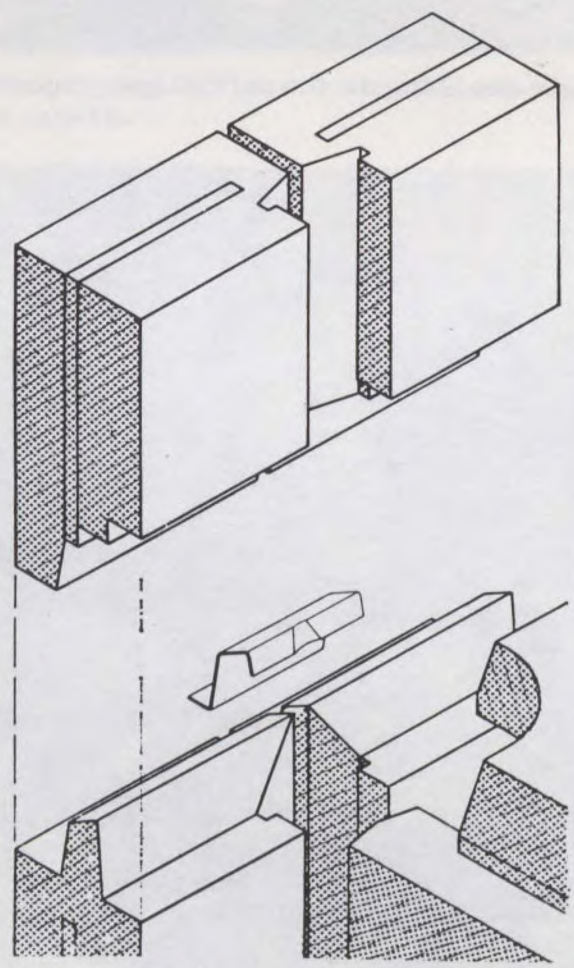
Medium rent apartment near Paris. Facing material used was Travertine and Slate.

Single dwelling in Grand Village project.

Single dwellings and row housing in Grand Village project.



Junction between floor and load bearing walls and façade detail.



Isometric view of the junction of the horizontal and vertical joints on the façade.

LES ENTREPRISES

BALENCY & SCHUHL

Les Entreprises Balency & Schuhl
14 rue Etex
Paris 18e, France

BALENCY & SCHUHL - PARIS

Principle and Origin

In the field of prefabrication, Balency & Schuhl have developed novel and original methods since their first major projects in 1949. At the present time they produce large structural units, made chiefly of concrete and therefore heavy. The number of man-hours involved in the construction of one flat, starting from the raw materials (sand, gravel, cement) has been reduced from 1800 hours to 950 hours.

The original features of the Balency & Schuhl processes are the following:

a) Functional units.

In a single operation they can mould highly complex "functional units" which have the advantage of being adaptable to different architectural designs. The functional unit contains air inlets, ventilation ducts, flues, waste stacks and services for five storeys. It contains all services: hot and cold water, waste discharge, electricity, gas, and all the necessary fastenings and attachments for installing the equipment. The integrated construction requires special techniques which have been developed.

The units are of shell-type construction, their thin walls can however support the floors.

When installed on a completed floor, they possess a stability which is favourable to erection.

They can produce a range of functional units, kitchen unit, bathroom unit, services unit, wall-cupboard unit, smoke flue unit and vertical ducts.

Because of this distinctive feature, they have called their system the "system with load-bearing functional units".

These units require highly complex moulds, especially if they are mechanized. In principle, architects must adopt such units unchanged in their design, unless the numbers of units required are so large as to warrant making special moulds.

The shell-type functional units have the advantage of solving many problems which in traditional construction involve a number of operations. Because of the accuracy of their production, the equipment and fittings can be prefabricated and installed quite simply.

b) Panels

Once the functional units have been incorporated into the architects' plans, the rest of the structure is composed of simple and essentially flat panels, just as in most other "heavy" prefabricated construction systems.

For these panels, Balency & Schuhl have concentrated on mechanizing the casting procedure. Use of extensible moulds enables them to vary the length to any required dimension (the height, which is the storey height of the building, is constant).

Façade panels form virtual curtain walls but still contain their load-bearing capacity.

These are sandwich panels provided with an intermediate insulating layer. The windows, with their glazing and external fastenings, form an integral part of the panels and are generally installed at the time of manufacture. The surface treatment, which determines the appearance of the façades, is very important.

Many surface finishes are available, which vary in cost and may be incorporated at the bottom of the mould or in the surface of the concrete: reconstituted stone; sand-blasted finish; scrubbed finish; ceramic or glass mosaic, etc.

The surface can be finished with either recessed or raised patterns.

Dividing walls are 15cm-20cm thick and sometimes have an insulating middle layer to ensure good thermal properties. Partition panels are 8cm-12cm thick.

All panels, partitions, and functional units are made of concrete and support the floors. There is no dead load from non-structural components. All the vertical elements are used to carry the load. The material is used logically, and floor spans are reduced to a minimum. They have developed a system of special door and window frames which are incorporated directly in the units at the time of manufacture. All the vertical panels contain ducts and special cavities for the installation of electrical equipment.

c) Stairs.

These are cast in special moulds. They are cast flight by flight by a technique which has now come into general use.

d) Floors.

Although relatively simple to prefabricate, floors are still constructed in situ in most cases, using precut special formwork for the following reasons:

(a) The solid-slab floor, concreted in situ, presents no difficulties and distributes its loading equally over all the walls, and partitions. There is no need for joints which are difficult to caulk properly, and the floor bears evenly on the supporting units.

(b) There is a saving in steel.

(c) It takes up and compensates for the tolerances in the erection of the vertical units.

(d) It provides excellent bracing and eliminates subsequent jointing.

(e) The various pipes and conduits -- heating, electricity and even gas -- can be installed without complicated joining and sealing at the joints.

(f) It avoids the need for transporting and installing structural units which are generally the heaviest and most bulky ones to handle and erect, which determine the capacity of the erecting crane, and which though they have to be transported in the vertical position, are laid horizontally.

(g) It can easily be adapted to variations in the shape and area of rooms in buildings constructed from their range of vertical units.

When large numbers are involved, as in the case of individual houses, they use prefabricated floors, but only under very special conditions.

Façades and their Possibilities

The concrete curtain wall can be combined with the lightweight curtain wall. This is a matter of cost and user's convenience.

The system can also be used for blocks comprising ten or more storeys, for the more conventional five-storey blocks or for detached houses.

Considerable freedom of architectural design and treatment is provided by the adjustable moulds and by the range of ready made moulds kept in stock.

They sometimes supply "exclusive" units not catered for by their range of standard moulds. These cost more than their multi-purpose units, but they can give a more pronounced individuality to the façades.

MANUFACTURING PLANT

a) Factories for large series of units

It is quite easy to set up a factory in an area of high-density residential building giving an outlet for considerable annual output, e.g., 1000 flats per year within a radius of about 50 km.

Under such conditions extremely high productivity can be attained, and it is easy to design a factory embodying a high degree of mechanisation and, indeed, automation. Their licensees at Balency - MBM of Milan is an example.

Production is planned on a "flow" basis, using the assembly-line principle, with highly specialized operations carried out at the successive working stations.

The total capital outlay, including transportation and erection equipment, is in the region of two million dollars and the number of man-hours per flat is cut down to 800.

However, a program of continuous construction on so large a scale cannot always be guaranteed by the authorities concerned.

b) Factories for small series (semi-mobile factories).

The scope for factories designed to turn out large series of units is still fairly limited, considering the market conditions. The contractors must adjust to the situation by adopting more modest workable conditions.

It was in this spirit that the plant at Villeneuve le Roi was established:

(a) Capital outlay was reduced to an extent that brought it within reach of the normal financial resources of the firm.

(b) Maximum use is made of conventional contractors plant.

(c) The installations can, without involving excessive cost, be transferred from one location to another.

(d) The factory is suitable for producing small series of units.

Handling operations both in the factory and on site can be carried out with tower cranes with capacities of 50-75 ton-metres (load X radius), which are now in common use among building contractors.

Manufacture is done in a plant of light construction which requires quite simple foundations. The structure has a sliding roof.

Two 70 ton-metre cranes travel on a track alongside the building. The cranes are used for removing the completed components from the building (through the opened roof) and for depositing them and subsequently reclaiming them, from a storage area, parallel to the production plant.

In comparison with the overhead travelling crane or the longitudinal monorail, this method of handling has the advantage of eliminating dangerous movement of the components over the working stations.

Before the components are placed in the storage yard, they are taken to a checking area, inspected and, if necessary, touched up. It is essential that structural units delivered at the construction site be in perfect condition.

From the automatic concrete batching plant the concrete is distributed by means of fork-lift trucks.

Methods of curing include superheated water produced by a central heating plant or automatically controlled electric curing, so that a daily output of between two and four components per mould can be attained.

They feel that outputs should not be too small. Otherwise even the smallest concreting installations and handling facilities would be poorly utilized. An output of at least 60 m^3/day is needed to justify a high-productivity concreting plant.

A good rate of production would be two flats per day with single-shift working. The output can be increased to three flats per day by working double shifts, giving a total of 500-750 flats per year.

The moulds comprise fixed portions which can be actuated by means of jacks and which enable the moulds to be set in position for removing the units from the mould, and manipulating the cores.

This mechanization is independent of the interchangeable or extensible parts of the moulds, which must provide scope for modification to meet the requirements of various designs.

A factory of this type, including the tower cranes, concrete handling trucks, mixers and compressors (regarded as an ordinary contractors' plant) and also including the semi-trailers and tractors (for haulage within 50 km radius) and the erecting equipment involves an outlay of around one million dollars.

ERECTION

When the factory is producing and delivering regularly erection can go ahead without any difficulty. The prefabricated units are lifted directly off the semi-trailer vehicles, whose arrival at the site is accurately planned.

In this way, temporary storage of the units on site, involving "double handling", can be avoided.

The production capacity of the factory must fully meet site requirements. Many mistakes have been made by providing inadequate capacity. This adversely affects the efficiency of site work -- so much so that erection times may be doubled if the job has to be kept waiting for fresh units to arrive.

From the technical point of view, erection presents no difficulty. Adjusting and securing the vertical units is done with the aid of adjustable inclined props. This system is now in general use. In their method, they secure the props at each end by means of bolts screwed into threaded sockets in the vertical units and in the floors.

Their "functional units" are stable in themselves and are very useful in ensuring stability during erection.

As the door-posts are incorporated in the prefabricated units, "door templates" enable the erectors to check that the units enclosing the rooms are accurately set.

The floors are cast on special-purpose formwork supported on light extensible props in accordance with their system.

This formwork can easily be adapted to any shape and contributes substantially to flexibility of layout planning. The reinforcement and heating pipes are installed in a single operation.

After the concrete of the floors has hardened, the formwork is separated by a simple operation and moved to the next room.

The few horizontal (at floor level) and vertical joints are then caulked, final trimming is performed with a grinding wheel, and the flat is ready for the installation of the equipment and fittings. No further operations by the structural erectors are required.

JOINTS

They have developed a type of joint embodying a double seal. The first seal is of plastic, behind a small decompression chamber which reduces the pressure exerted by high winds, and the second is of concrete. A vented draining channel separates them.

General Comments

1) They have two factories at Villeneuve-le-Roi. one for providing single family dwellings and one for providing multi-storey apartments.

2) The cost of a 5-room prefabricated house is $14,000, compared to about $18,000 - for traditionally built houses of the same design.

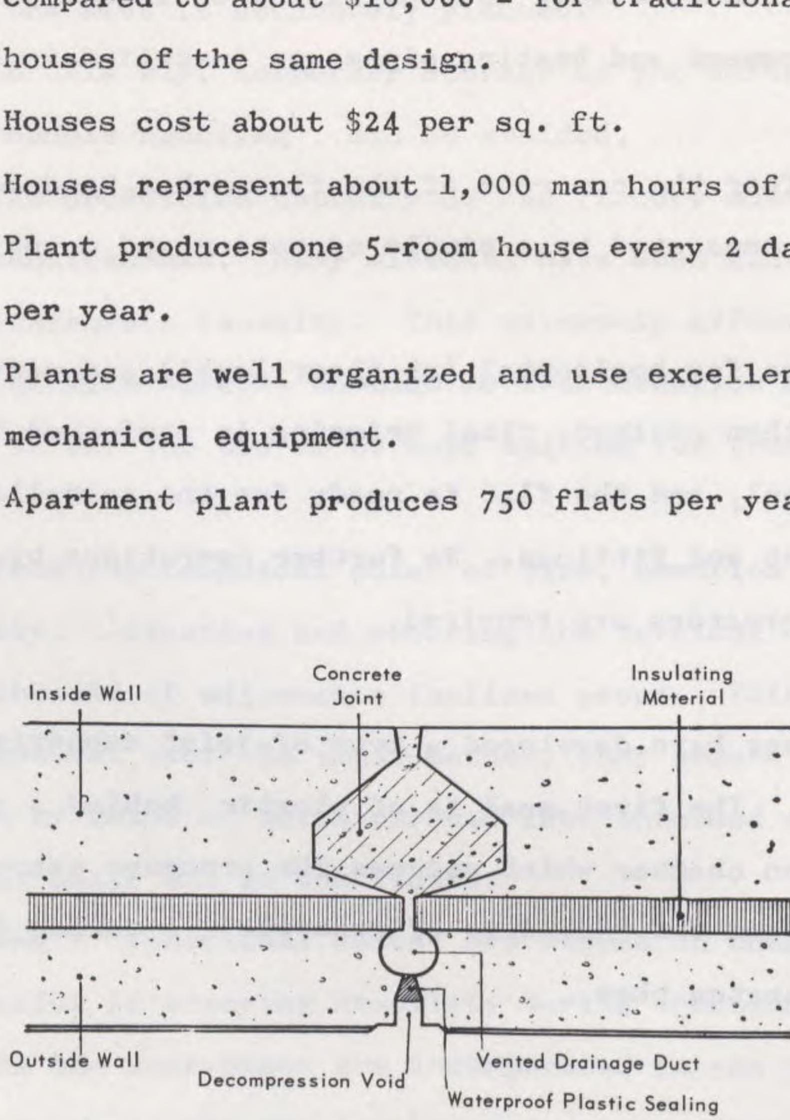
3) Houses cost about $24 per sq. ft.

4) Houses represent about 1,000 man hours of labour

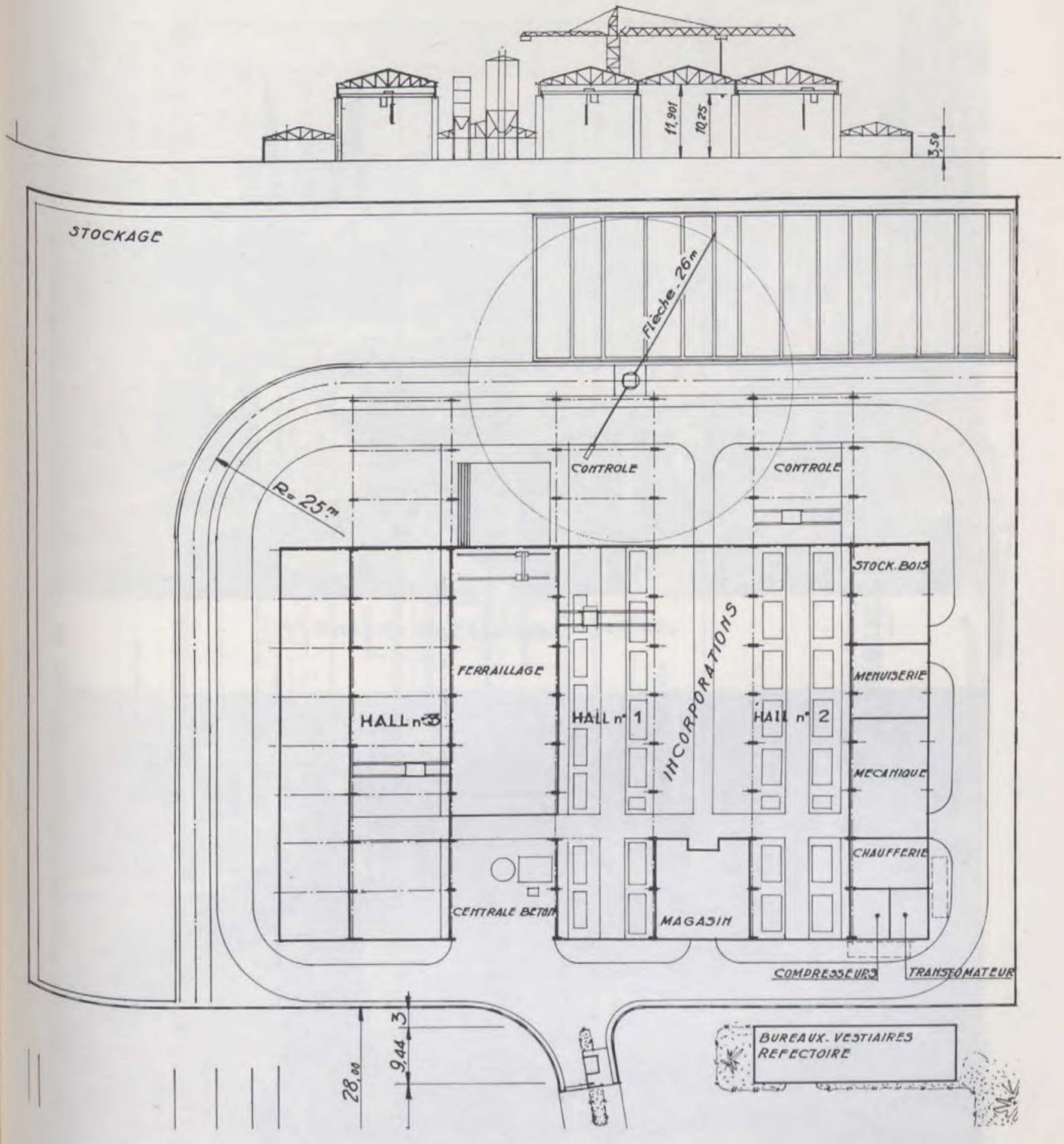
5) Plant produces one 5-room house every 2 days - 250 per year.

6) Plants are well organized and use excellent mechanical equipment.

7) Apartment plant produces 750 flats per year.



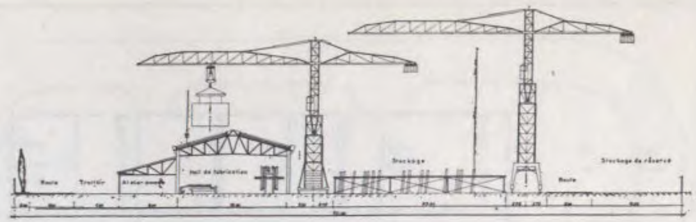
Detail of façade joint.

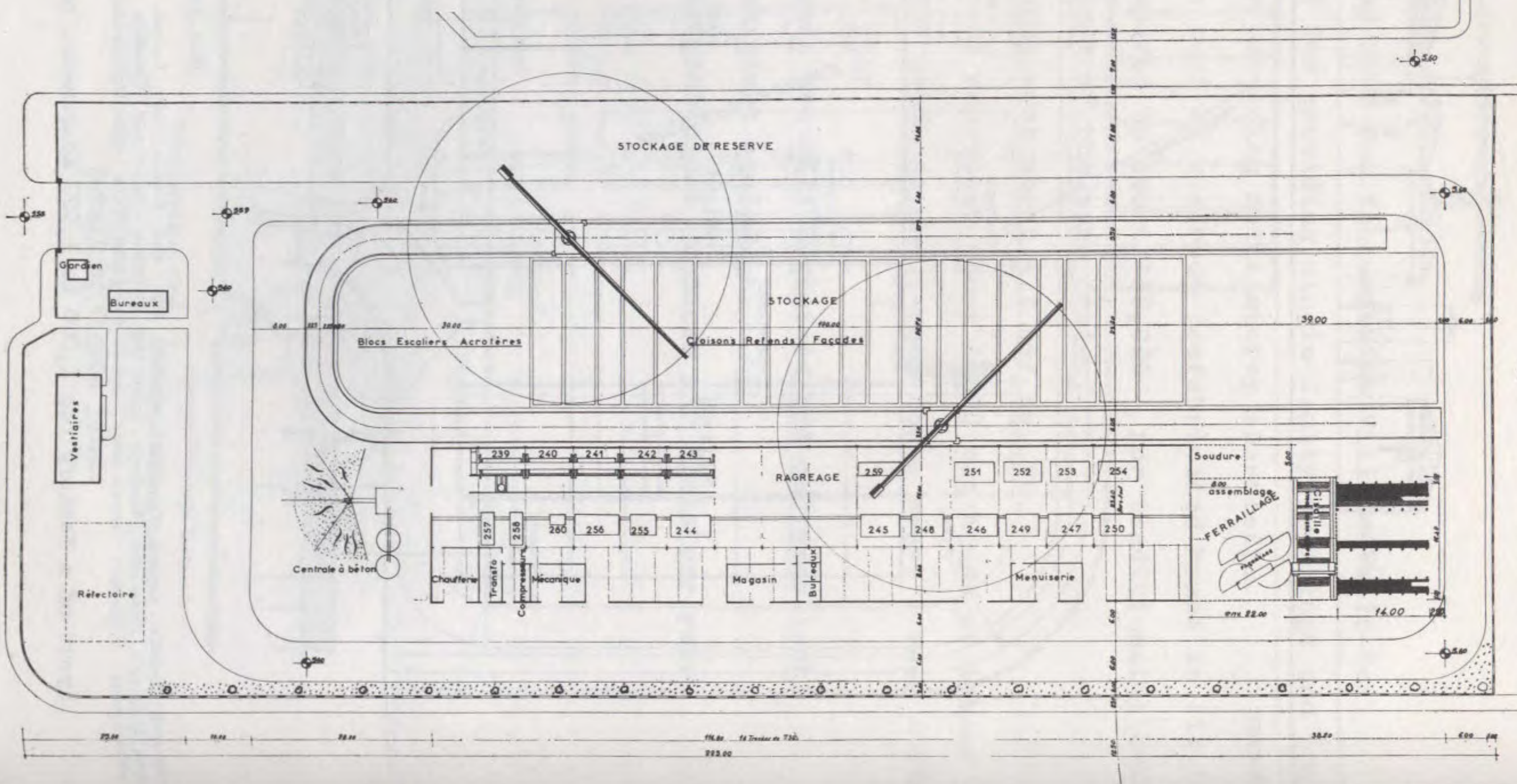


Stockage : *storage yard*. Contrôle : *checking*. Ferraillage : *steel-fixing*. Hall : *shed*. Magasin : *store*. Bureaux, vestiaires, refectoires : *offices, cloakrooms, canteen*. Stock bois : *timber store*. Menuiserie : *joiners' shop*. Mécanique : *fitters' shop*. Chaufferie : *heating plant*. Compresseurs : *compressors*. Transformateurs : *transformers*. Centrale béton : *concrete mixing plant*. Flèche : *radius*. Incorporations : *installing ancillary*.

Layout of a factory for 1,000 to 1,500 apartments per year.

Stockage de réserve : *storage yard.* Soudure : *welding shop.* Assemblage : *assembly.* Ferraillage : *steel-fixing.* Façonnage : *bar-bending.* Menuiserie : *joiners' shop.* Magasin : *storeroom.* Mécanique : *fitters'shop.* Chaufferie : *heating plant.* Transfo : *transformer.* Compresseurs : *compressors.* Centrale à béton : *concrete mixing plant.* Réfectoire : *canteen.* Bureaux : *offices.* Vestiaires : *cloakrooms.* Cloisons, refends, façades : *partitions, division walls, façades.* Blocs, escaliers, acrotères : *stairs, coping.* Gardien : *gatekeeper.* Ragreage : *check point.*

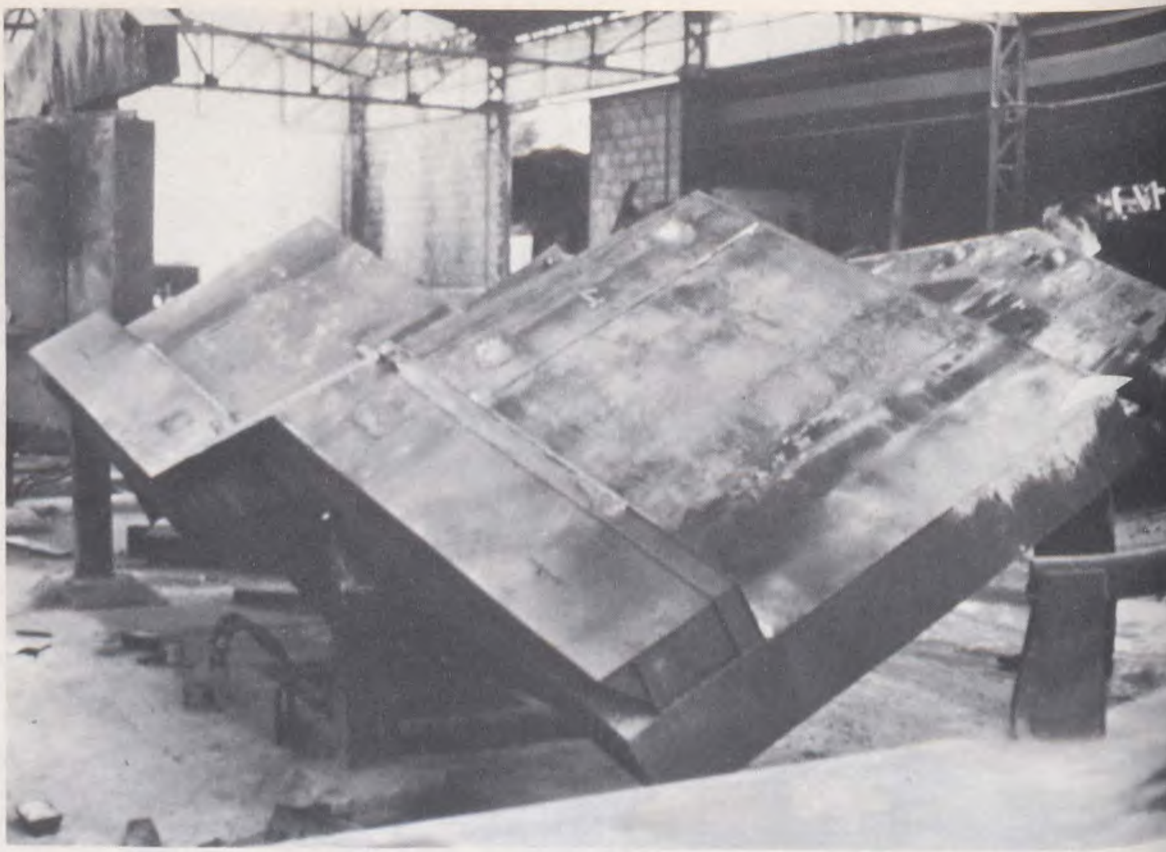




Layout of a factory for 500 to 750 apartments per year.

Factory at Villeneuve-le-Roi.

Horizontal façade moulds.

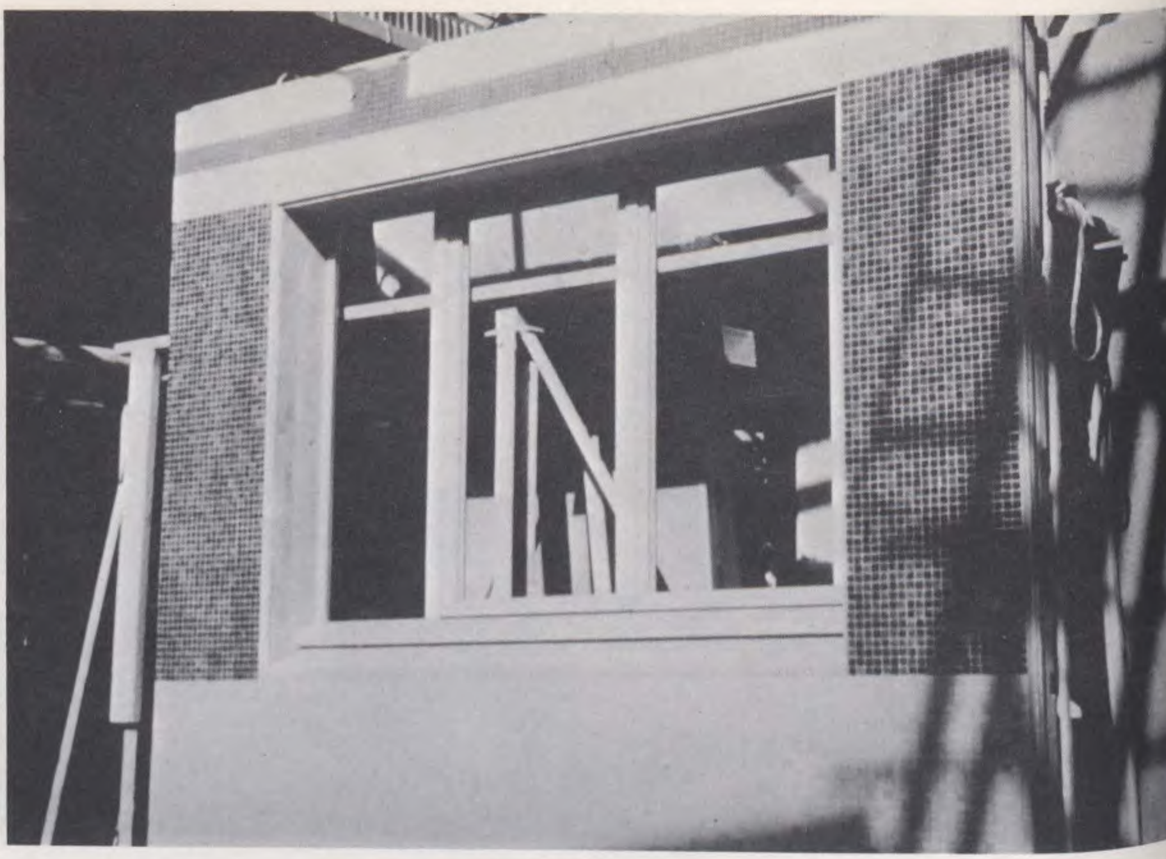


Mould for precasting stairs.

Precast stairs.

Mould showing plumbing, heating and electrical conduits installed to service kitchen and bathroom.

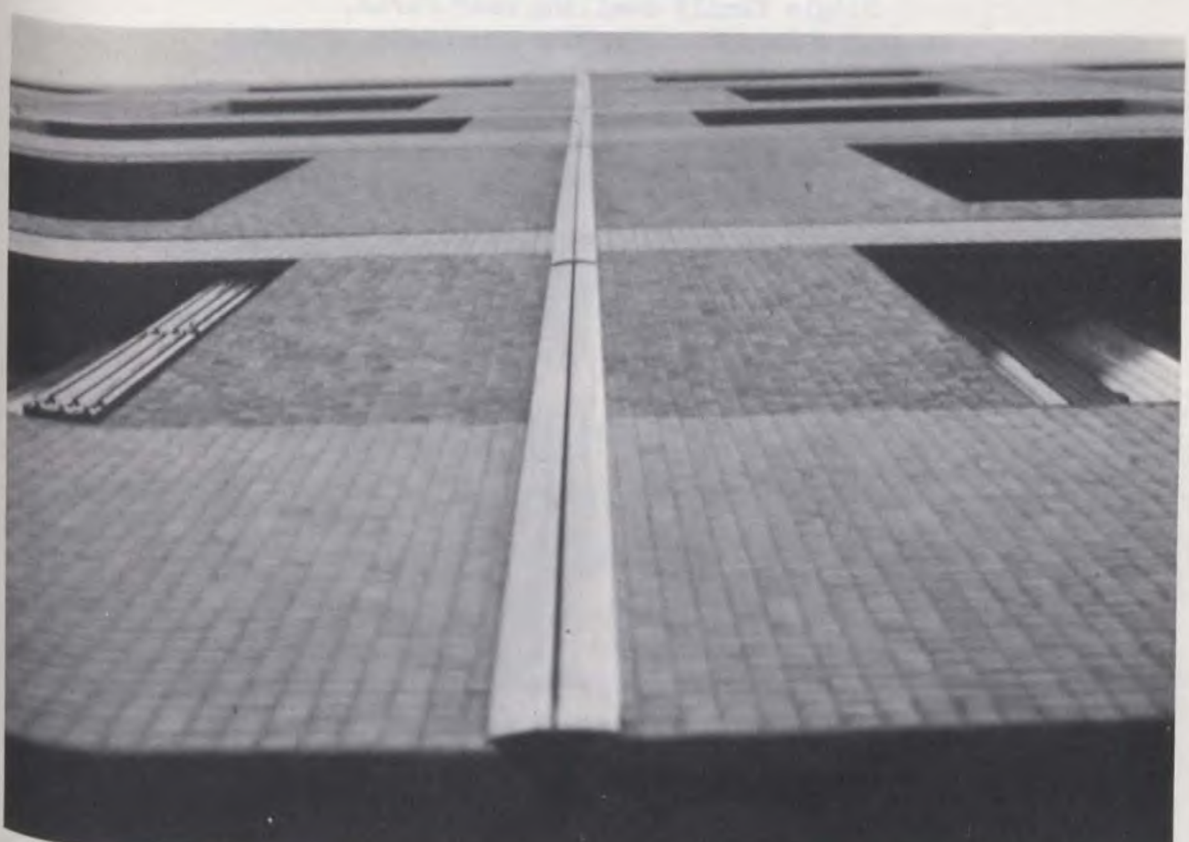
Demoulding of a functional unit.



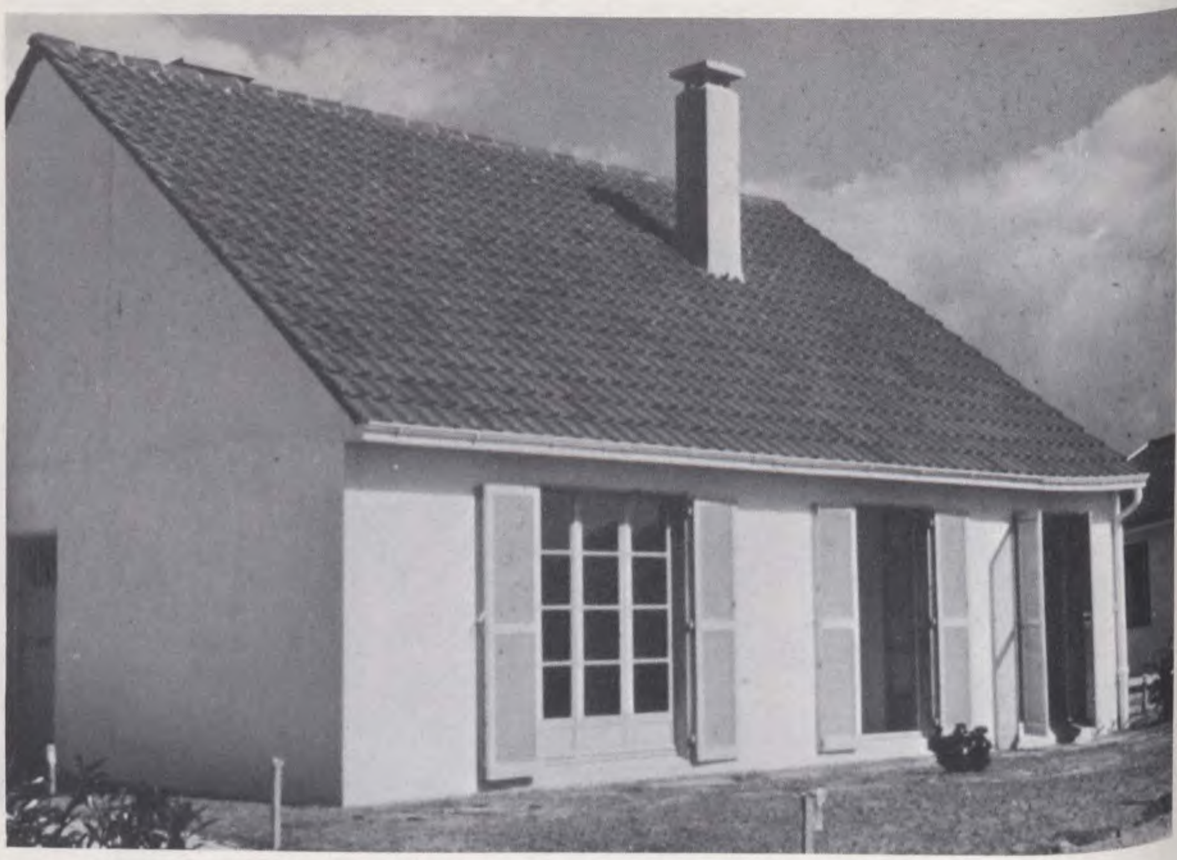
Façade panel.

Floors are poured in situ on precut formwork.

Low rent apartment project under construction near Paris.



Low rent apartment project under construction near Paris.



Single family dwelling near Paris.

IMPRESA GENERALE COSTRUZIONI MBM s.p.a.

Impresa Generale Costruzioni MBM s.p.a.
Trezzano sul Naviglio
Milan, Italy

Balency-MBM has created an industrial organization for the production of dwellings, employing the principles and methods of the most advanced industrial operations and using modern mechanical resources and materials.

Balency-MBM believes that today's best technological approach is to prefabricate load-bearing wall panels by means of suitable equipment. These panels are made of concrete and are completely finished with exterior veneers, interior finishes, windows, insulation, and electric raceways; they are of the same length and height as the rooms they enclose. From the plant where they are precast, the panels are transported to the building site, where cranes are used to assemble them into a structure of great solidity.

Balency-MBM considers precasting alone as insufficient and as only the first stage of modern construction technique. The second stage, far more important, is the scientific organization of work and programming of all operations to the point of ultimate industrialization. Under this total concept, the organization of work results in a continuous flow of production from the casting of the basic panels to the finished dwelling, much like the continuity of an assembly line in an automobile factory.

Balency-MBM believes its systems have many advantages over conventional and other techniques, namely:

- a considerable reduction in man-hours, especially with regard to skilled labour, the possibility of quickly training unskilled labour; greater continuity of employment and greater job security for all personnel; amenities comparable to those offered by other industry.
- a remarkable speed of construction and completion of buildings on schedule, allowing the client to benefit from reduced interest payments during construction and to receive earlier returns from the building.
- higher standards of quality than obtainable in conventional construction, since machine-made parts meet uniformly pre-established standards, which is not the case with site-fabricated elements. Furthermore, the very requirements of industrial production make it mandatory to use only carefully selected materials, lest the production process be seriously hampered.
- there is no preoccupation with finishings, the nightmare of traditional building -- also economical: all that is necessary is incorporated in the panels.
- building shells are completely fireproof. Exterior walls, interior partitions and stairs are made of materials with the highest fire rating.
- solidity of the building applies not only to the load-bearing feature of the structures, but extends to all

the finishes and built-in mechanical elements. Thus, durability can be guaranteed, with practically no maintenance, for periods of time unheard of in conventional construction.

- the possibility of architectural diversification is nearly unlimited. In fact, there is no reason why the superior technological aspects of a building built with the Balency method should not be matched by architectural beauty.
- the client has full opportunity to check all parts of the mass-produced buildings before entering into a contract.
- it is possible to make installations of any size, according to market demand. The production capacity may vary from 300 dwellings a year (or 150 one-family houses) to 2,000 or more. Both with the small but efficient mobile plants that can be moved from one building site to another, and with the large, permanent installations, it is possible to obtain the desired results. Obviously the increase of productivity is commensurate with the size of the investment.
- the reduction of costs: fewer man-hours, and reduced cost of utilities and their incorporation, are far greater than the depreciation of the necessary plants.

The saving is from 10 to 15 per cent over conventional construction costs.

- the building yard requires few installations, since these have been transferred to the production plant: hence it may be quite small and still operate profitably. Panels can be distributed economically within a radius of 70 miles or more.
- the same plant can produce buildings of any type: multi-storey buildings, one-family houses, schools, dormitories, hotels, hospitals, nursing homes, etc. Furthermore, the same series of panels can be used for different layouts. Low-cost, medium-cost, and luxury markets can be serviced by using different sizes, shapes, and finishes.

The principle underlying the Balency-MBM systems consists of visualizing the building as constructed from simple parts, generally slabs to be constructed outside the building site, and subsequently assembled and attached on the building site itself.

These parts, in addition to the volumetric definition of the building and the satisfaction of esthetic requirements, assume - depending on their position in the building, their form and the materials used in their design - stabilizing, heat insulation and sound proofing functions as well as others of a technological nature.

Features of the Balency-MBM System

Buildings are entirely or partially constructed from vertical prefabricated wall panels, normally attached by means of horizontal floor foundations cast on the building site.

Concrete is employed and is reinforced with welded wire mesh and rods.

The panels are produced in specially equipped factories and following curing, are hauled to the assembling site. Here, they are placed in position with the help of adjustable, inclined props. Next, a full concrete floor foundation is cast on a caisson and incorporates all the heads of the panels and the metal reinforcements protruding from them, connecting and monolithically solidifying the combined vertical and horizontal structures. Sealings in cement mortar complete the vertical connection between the panels while continuous steel reinforcements, obtained by means of strong welding connections, are placed where there are tractive forces.

Prefabricated elements

Inside wall elements - are of the same height as the storey of the building, variable in length from less than a meter to about 6 meters. Their thickness is dependent on stability requirements and the need for heat insulation and sound proofing. The ducts and housing for the electrical wiring are provided in the thickness. Also incorporated are the anchorings for the doorposts or the doorposts themselves. Table I illustrates a panel subject only to compression stress. The steel reinforcement is generally designed to satisfy hauling requirements, aside from the contour details necessary to permit connection with other structures.

Table II shows a panel which performs windbracing functions or which may be strained by tractive forces. The main vertical reinforcement is designed in such a way as to be placed over the reinforcement of the underlying panel and welded to it.

<u>Outside wall elements</u> consist of:

- an outside layer in reinforced concrete of a minimum thickness of 5 cm. (excluding eventual covering), which serves as a support for any covering.
- a layer of expanded polystyrene serving as heat insulation of a thickness varying from 2 cm. to 3.5 cm., depending on insulation requirements.
- an inside layer of reinforced concrete, serving as supporting framework, of a minimum thickness of 10 cm.

The outside layer, which is supported by the inside layer, is connected to it by means of reinforced framework. When necessary, openings for windows are provided in the wall panel. Table III shows a typical outside wall panel.

These panels, in general, are only subject to compression stress; however, for the stability of the panel itself, the main vertical reinforcement has the same design as that of the panels shown in Table II.

Functional blocks - In order to make provision for the installations of the dwelling, different types of blocks (always self-supporting) are fabricated, for example chutes for garbage disposal, blocks for vertical panels of the electrical and heating systems, etc.

By way of example, Table IV shows a block constituting the dividing wall between the bathroom and the kitchen.

This block includes pipes for the absorption of fumes from the gas hot water heater, vent stacks for the bathroom and kitchen, smoke stacks for eventual stoves. All pipes for the supply of hot and cold water and drainage in the bathroom and kitchen are incorporated and the openings for the insertion of electrical wiring are also obtained.

Stairs ramp elements - are constituted by floor foundations attached at one end to the façade panel and fixed at the other end to the landing of the building storey (cast on the building site). The steps are also precast as may be seen from Table V.

Manufacturing Process - The parts are prefabricated on metallic moulds whose contact surfaces are heated to 90-95°C by means of a hot water circuit, which keeps them at a temperature of between 85 and 90°C.

At these temperatures, the process of hardening of the cement is accelerated, and after a period varying from two to four hours, depending on the thickness of the element, it is possible to knock out the panel. During knocking out, the panel is not subject to any great bending stress and in practice all stress due to the actual weight of the panel itself is absorbed by the steel reinforcements, which work by traction. For this reason, the moulds are preferably vertical and if, for casting purposes, they happen to be horizontal they are turned to the vertical position by means of hydraulic jacks.

The pieces taken from the moulds are examined in an inspection area and piled vertically in the stockyard, where curing is completed in a minimum of 10 days.

Assembling

After the foundations have been completed by methods adapted to the nature of the ground, and the floor surface laid, they proceed with the layout of the building to be constructed. In practice, they trace the design on the floor surface, on the same scale as the actual construction. The panels are lifted from the trailers by the tower crane and placed on the layout, supported by duraluminum wedges. Their stability is temporarily secured by adjustable inclined props, which are attached to the panel and to the ground by means of railway type screw spikes. The panels are placed in position by activating the wedges and inclined props. They then proceed with the sealing of the horizontal joints with thick cement mortar. The vertical joints are poured from above with plasticized mortar. The floors are cast on plywood caissons having the same dimensions as the space occupied by the vertical panels. Before casting, the irons protruding from the heads of the panels are bent in the thickness of the floor and all necessary connections are made in the electrical and heating systems to be incorporated in the floors. In the thickness of the floor are also incorporated the bushings for the fixing of the screw spikes which block the foot of the included props.

Framework stability

The prefabricated slabs are joined in such a way as to form a box-shaped structure.

Connections are made in such a way as to be able to identify, in every part of the construction to be carried out, series of connections which may be diagrammed as in table VI.

Referring to this table and supposing slab (a) attached to the ground, it is seen that a connection such as that formed between walls (b) and (c) - not lined up and attached at the top and bottom by means of two pairs of hinges - and slab (d), does not leave this latter slab any freedom of movement, so that a stable box-shaped structure has been constructed. A combination such as that illustrated in table VI is therefore capable of balancing forces however directed in space; on the direction, line and natures of these forces will depend the dimensioning of the slabs and hinges and the necessity that the ideal pattern of connections be valid in space or only in determined planes or directions and around determined axes of rotation, finite or infinite.

The details of attachments are therefore studied case by case; however, basically there are only two types:

(a) hinges

(b) non-sliding supports

"Hinge" is defined as an attachment capable of transmitting shearing forces, with or without the presence of normal forces.

"Non-sliding" support is defined as an attachment capable of transmitting shearing forces only when adequate normal forces are present.

Stability diagrams

Table VII shows a typical portion of a building constructed by Balency-MBM techniques. (Tables VIII, IX, X show typical horizontal and vertical sections of table VII).

The stability pattern may be represented as in table XI, where it is possible to identify, by means of sections which are either parallel or orthogonal to the façade, sections as in table XII. The attachments shown may be real hinges or simple non-sliding supports.

When attachment (a) of table XII must only react to vertical forces, directed downwards, a simple non-sliding support is sufficient. In practice, this attachment is formed as in table XIII.

Attachment (b) is always a real hinge (table XIII).

When, on the other hand, there are vertical forces directed upwards, attachment (a) as per table XII becomes a real hinge and is capable of transmitting tractive forces (table XIV).

Attachment (c) may be described as a non-sliding support when there are vertical forces directed downwards.

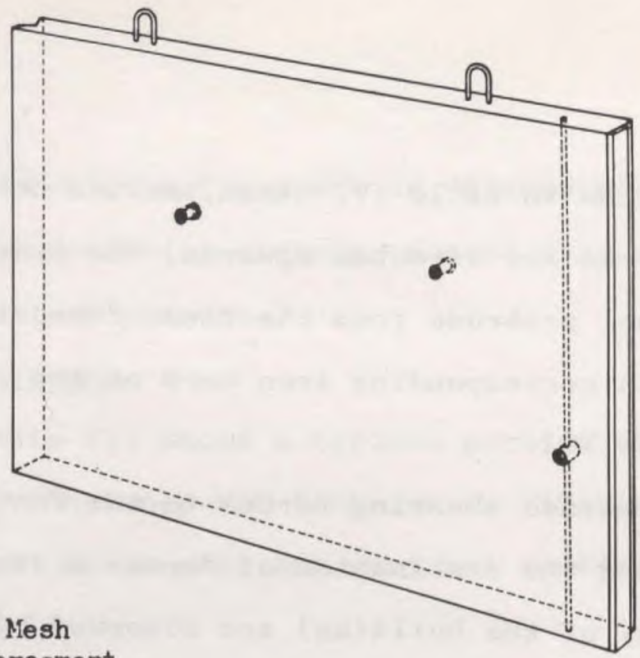
It may be formed as in table XV. When, on the other hand, the vertical forces are directed upwards, the iron bars of the lower panel protrude from the floor foundation and are welded to the corresponding iron bars on the upper panel as in table XVI.

The combined shearing forces to the foot of the panel (considering the combination of forces acting on the entire storey of the building) are absorbed by forces of friction which occur, through the corresponding action of the vertical loads, between the extrados of the floors and the bed of sealing mortar with the overlying vertical panel. If there are no vertical loads, the shearing force is absorbed by a reinforcement arranged as in tables XIV and XVI.

(It is calculated that each panel absorbs only components of shearing forces which are directed in the same way as the main horizontal dimension of the panel itself).

TABLE I

INSIDE PANEL subject only to compression stress



1. Welded Wire Mesh
2. Upper reinforcement
3. Lower reinforcement
4. Lifting hook
5. Bushing for positioning screw
6. Embedding for electrical outlet box
7. Ducts for electrical wiring
8. Doorpost

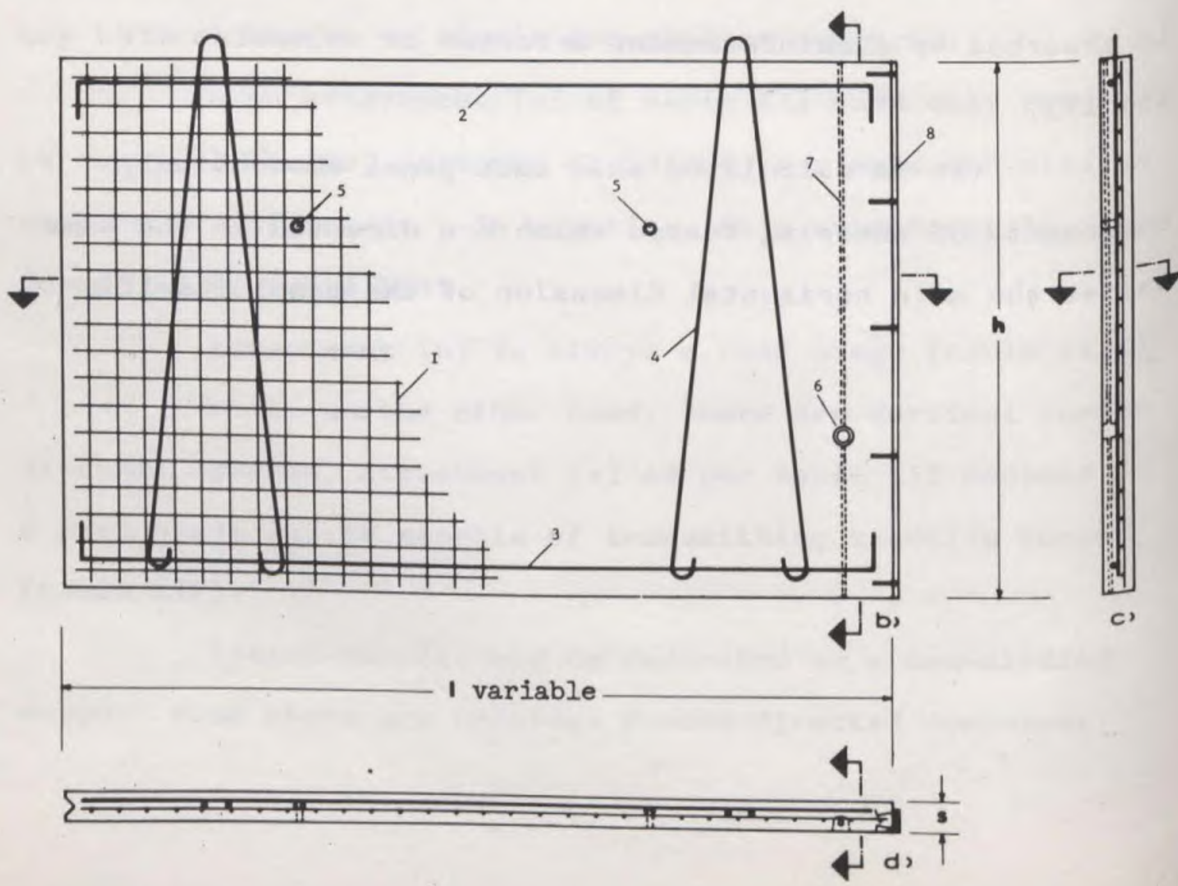
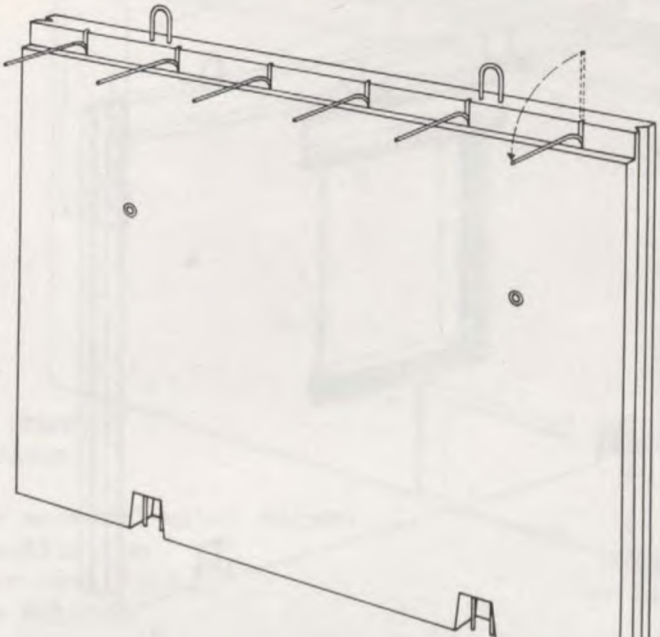
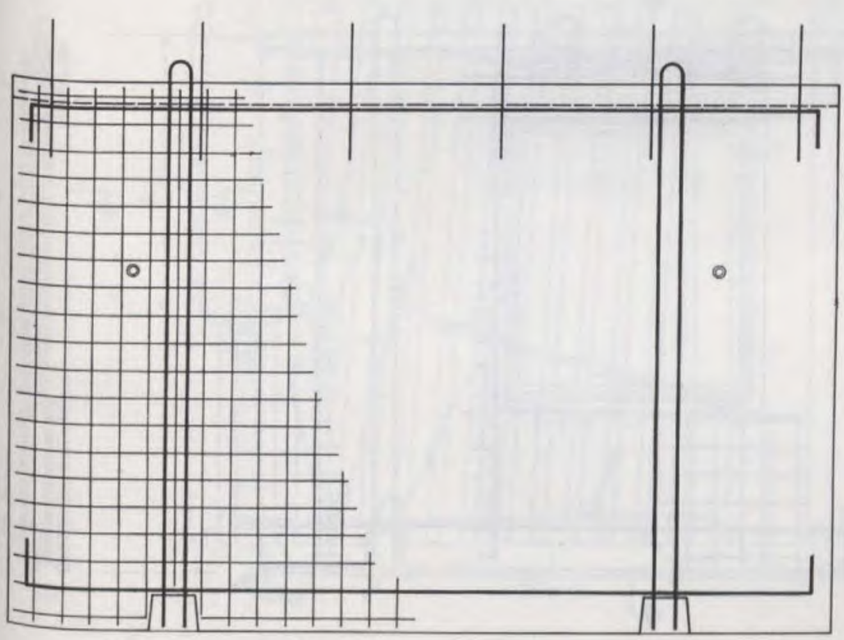
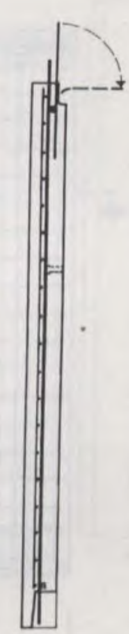


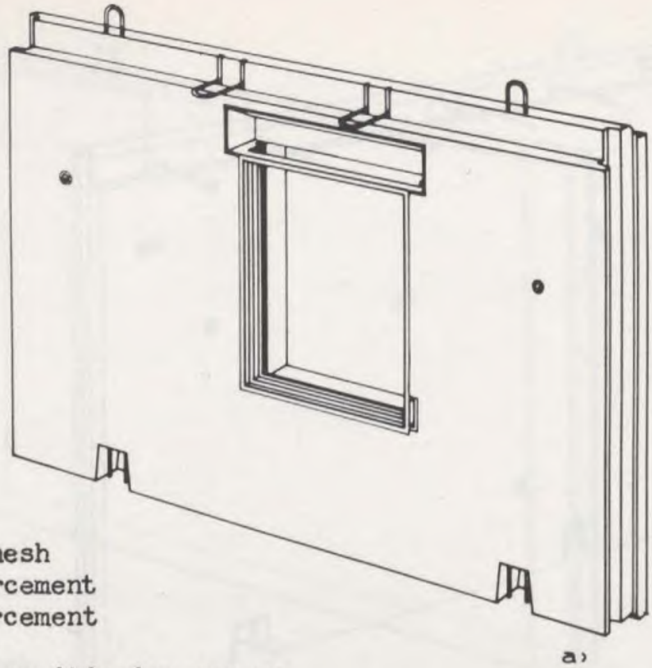
TABLE II

INSIDE PANEL subject to windbracing

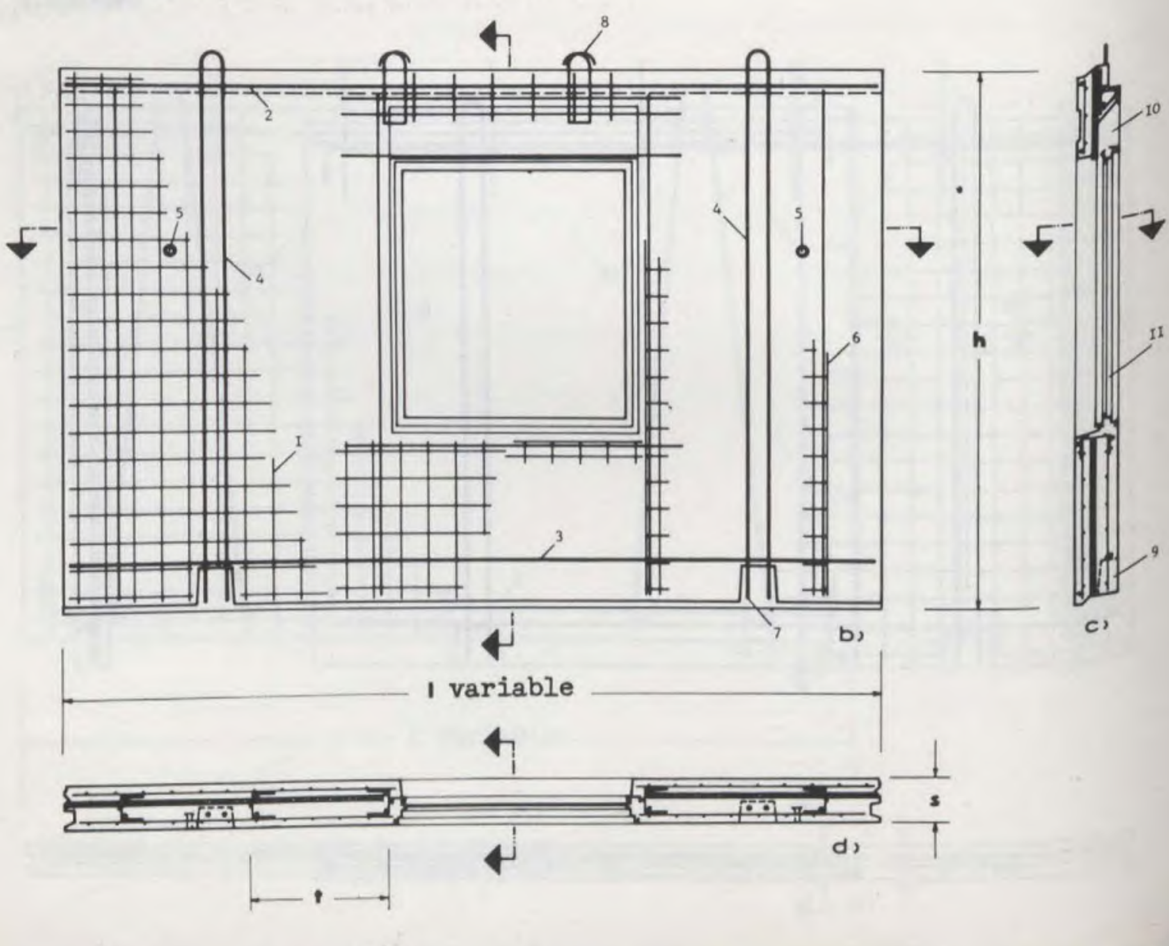


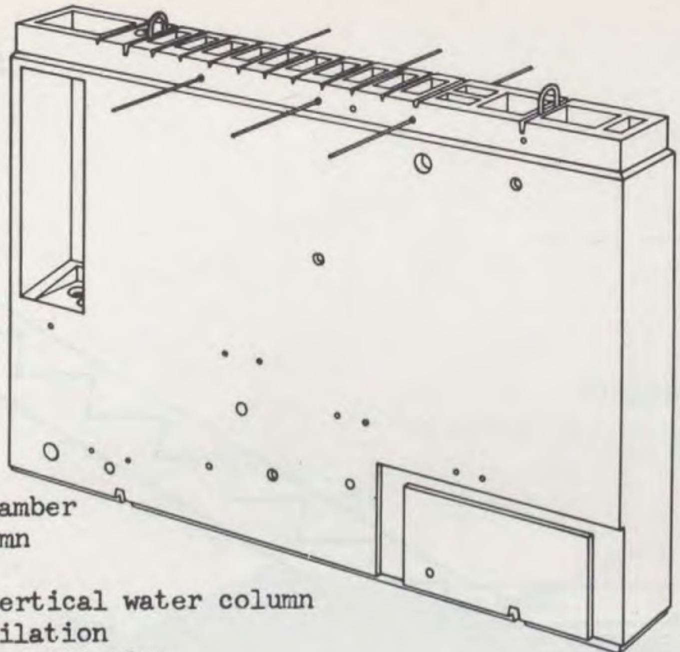






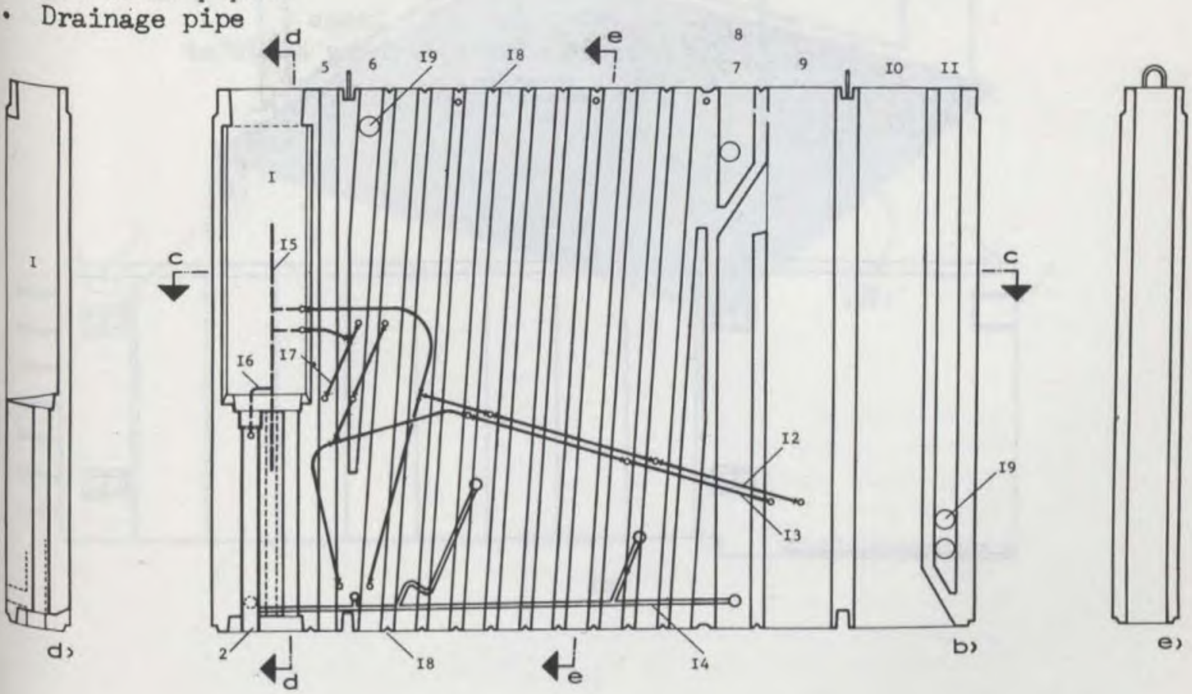
1. Welded wire mesh
2. Upper reinforcement
3. Lower reinforcement
4. Lifting hook
5. Bushings for positioning screws
6. Reinforcement for ribs
7. Reinforcement to be connected by welding on building site
8. Reinforcement for anchoring to floor foundation
9. Opening for welding
10. Opening for plugs
11. Window frame



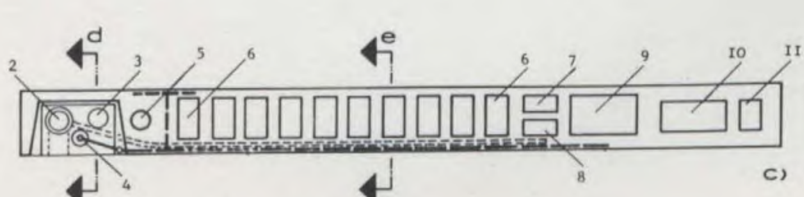


a)

1. Inspection chamber
2. Drainage column
3. Downspout
4. Chamber for vertical water column
5. Drainage ventilation
6. Water heater ventilation
7. Vent stacks kitchen
8. Vent stacks bathroom
9. Collective vent stacks
10. Collective smoke
11. Smoke stack
12. Cold water pipes
13. Hot water pipes
14. Drainage pipe
15. Vertical water column
16. Rapid discharge pipe
17. Water pipes kitchen
18. Embeddings for sealing
19. Insertion and inspection smoke stack



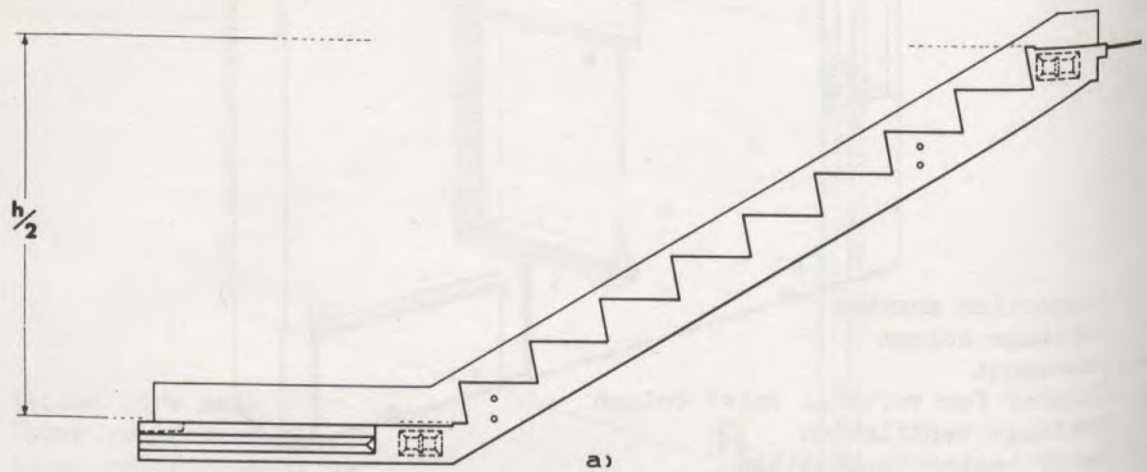
d) b) e)



c)

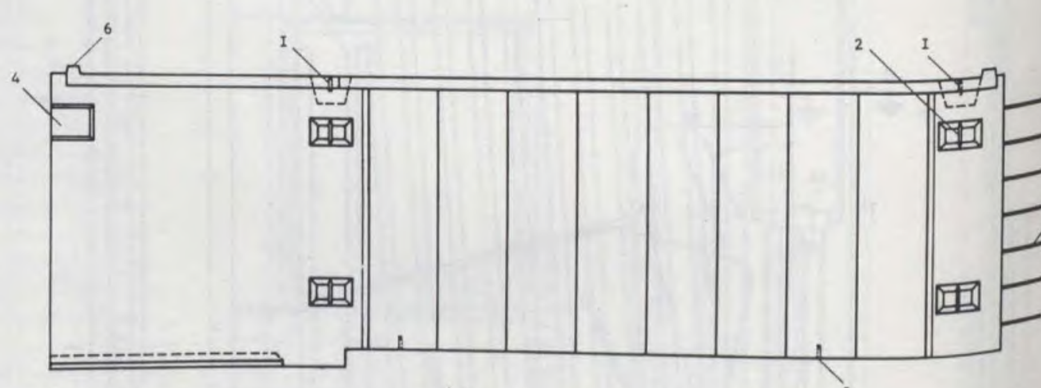
TABLE V

STAIRS RAMP PANEL



a)

1. Hooks for knocking out and hauling
2. Positioning hooks
3. Fixed joint irons
4. Chamber for wall irons
5. Ferules for attaching banister
6. Wall spacer



b)

TABLE VI

Diagram of Connection

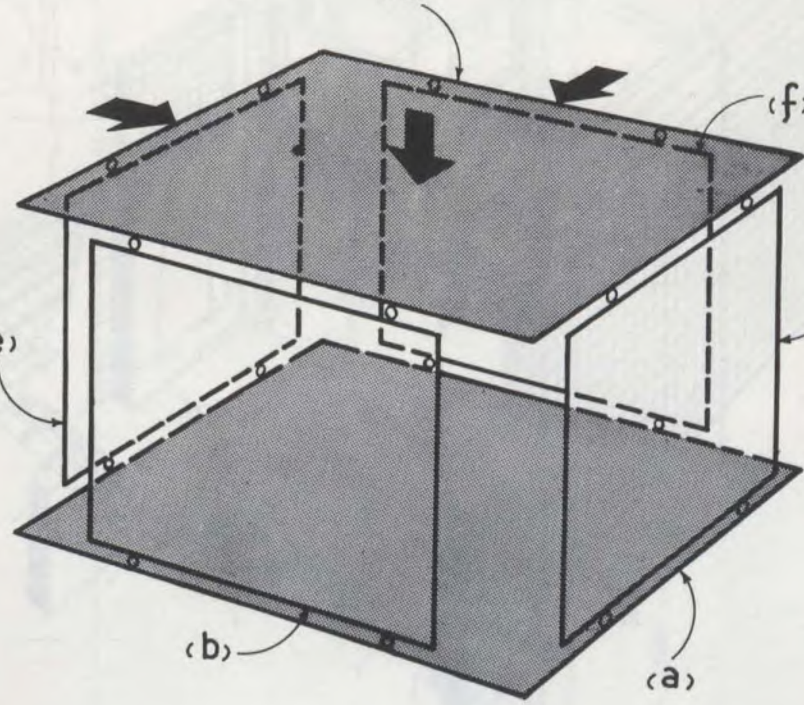
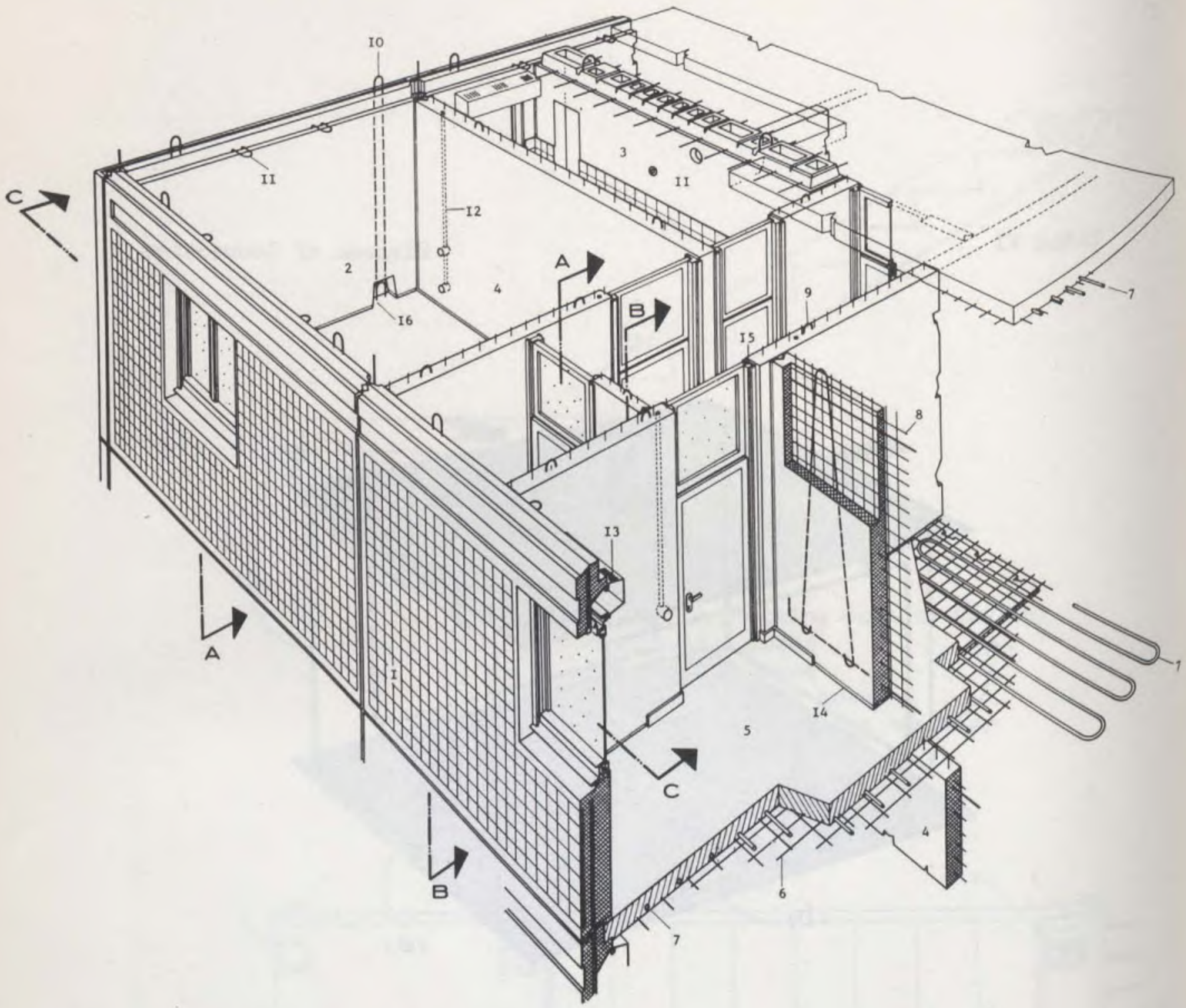


TABLE VII

SAMPLE CONSTRUCTION TYPE - Section in perspective



1. Outside panel
2. Outside header panel
3. Functional block
4. Inside panel
5. Cement floor foundation cast on building site
6. Welded net reinforcement for floor
7. Heating coils
8. Welded net reinforcement for panels
9. Protruding panel reinforcements to be anchored to floor foundation
10. Continuous reinforcement
11. Reinforcement for attachment to floor
12. Ducts for electrical wiring
13. Air intake tubes
14. Horizontal sealing in mortar
15. Doorpost incorporated into panel
16. Opening for welding of continuous reinforcements.

TABLE VIII

SECTION A-A OF TABLE VII

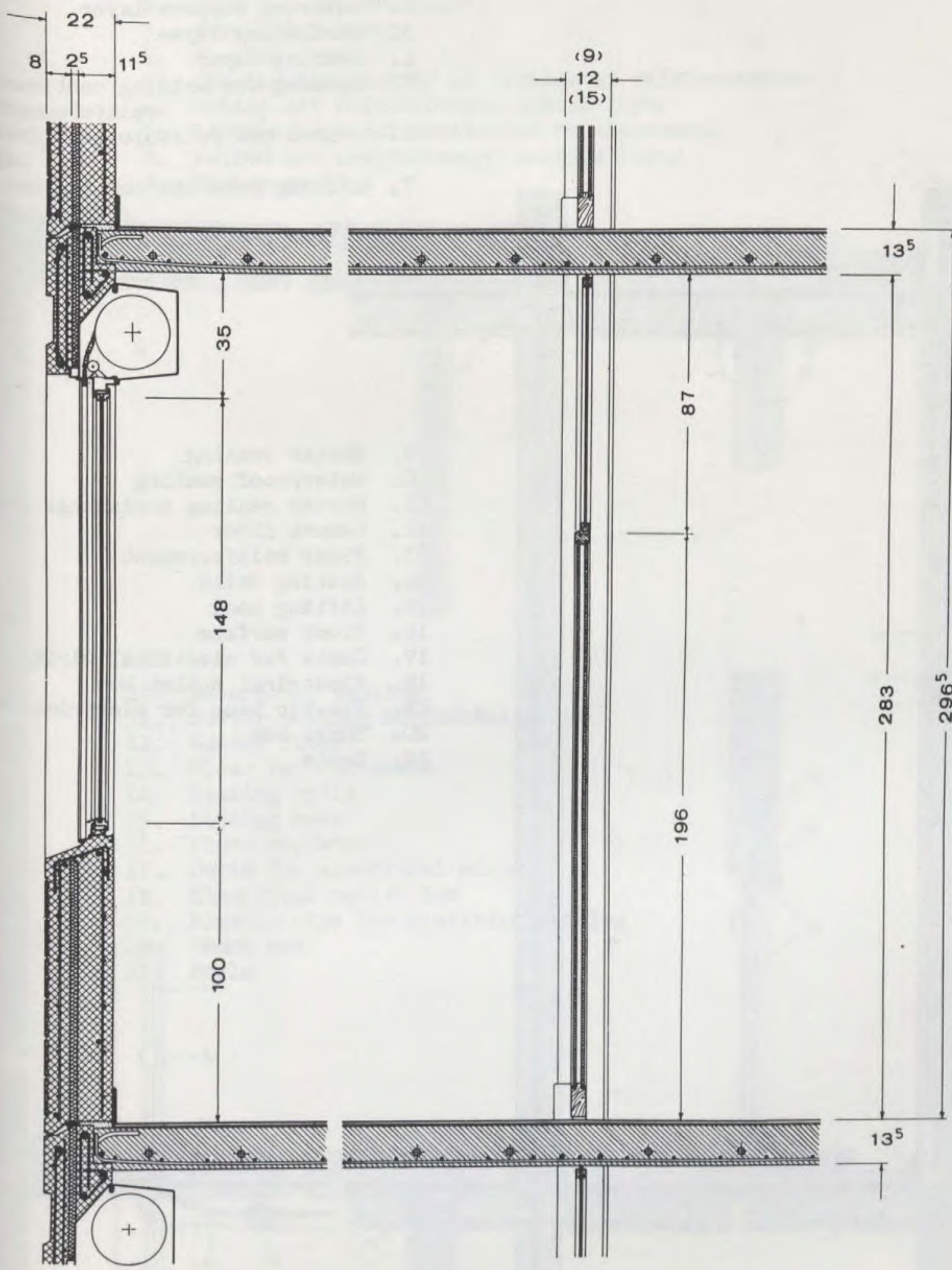
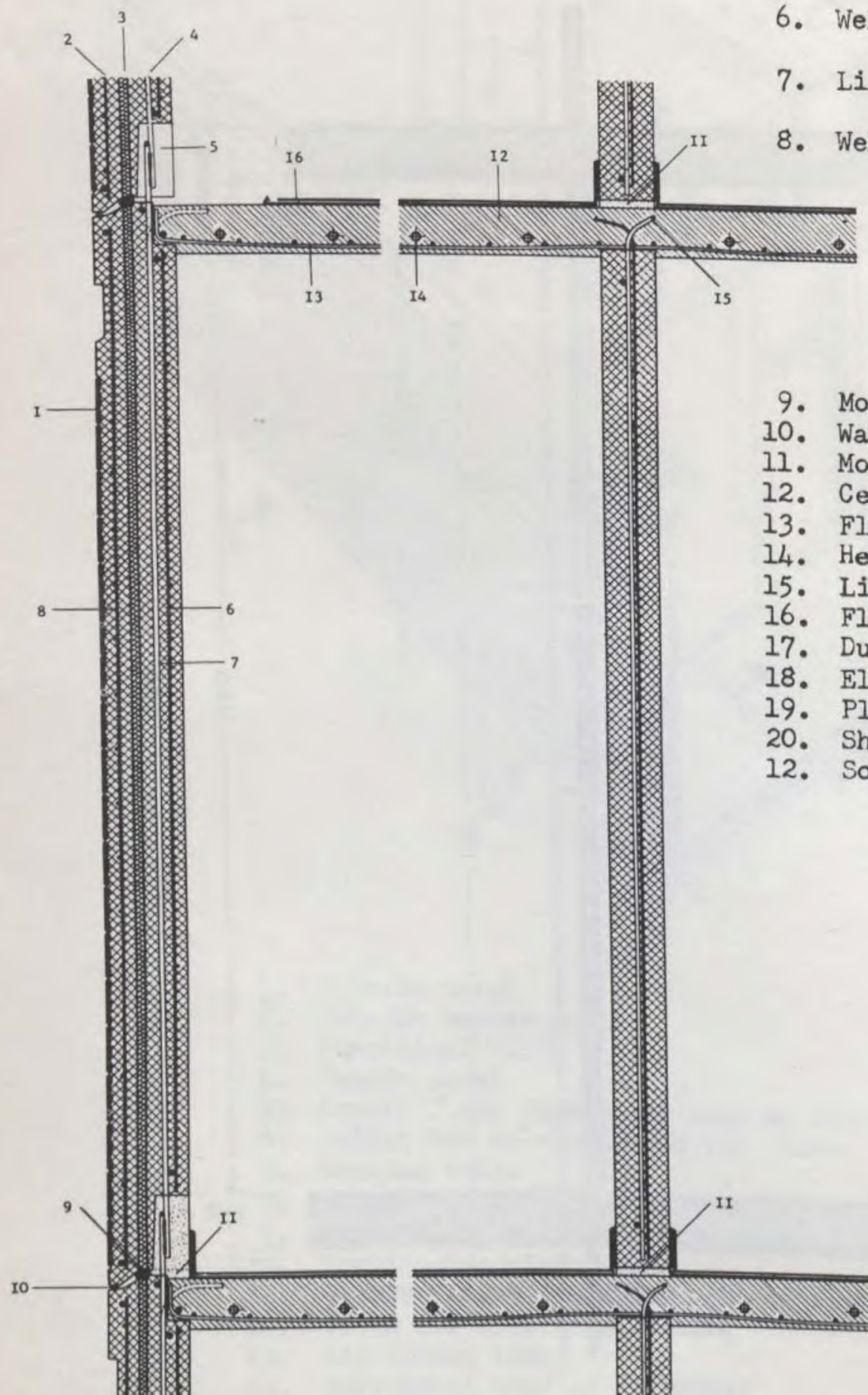


TABLE IX SECTION B-B OF TABLE VII

1. Outside covering
2. Covering support layer
3. Insulating layer
4. Bearing layer
5. Opening for welding continuous reinforcements
6. Welded net reinforcement inside layer
7. Lifting hook and continuous reinforcement
8. Welded net reinforcement outside layer



9. Mortar sealing
10. Waterproof sealing
11. Mortar sealing horizontal joint
12. Cement floor
13. Floor reinforcement
14. Heating coils
15. Lifting hook
16. Floor surface
17. Ducts for electrical wiring
18. Electrical outlet box
19. Plastic pipe for electrical wiring
20. Shunt box
12. Socle

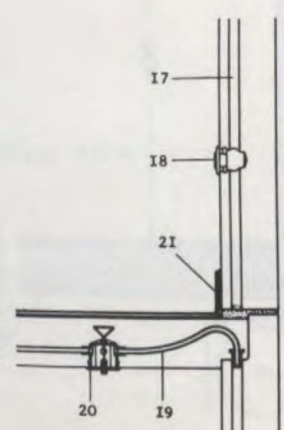
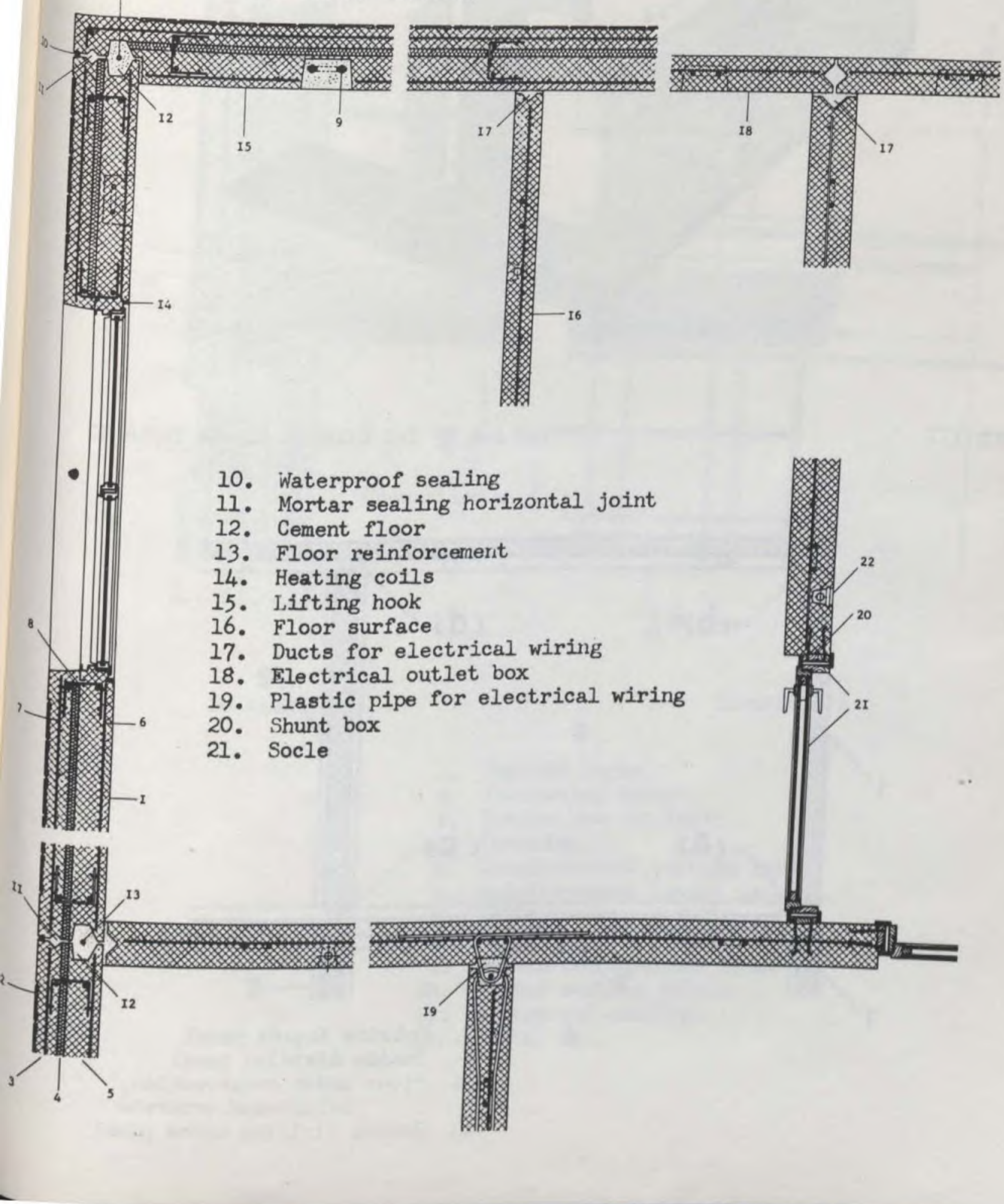


TABLE X

SECTION C-C OF TABLE VII

1. Outside covering
2. Covering support layer
3. Insulating layer
4. Bearing layer
5. Opening for welding of continuous reinforcements
6. Welded net reinforcement inside layer
7. Lifting hook and continuous reinforcement
8. Welded net reinforcement outside layer
9. Mortar sealing



10. Waterproof sealing
11. Mortar sealing horizontal joint
12. Cement floor
13. Floor reinforcement
14. Heating coils
15. Lifting hook
16. Floor surface
17. Ducts for electrical wiring
18. Electrical outlet box
19. Plastic pipe for electrical wiring
20. Shunt box
21. Socle

TABLE XI STABILITY DIAGRAM OF STRUCTURE AS PER TABLE VII

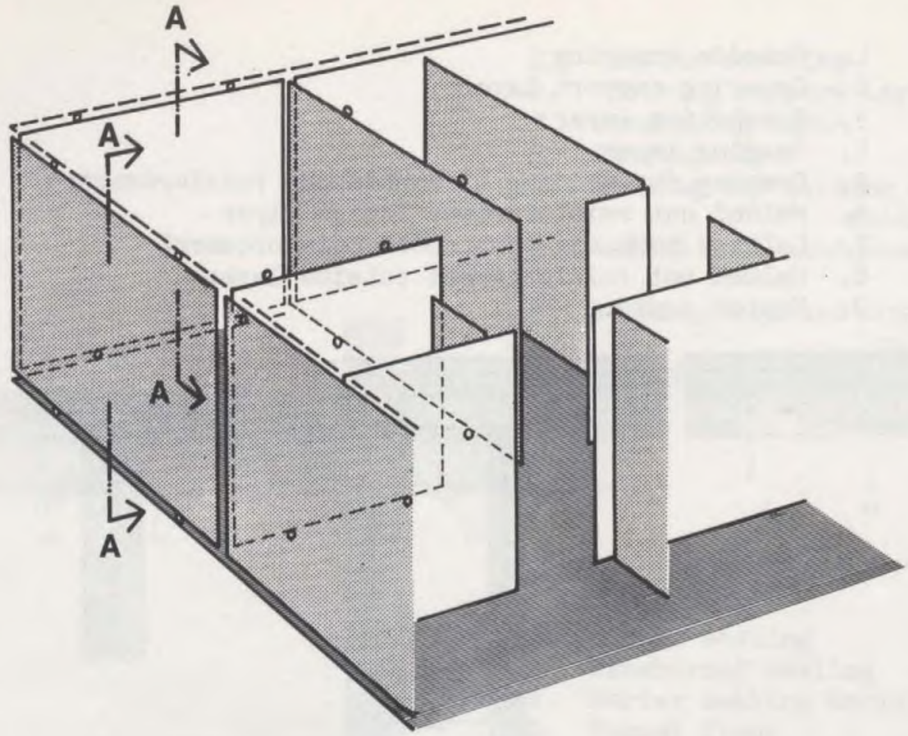
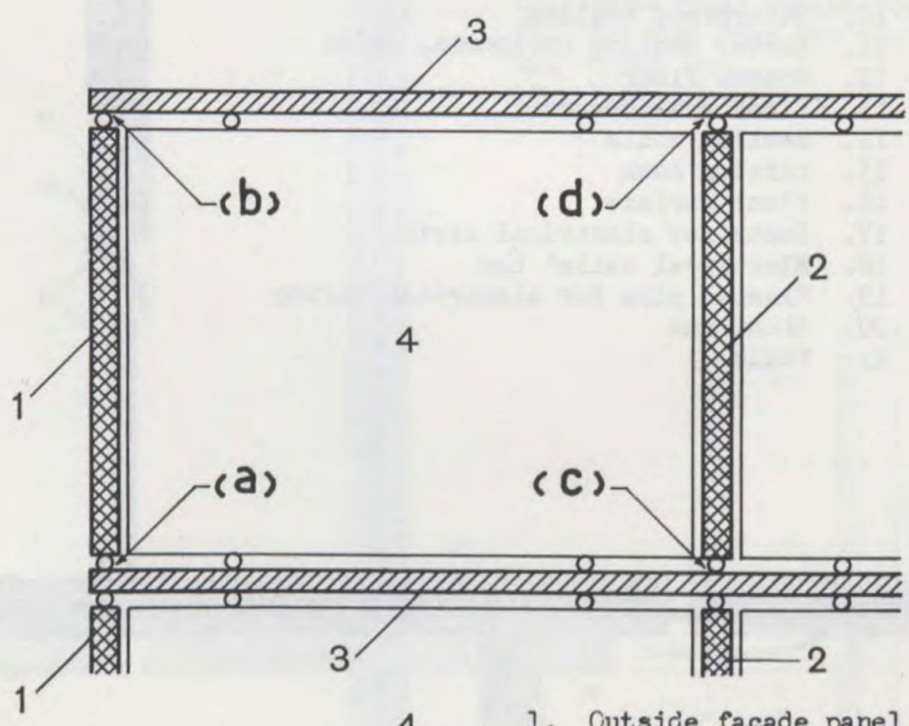
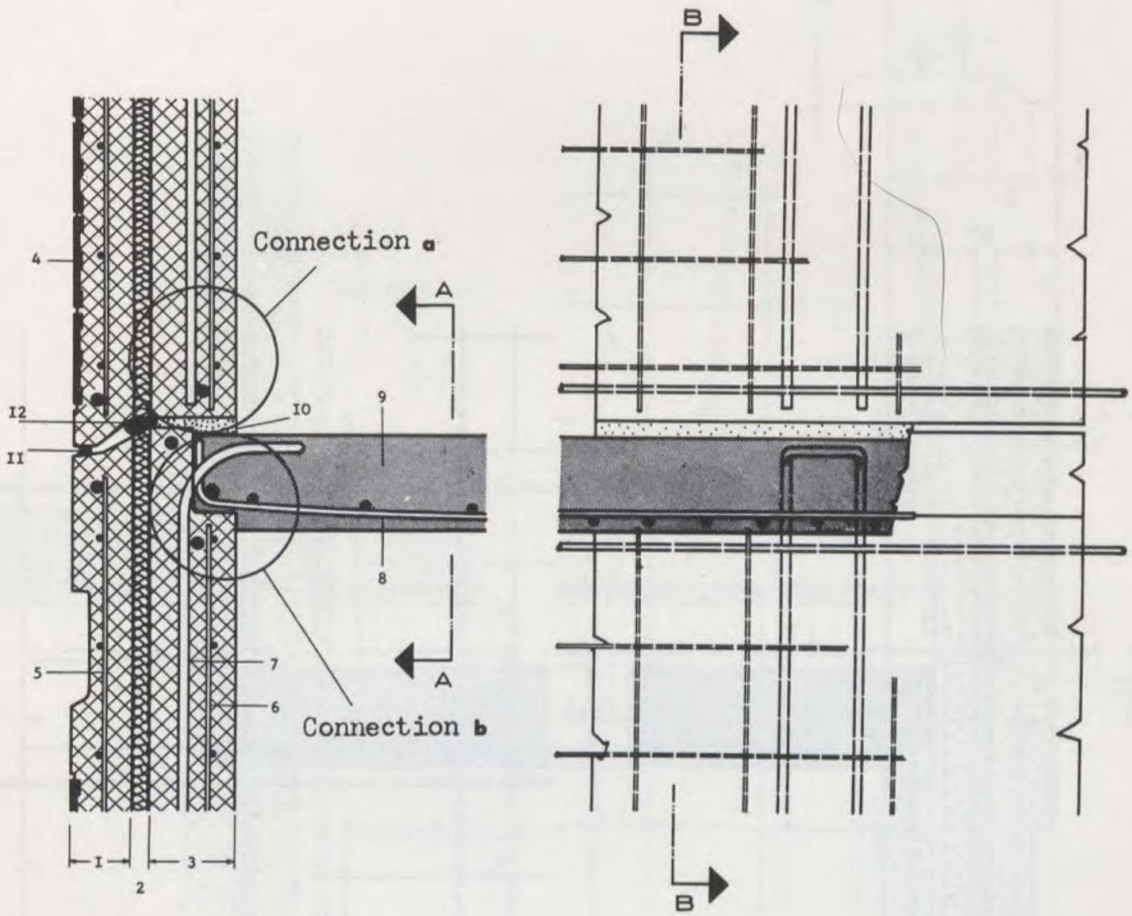


TABLE XII SECTION A-A OF THE DIAGRAM AS PER TABLE XI



1. Outside façade panel
2. Inside dividing panel
3. Floor under construction, reinforced concrete
4. Inside dividing cross panel

TABLE XIII REALIZATION OF ATTACHMENTS DIAGRAMMED IN TABLE XII



Section B-B Section A-A

1. Outside layer
2. Insulating layer
3. Inside bearing layer
4. Covering
5. Reinforcement outside layer
6. Reinforcement inside layer
7. Lifting hook
8. Floor reinforcement
9. Reinforced concrete floor
10. Mortar sealing joints
11. Waterproof sealing
12. Mortar seal

TABLE XIV

REALIZATION OF ATTACHMENTS DIAGRAMMED IN TABLE XII

(Attachment (a) subject to traction)

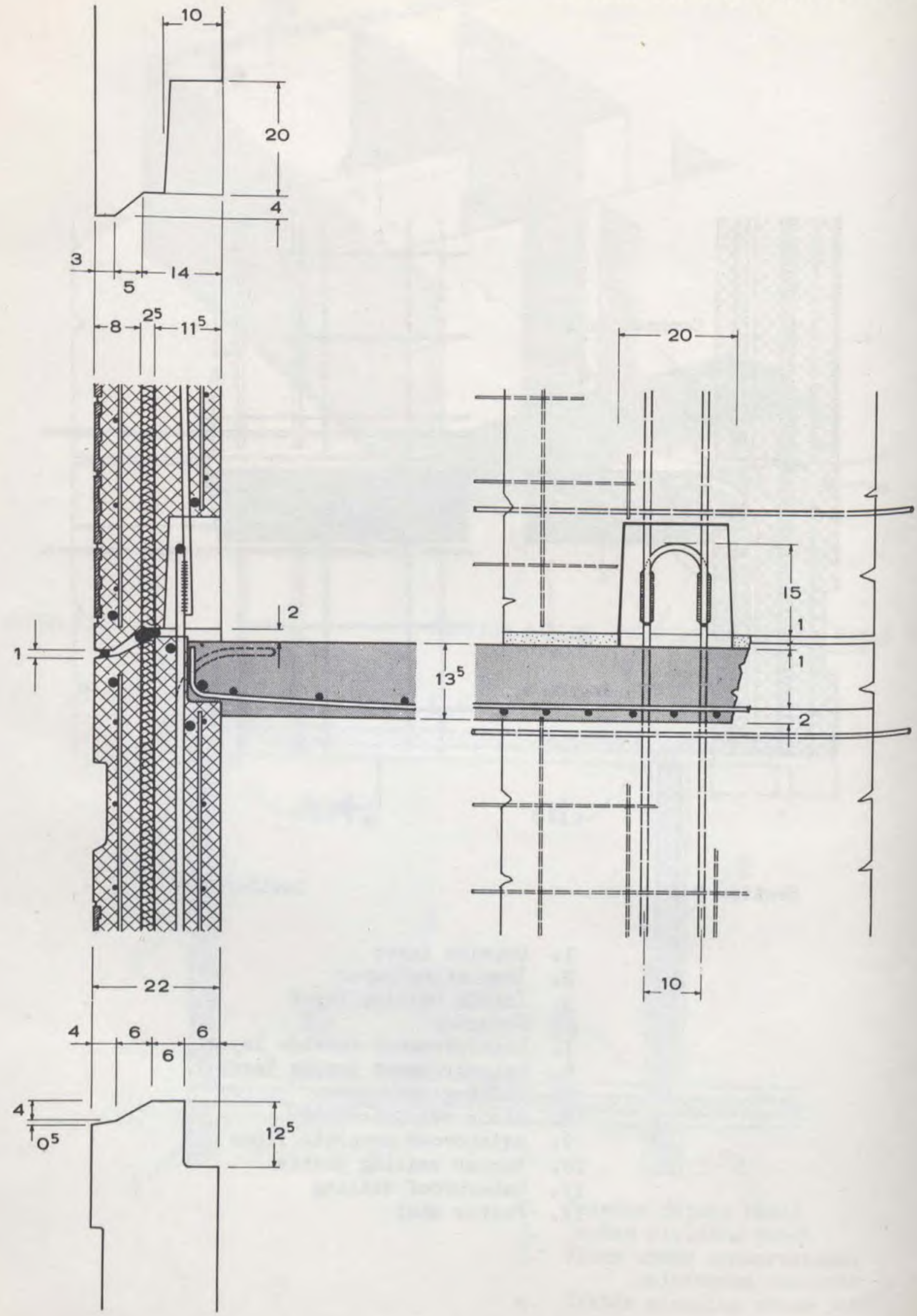
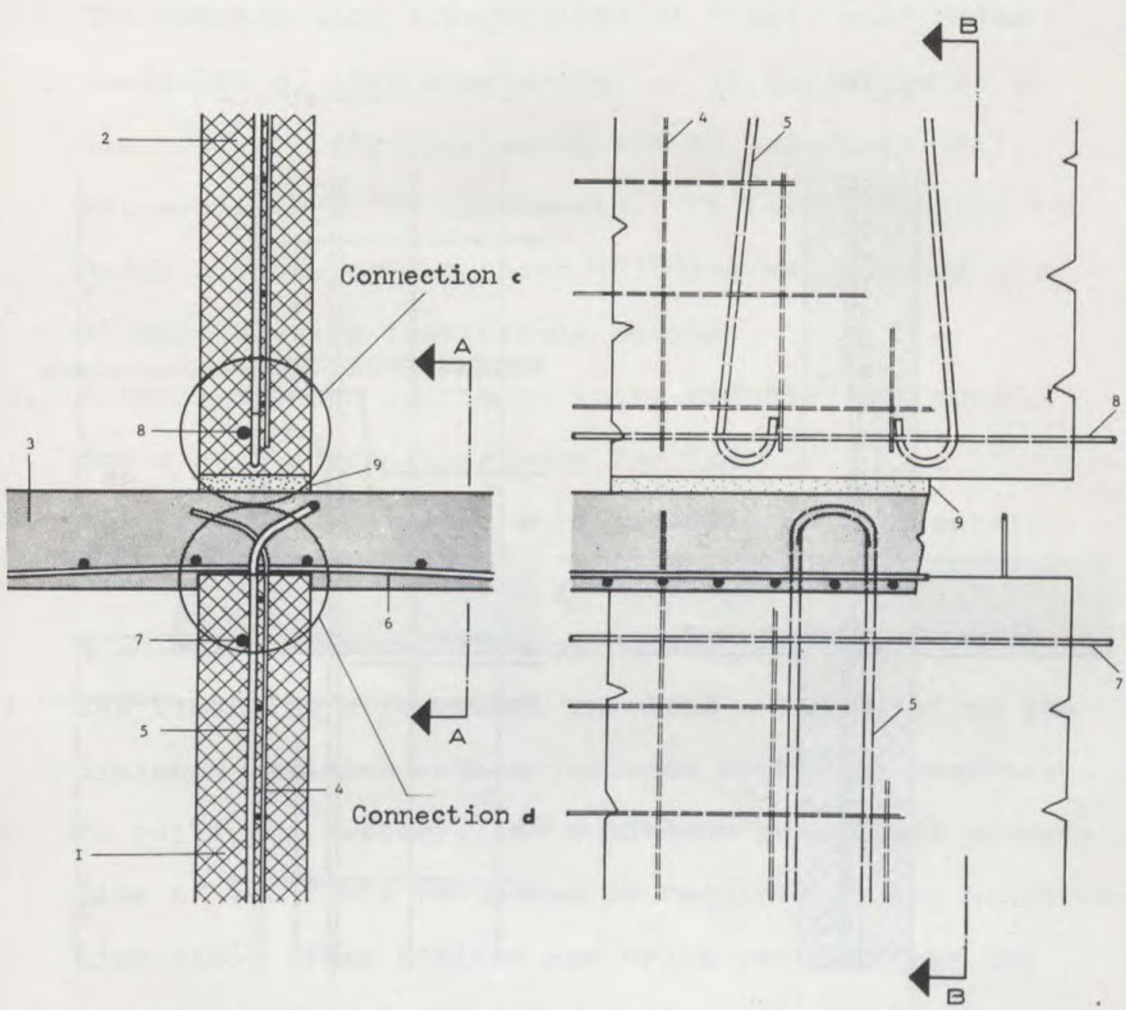


TABLE XV REALIZATION OF ATTACHMENTS DIAGRAMMED IN TABLE XII

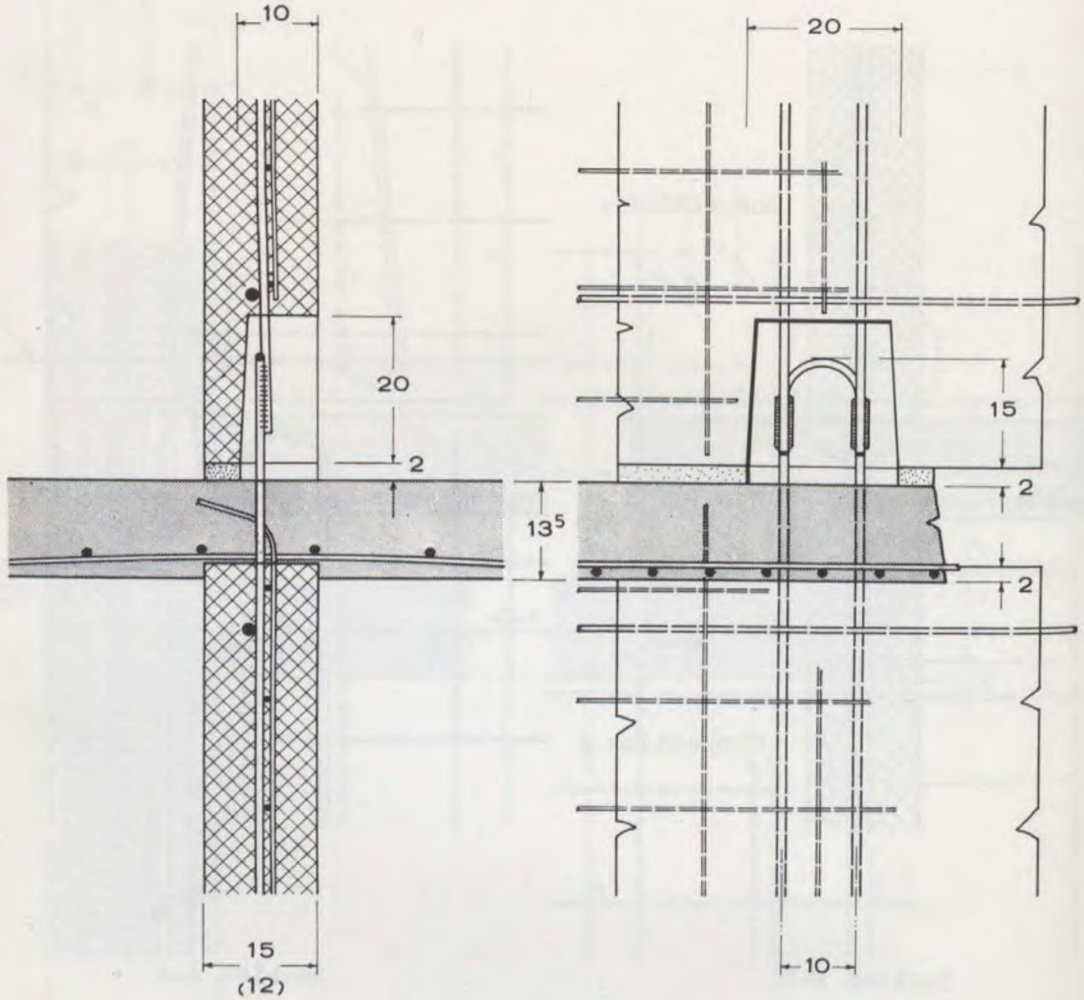


Section B-B Section A-A

1. Lower panel
2. Upper panel
3. Floor
4. Panel reinforcement
5. Lifting hook
6. Floor reinforcement
7. Reinforcement upper panel
8. Reinforcement lower panel
9. Sealing joints

TABLE XVI REALIZATION OF ATTACHMENTS DIAGRAMMED IN TABLE XII

(Attachment (c) subject to traction)



General Comments

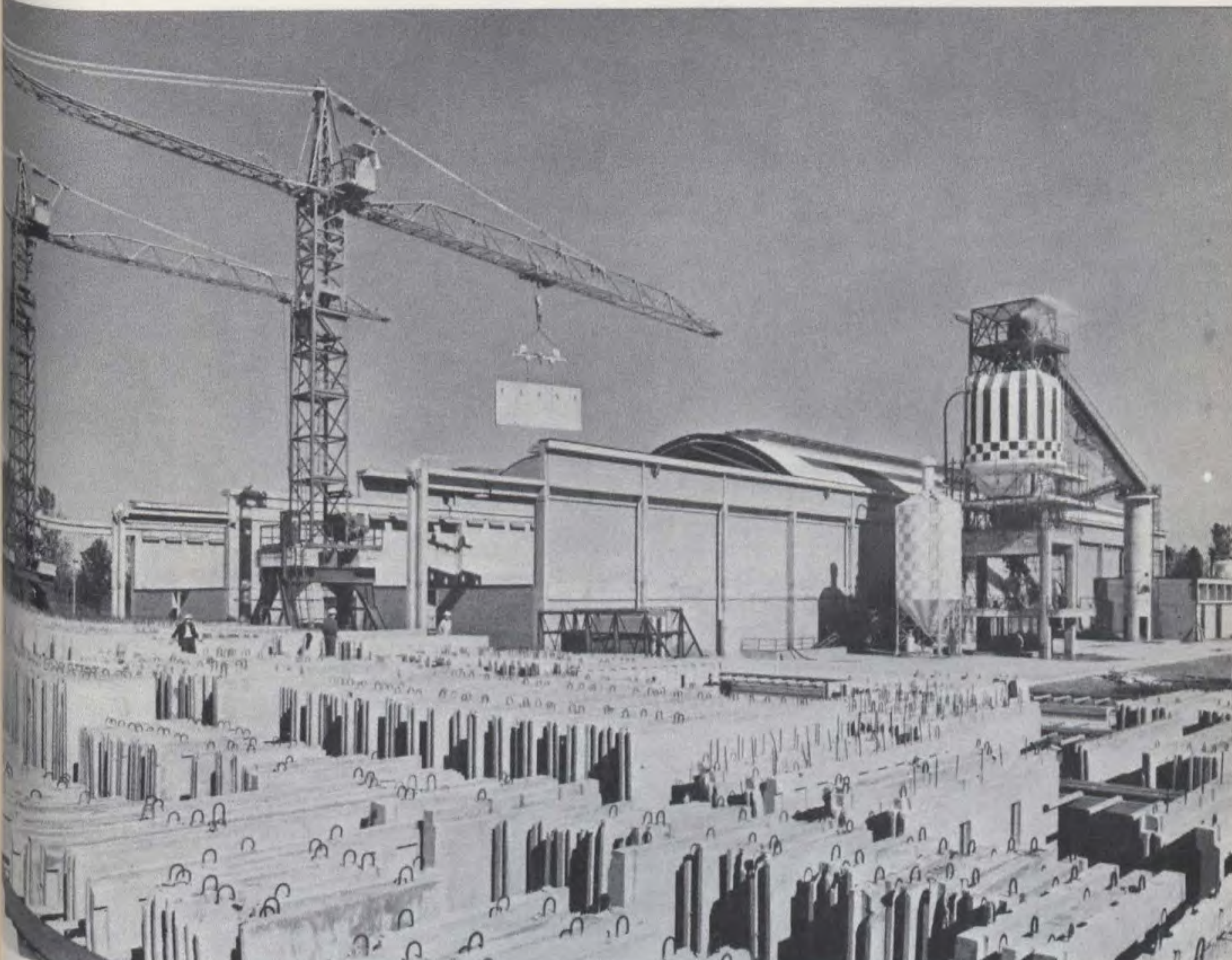
1. The construction site visited at Baggio near Milan consisted of 1540 apartments, -- 12 buildings of 10 storeys with 480 apartments and 15 buildings of 7 storeys with 1,060 apartments. It takes 7 months to build a 7-storey apartment building as compared with 18 months using traditional methods.

2. A three-bedroom apartment rents for $65 per month. and a one bedroom apartment for $38.

3. All apartments visited were intended as low rental housing and the kitchens were equipped only with a sink. There were no cupboards and counters.

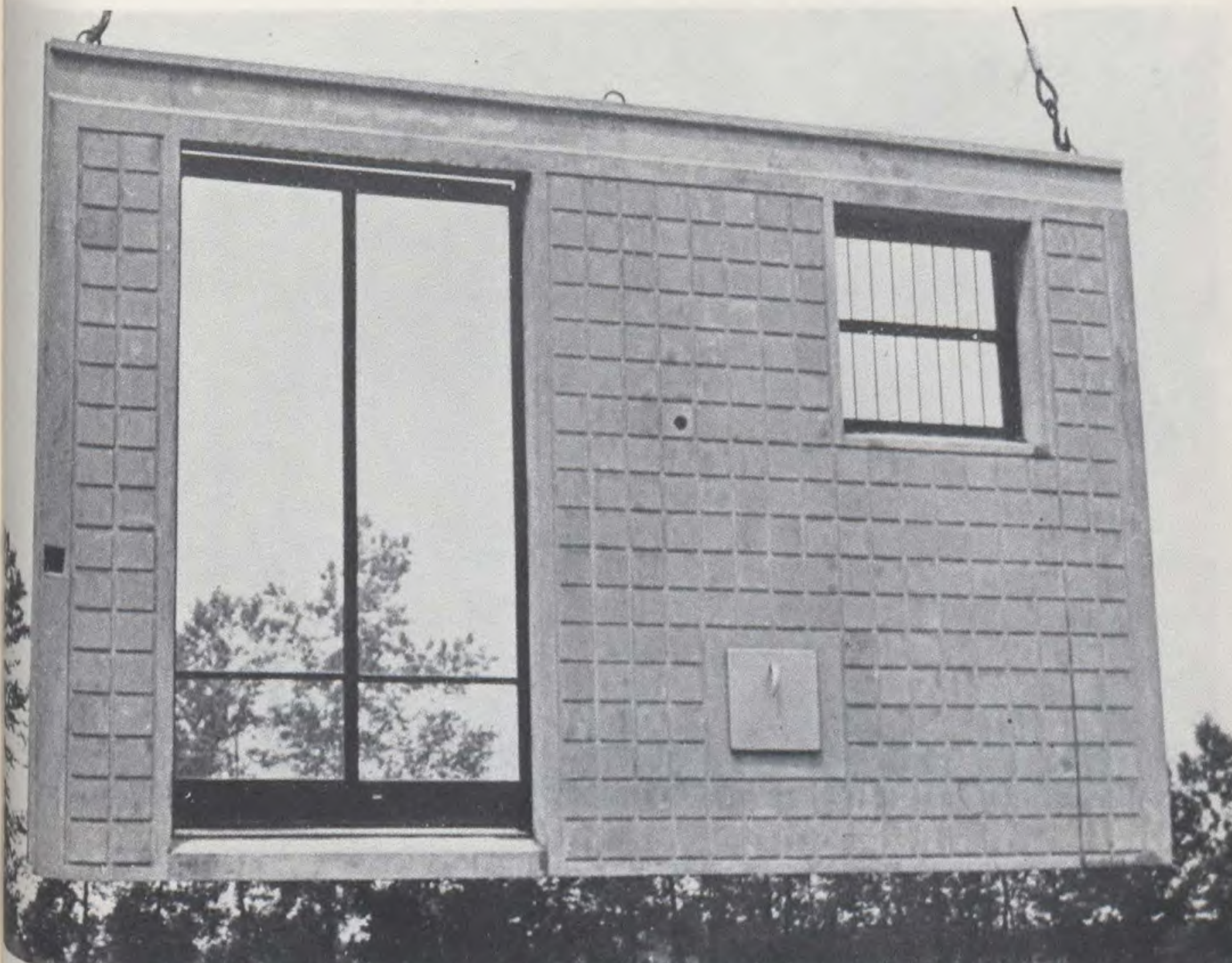
4 The licensing arrangement involved a fee based on the finished building. This includes technical assistance to build the factory, and a minimum guaranteed production of 400 flats per annum is required on the construction site. They utilize one crane per flat per day and 25 people per crane are employed to build the entire apartment; 18 people are involved in erection, seven in finishing and two in supply.

Speed of construction is due to the simplicity of building site operations (every crane erects 1-2 unfinished dwellings per day) and the reduced number of finishing operations. Buildings such as these, under construction in the vicinity of Milan, are delivered to the tenants within 7 months following the date foundations are begun, while 18-20 months would have been required with an excellent traditional building site.
Consequently, the customer benefits from a sizeable reduction in final costs, because of lower passive interest, earlier revenue from the building, in addition to the saving on maintenance costs, due to the decided technological improvement and the solidity of the finishing work.

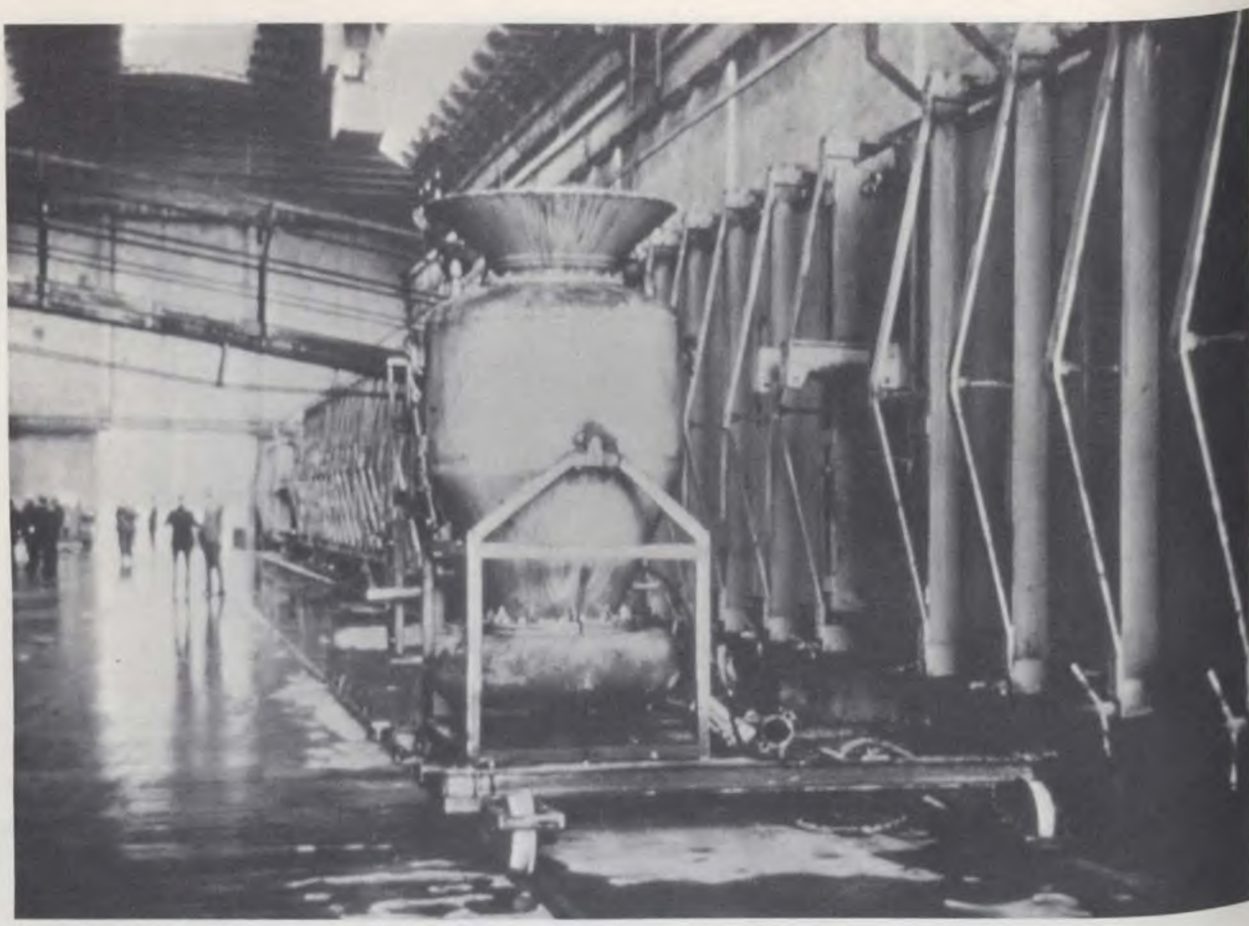


The MBM plant at Trezzano sul Naviglio, near Milan, will produce 2,000-2,200 dwellings per year when completed. The first half of the plant, which has been operating since April 1964, produces four apartments per day. The production of precast panels, their storage in especially equipped yards, their shipment to the building site at the proper time, and their assembling and finishing to completion are all carefully planned.
The Program and Methods Department determines the most efficient distribution of work and secures the necessary equipment for each operation.

All phases of production are mechanized to the highest possible degree, in order to reduce labour and improve the quality of the product, though permitting the building firm to adapt itself to the requirements of architects and various customers.
The knocking out of the panels, in this case a balcony floor, is carried out by means of a crane, the opening of the mould being operated by hydraulic jacks.

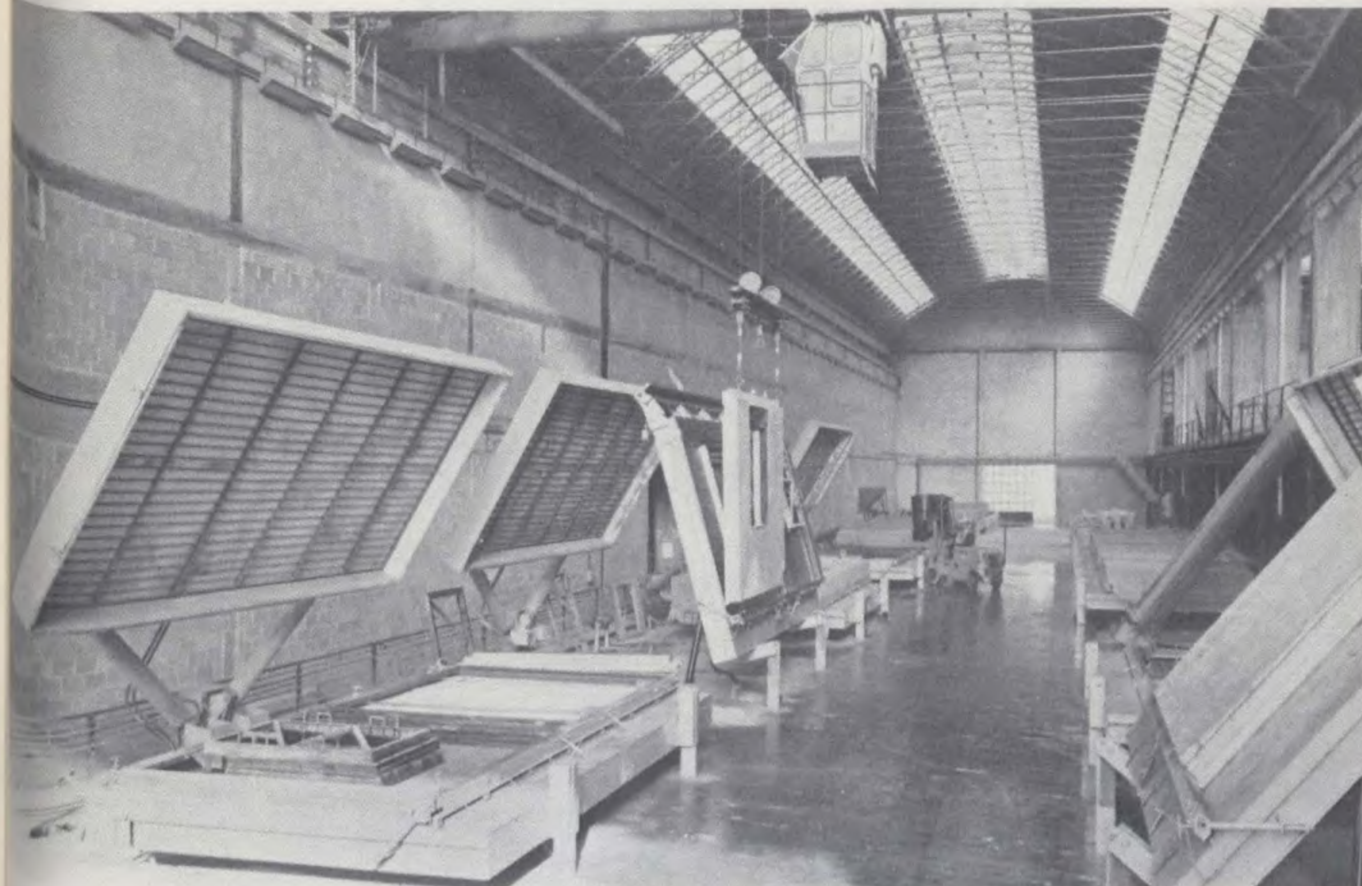


Plant-produced load-bearing concrete panels are completely finished and include all necessary mechanical elements. Dimensions may vary according to different plans.
The great weight of the panels provides good acoustical insulation by mass, and the cast-in thermal insulation greatly improves thermal properties.
By shifting the production from the building site to the plant, site-assembly becomes practically independent of the weather; at the same time, production is entirely mechanized.
The fundamental importance here is that the product is made by machinery, and the simple direct or indirect control (automation) of the latter is entrusted to man.
Thus, all stages of production are calculated scientifically, and complete industrialization of the building craft is achieved with appreciably reduced production costs and more efficient utilization of men and materials.

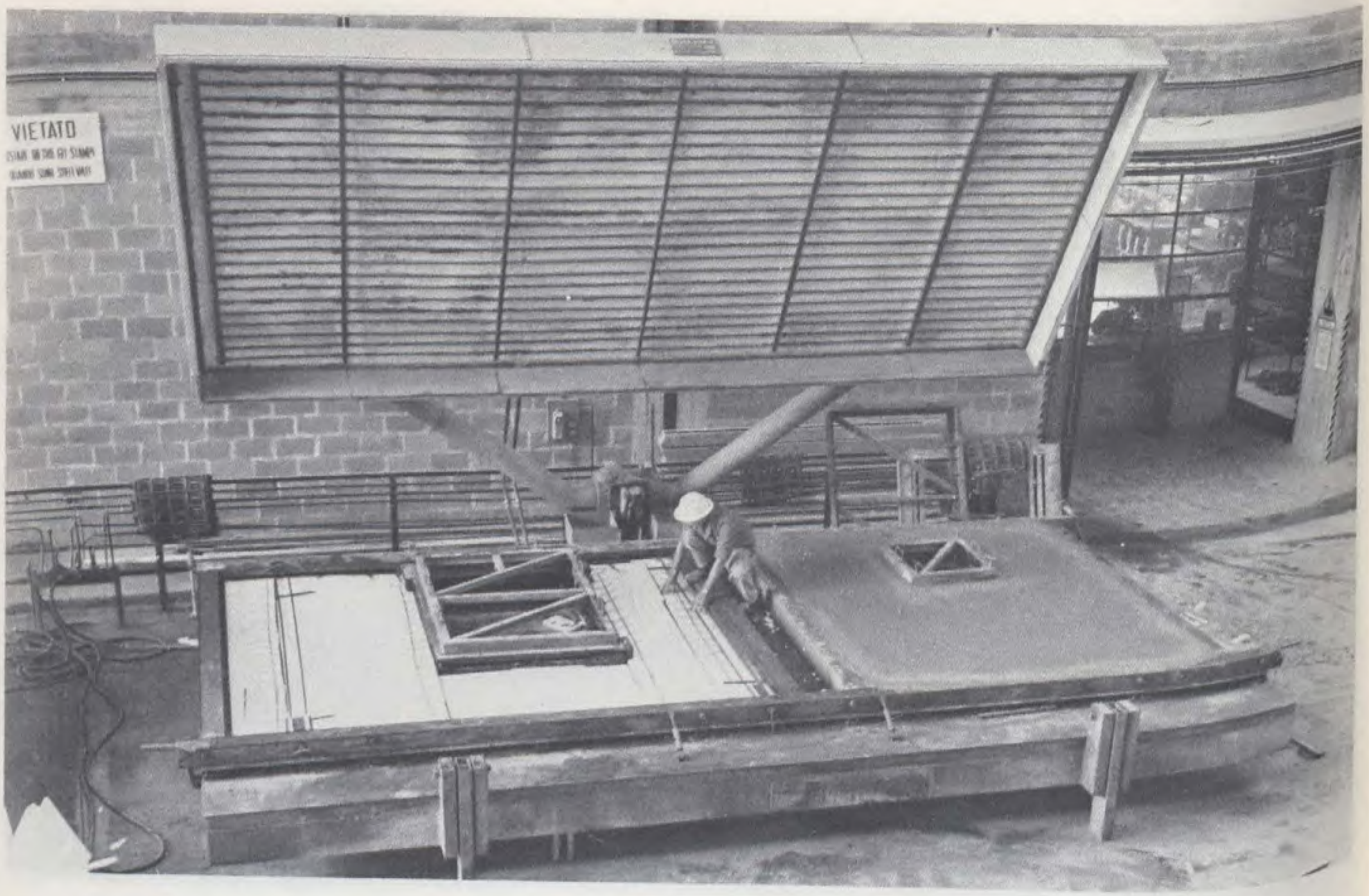


Multi-purpose casting machines produce interior wall panels. The machines can be easily adjusted to dimensional changes in length, height, and thickness of panels. One side of the machine is operated by hydraulic jacks, in order to facilitate the insertion of reinforcing steel, and later, removal of the finished panel. The concrete, brought by a forklift from the batching plant, is fed into a pump which fills the casting machines from the bottom. This method, aided by vibration, produces panels with two perfectly smooth surfaces.

The casting machines are heated with hot water to accelerate the curing of the concrete. Thus, panels can be removed from the machines 2-3 hours after casting. Door jambs and electric raceways are cast into the panels. Either an indoor overhead bridge crane or an outdoor tower crane is used for removing the panels from the casting machines, depending on conditions such as the complexity of the production, and local climate.

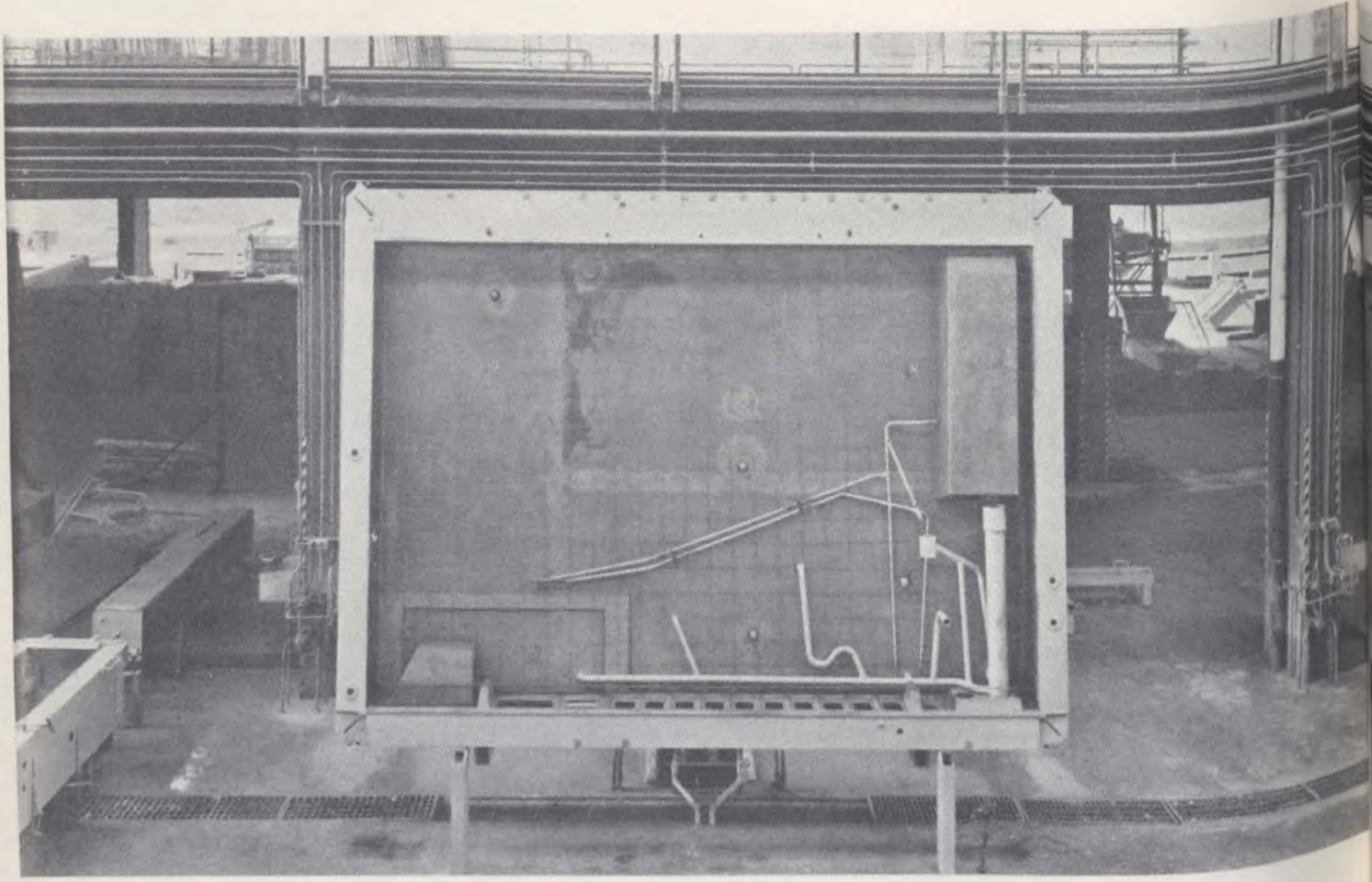


Horizontal casting machines are used to make the exterior wall panels. These panels consist of an exterior veneer embedded in concrete, a sheet of cast-in rigid insulation, and the load-bearing concrete layer with the interior finish. Window frames and electric receways are cast in. The exterior veneers may consist of brick mosaic tile, marble, marble chips, aggregate, colored cement, etc.
Like the vertical casting machines, the horizontal ones are adjustable to the desired dimensions of the panels. The table and cover of the machines are heated with circulating hot water and operated by hydraulic jacks. The jacks raise the machines to a vertical position; panels can be lifted out four hours after casting.
Each panel is then classified and removed to the inspection area where it is cleaned and minor flaws are corrected, so that no finishing whatsoever is needed at the building site.

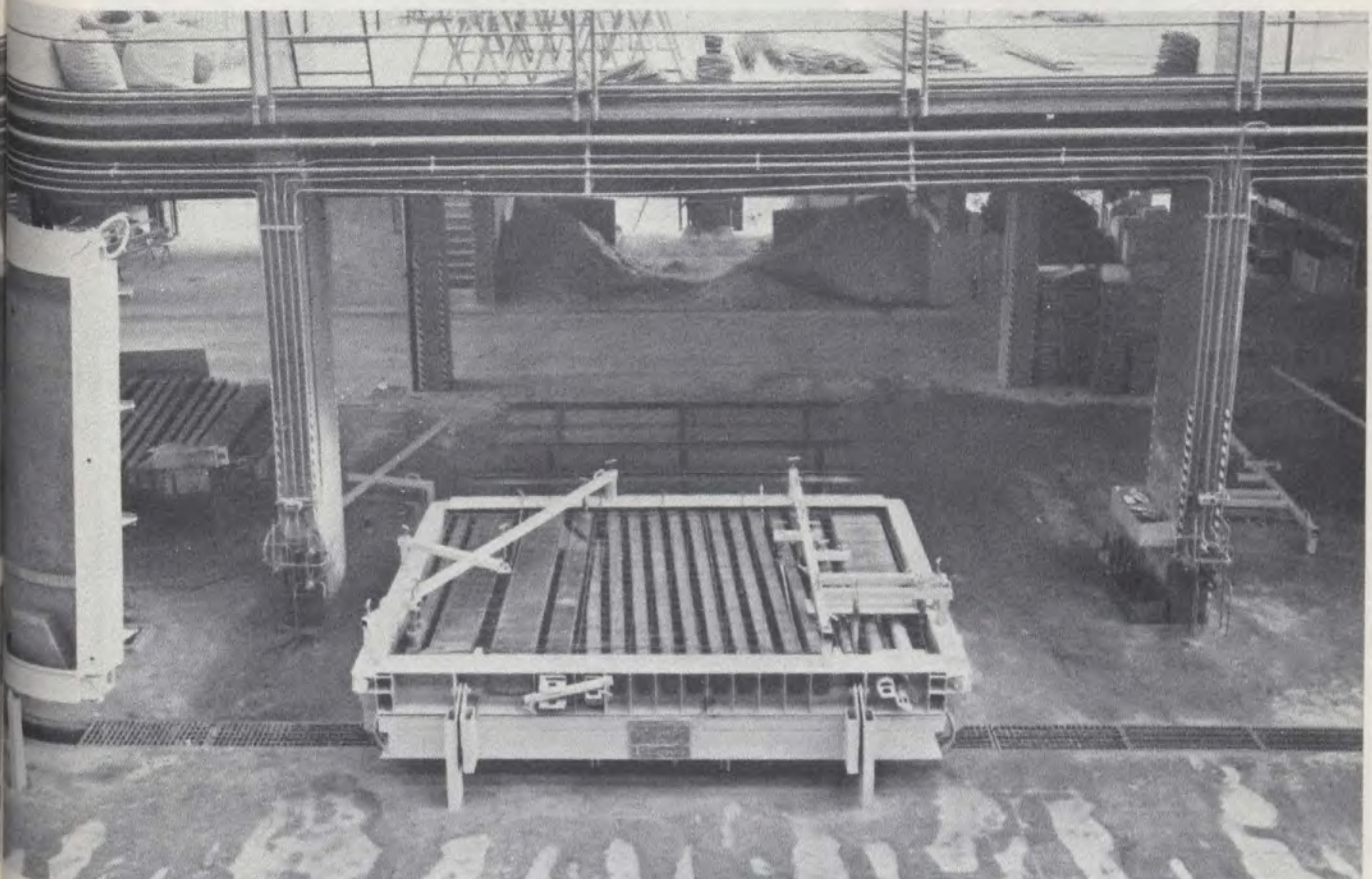


A continuous layer of polystyrene, incorporated in the façade panels or placed over the covering, envelops the entire building without any break in continuity and ensures total insulation.

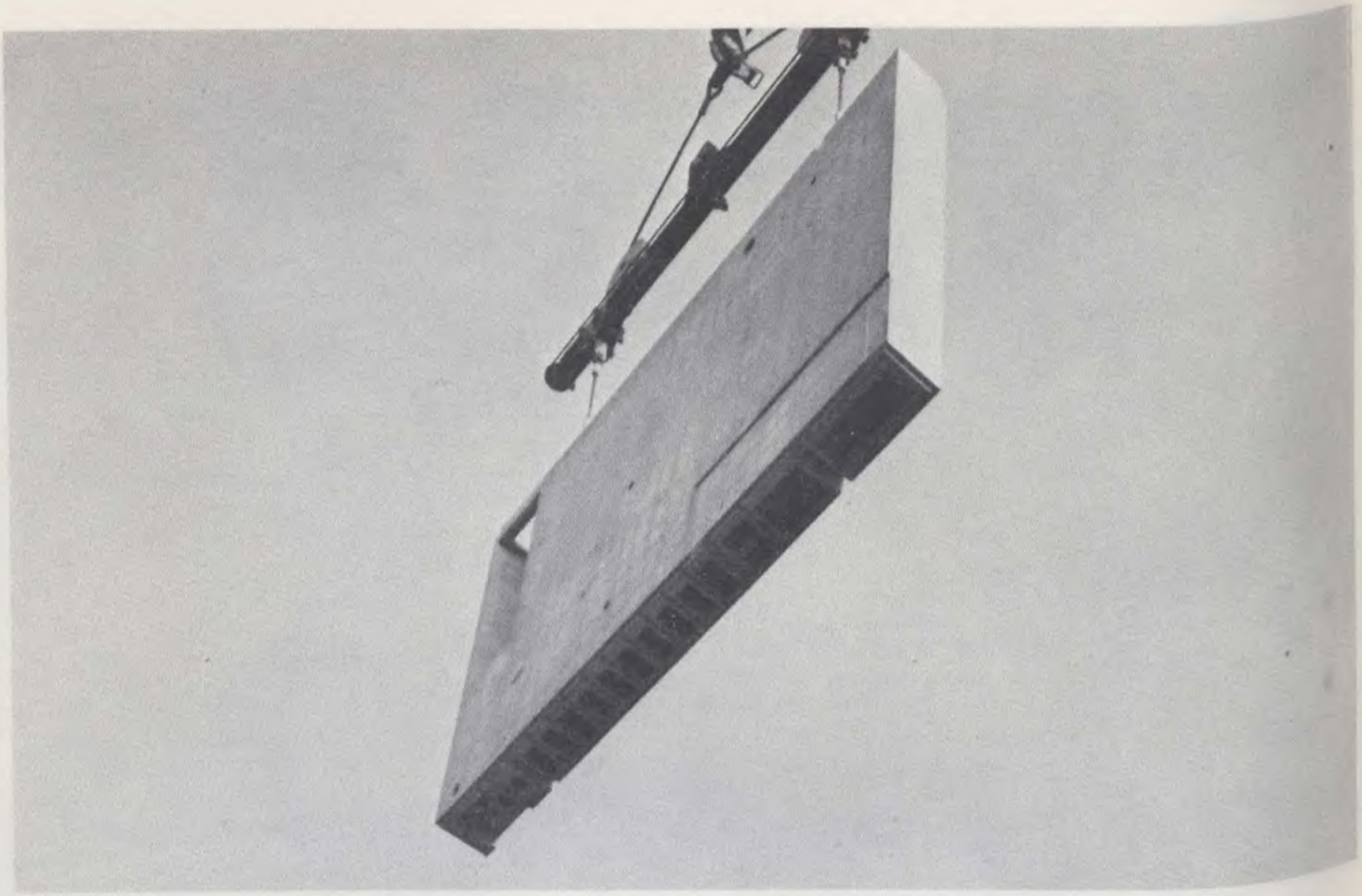
The panel reinforcements are prepared on the first floor of the central bay.
On arrival, the material is picked up by the cranes and set down on the storage terrace. From here, it is processed and distributed to the individual moulds.



The laminated steel hot and cold water pipes are arranged on the bathroom side of the mould (here raised in a vertical position). The drainage pipes are connected with a section of the vertical drainage column. Connections between storeys will be made by means of plastic joining pipe. The pressure pipes have welded fitting permitting capillarity.

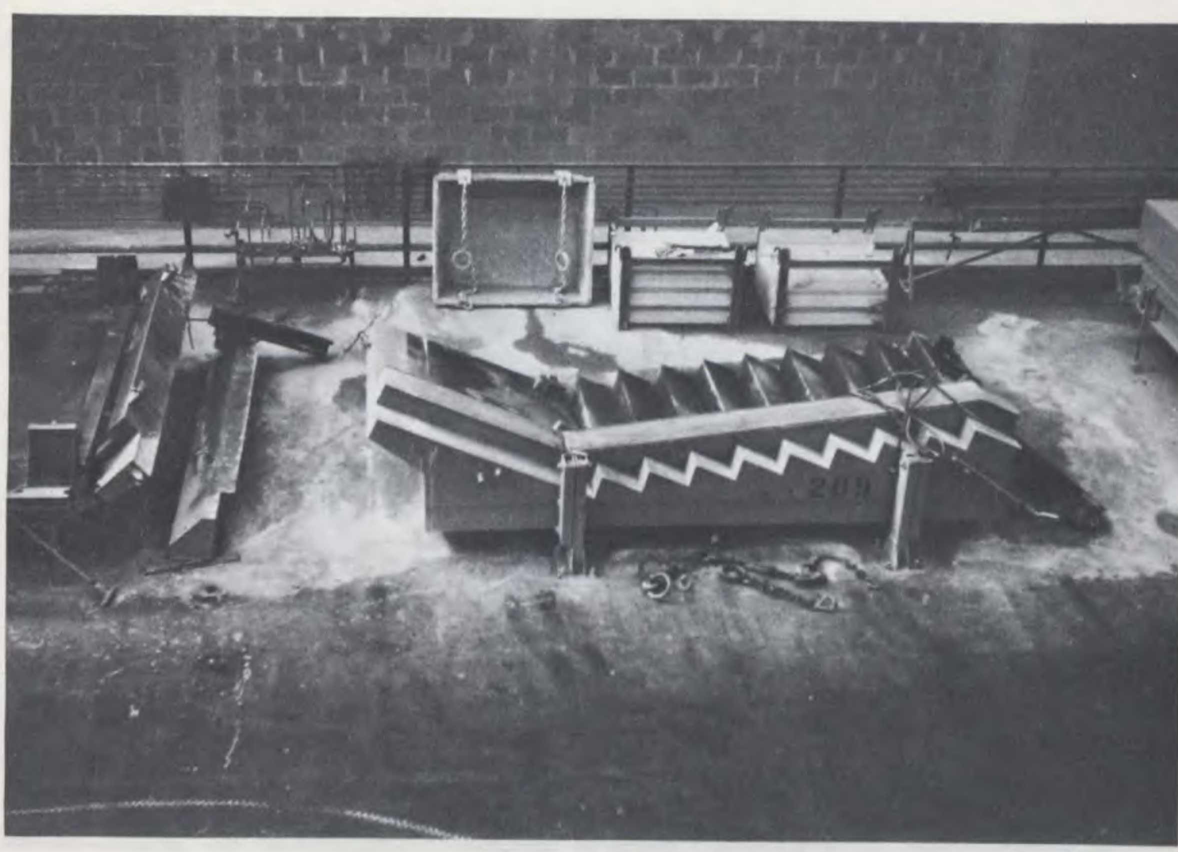


The preparation of the mould shown in the preceding photograph has been completed and the pouring of the concrete may now begin. The templates over the mould sustain the installations on the kitchen side. The mandrels which form the ventilating ducts will be removed as soon as the concrete has hardened.

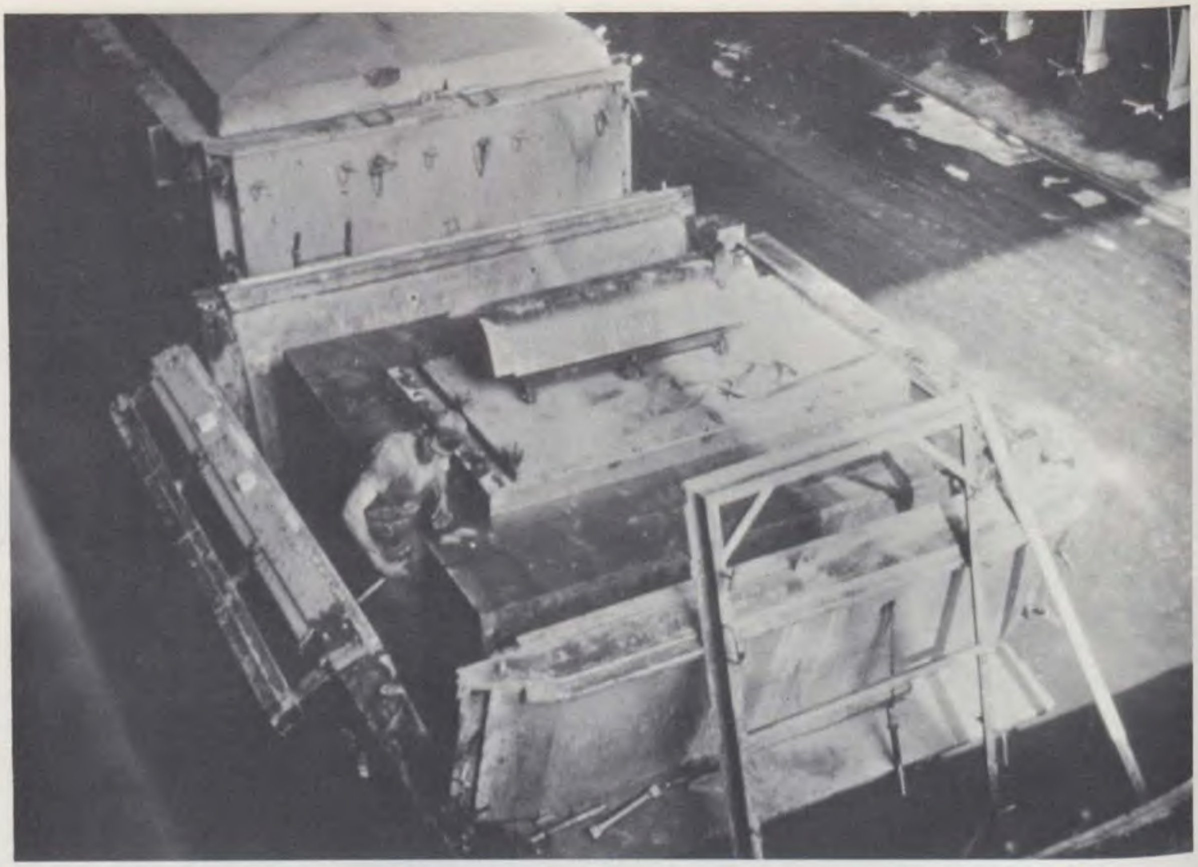


The panel formed by the mould shown in the preceding photographs weighs almost 7 tons. It is possible, by means of other methods, to incorporate the water and drainage systems in a simpler manner and so obtain lighter panels.

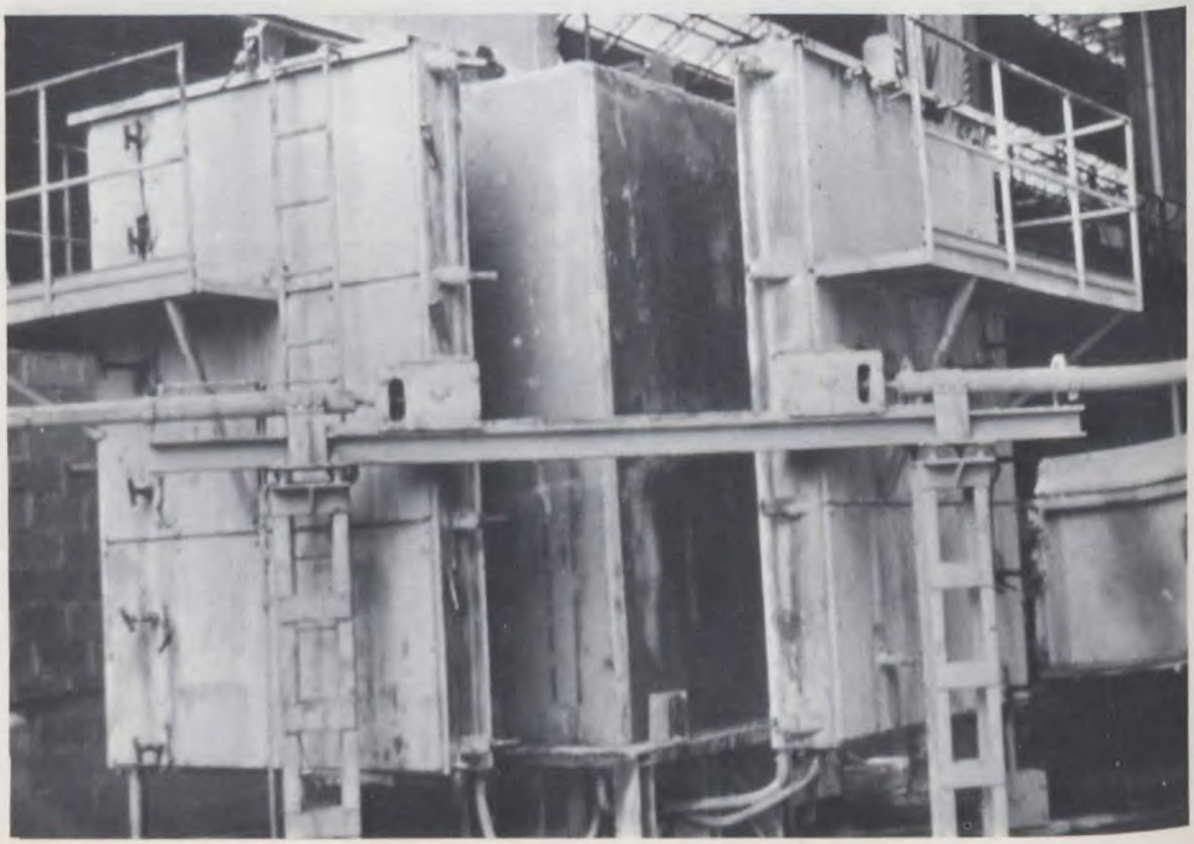
Casting table showing window opening and ceramic tiles applied on the face of the mould.



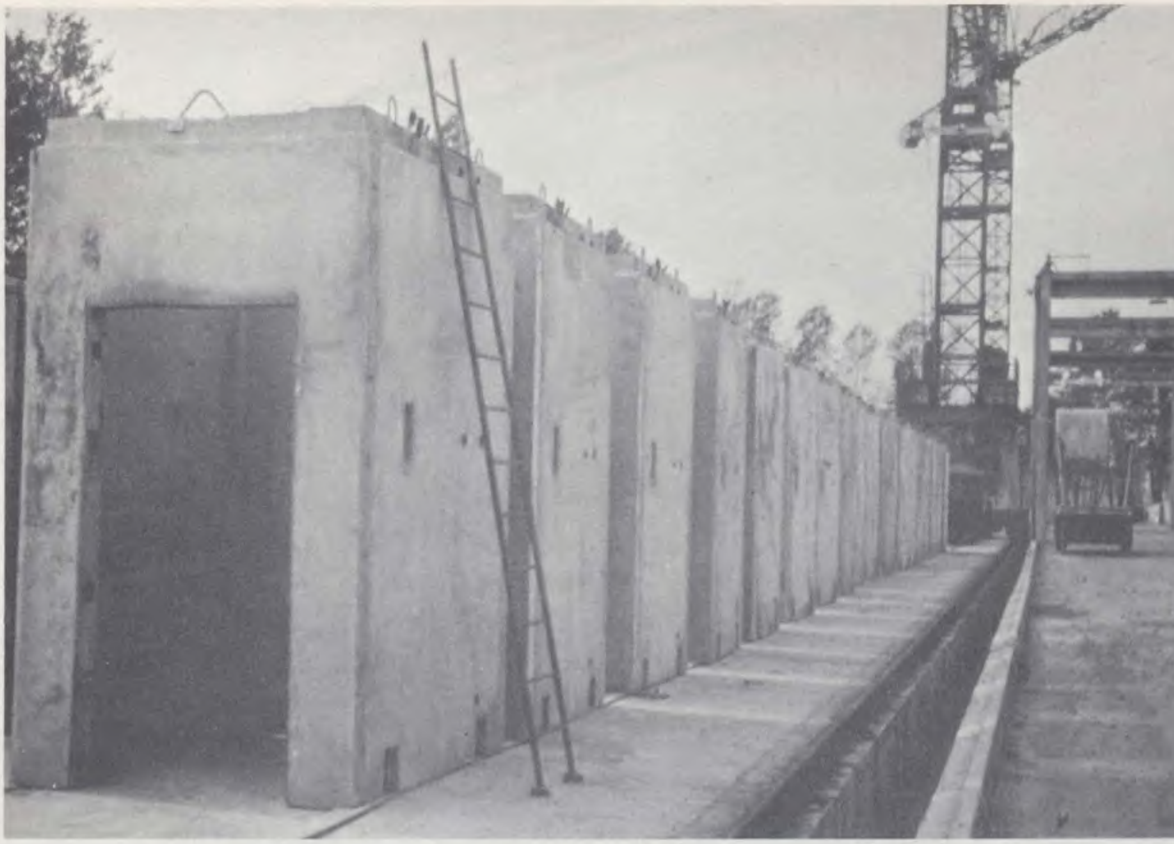
Machine for precasting stairs.



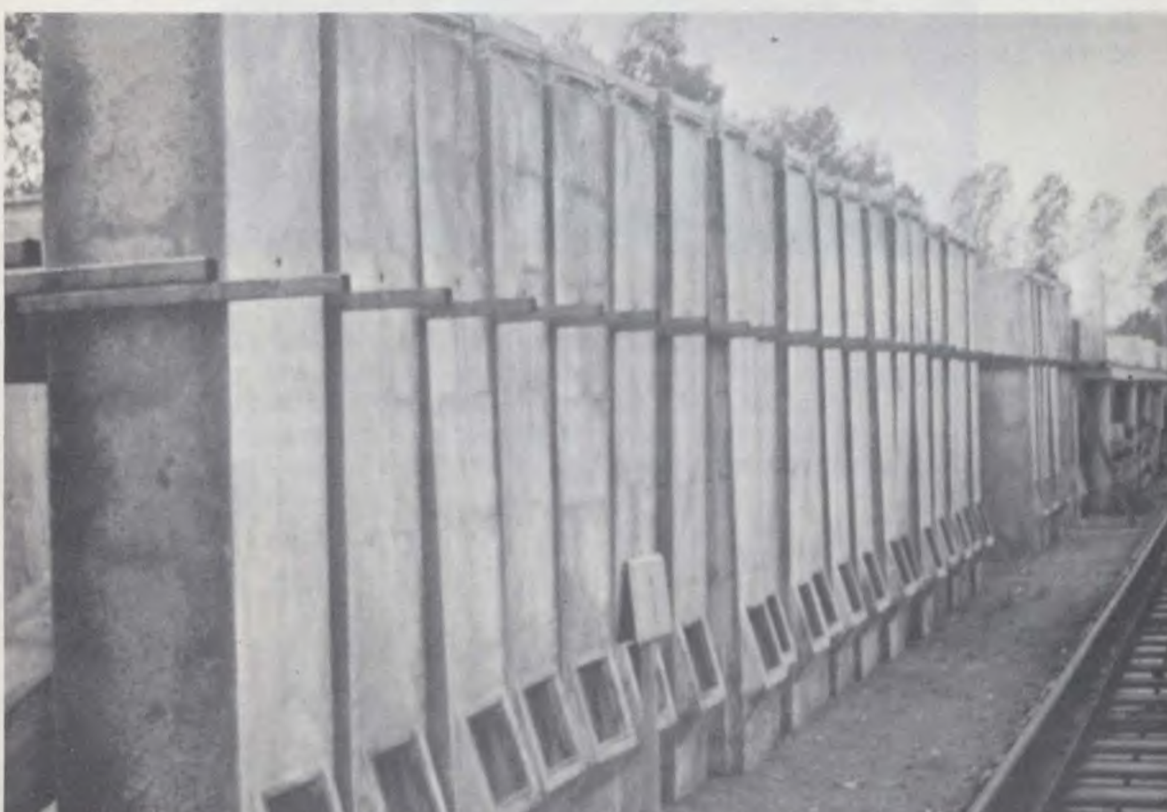
Machine for precasting balconies.



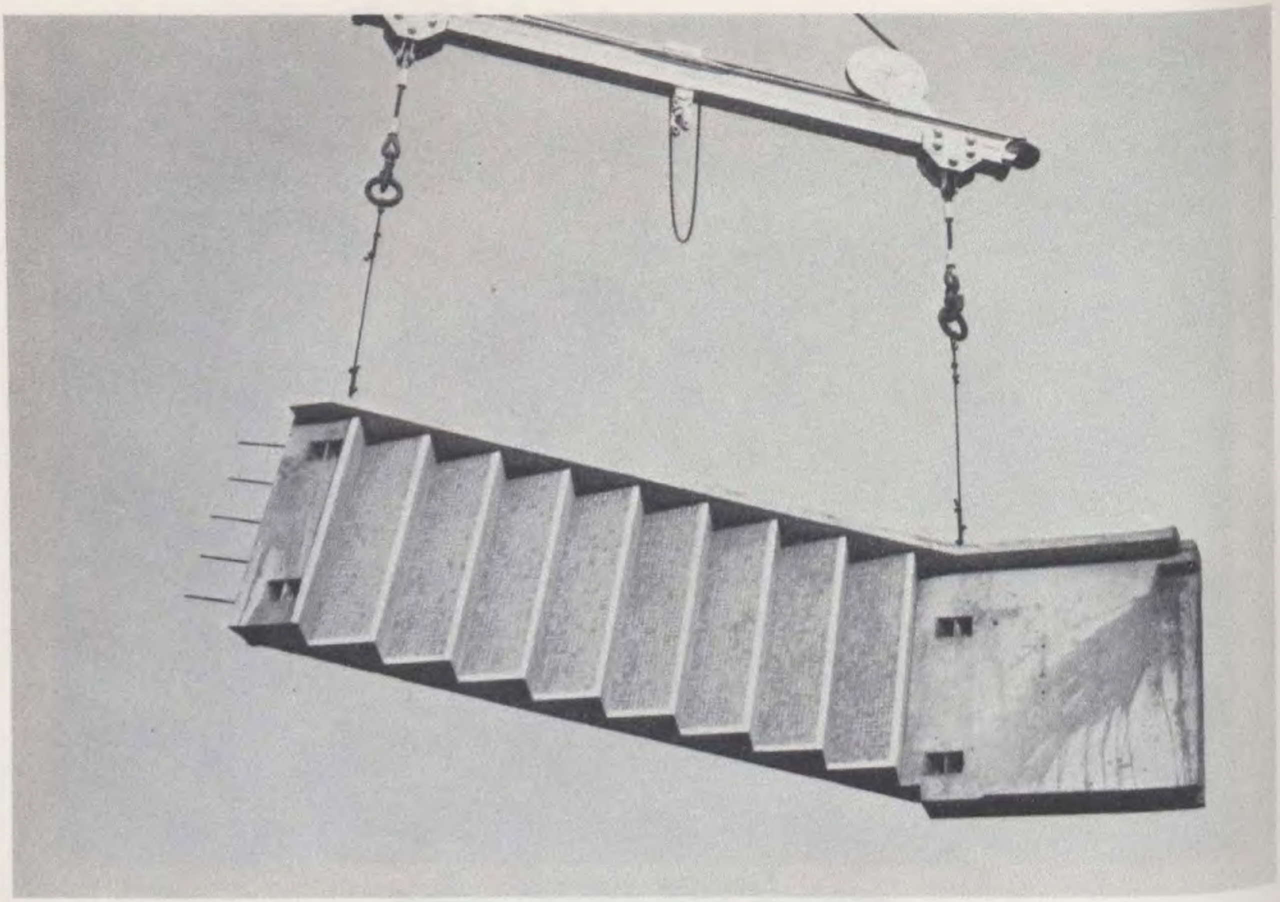
Machine for precasting elevator shaft.



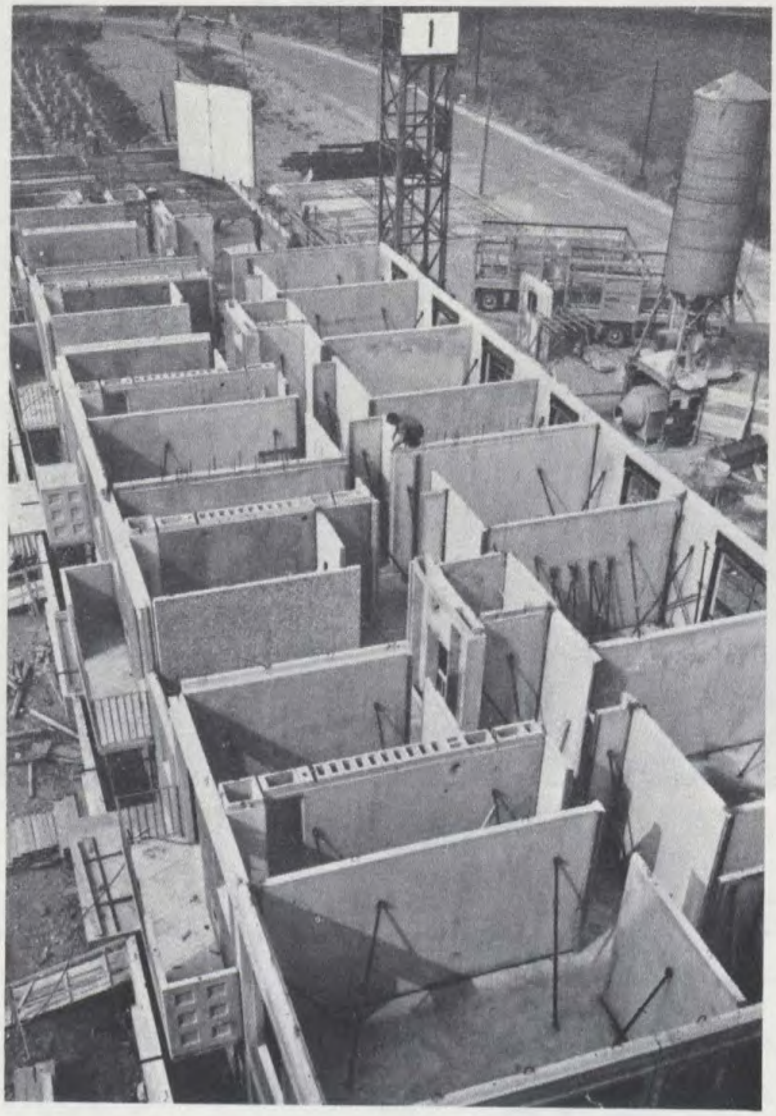
Elevator shaft



Garbage chute

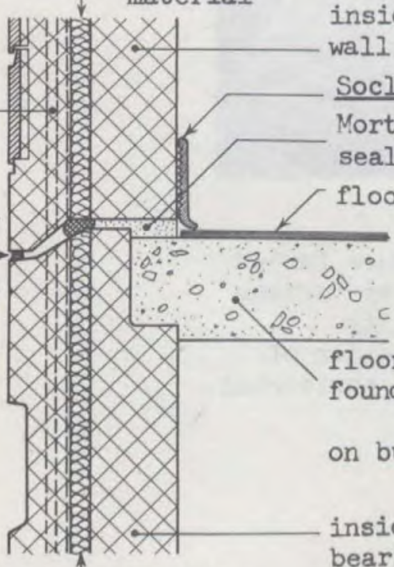


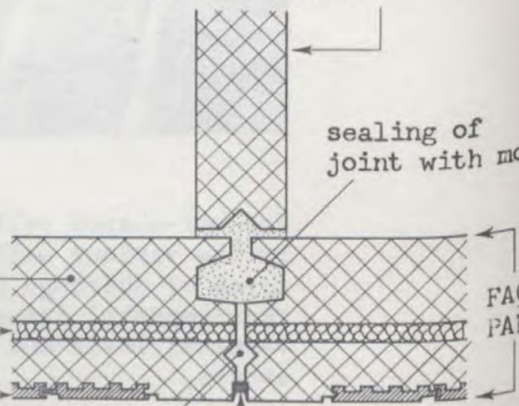
The covering of the stairs ramp may be of any type: here the tread is constructed from grès tiles and the riser from marble; the covering of the landings will be completed following laying.



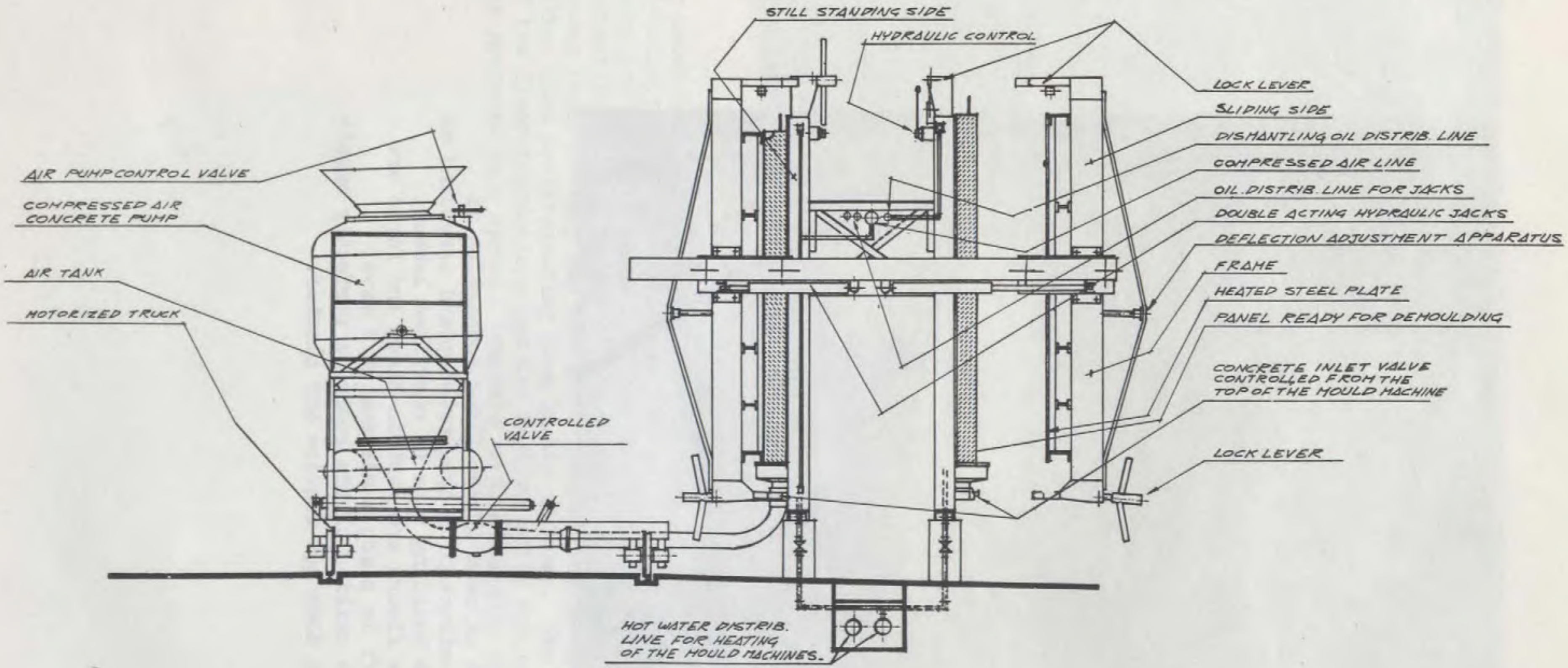
The box-shaped self-supporting structure formed by the various wall panels connected by various types of joinings depending on stability requirements, ensures an even distribution of vertical loads and high resistance to horizontal stress.

Balcony being erected.

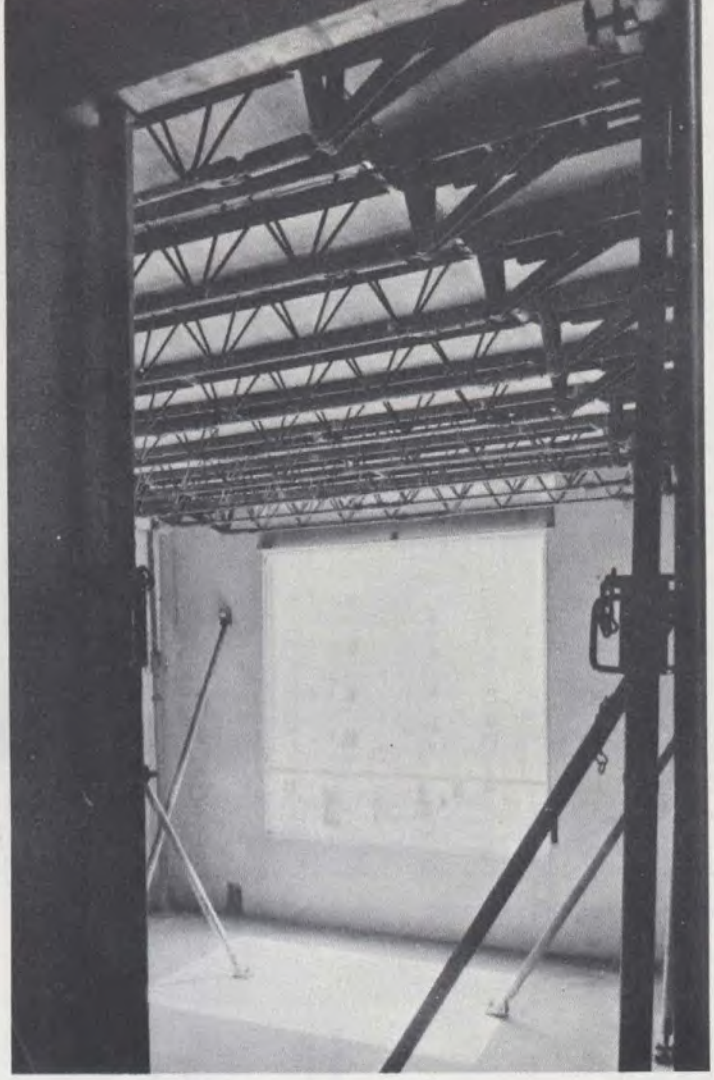




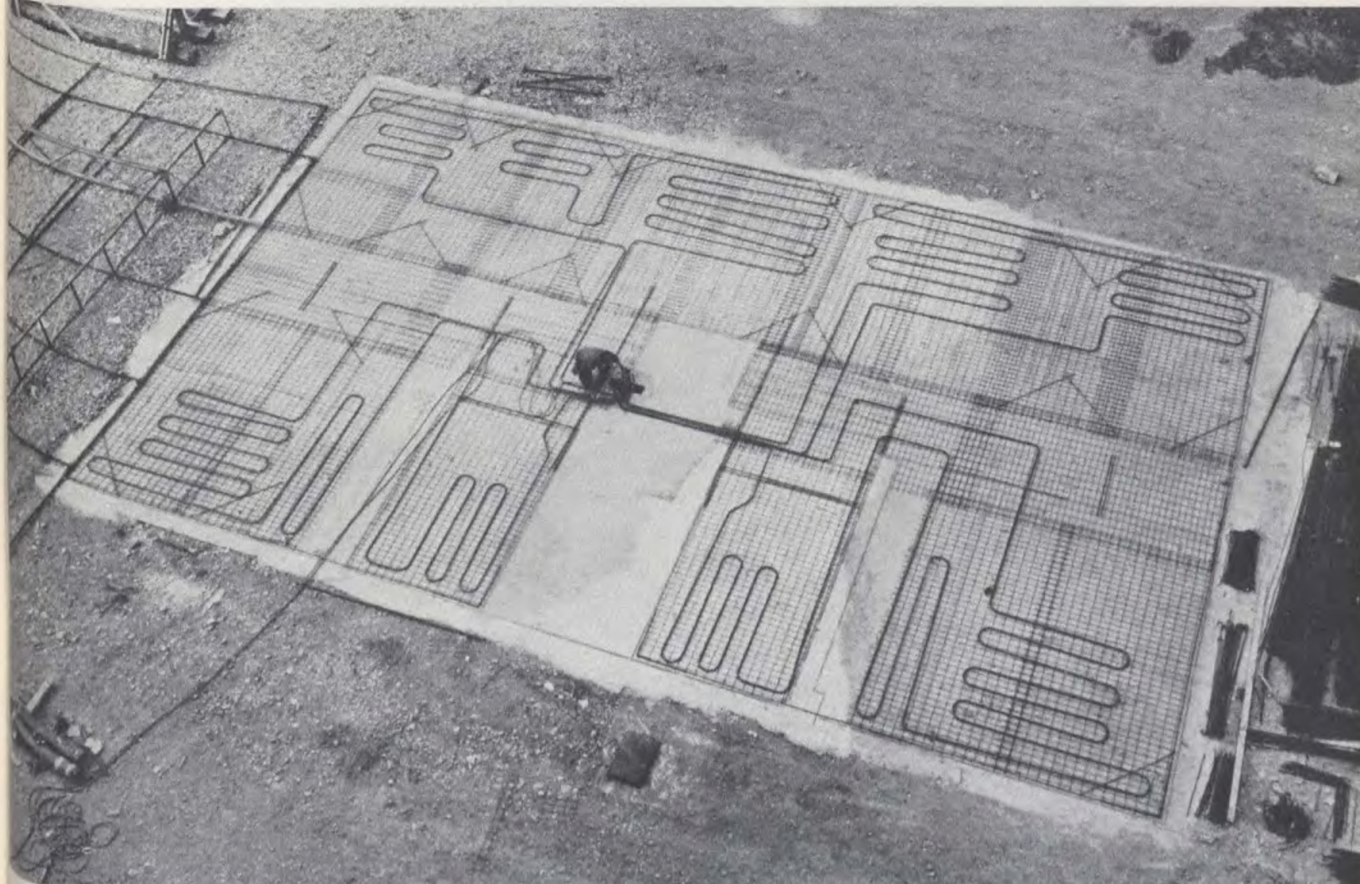
The outside and inside joints, like all the technical details of the house, are thoroughly studied. As may be seen from the drawing, the façade joint has a double closing; the first is in plastic and the second in concrete, with a drainage duct between them. The inside joints are of various types depending on stability requirements.



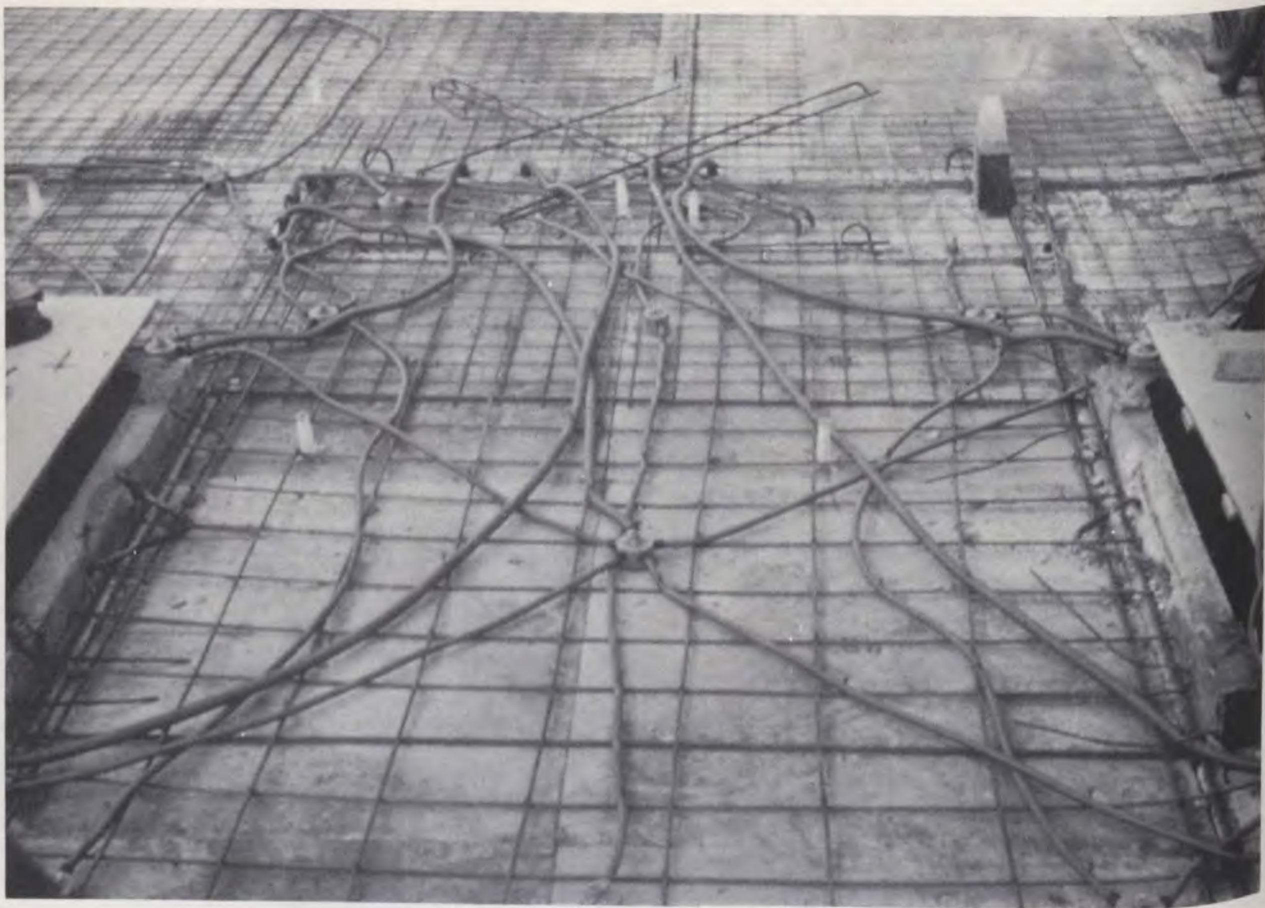
In order to prevent the formation of air holes on the surface of the precast panel, the concrete mix is pumped into the vertical casting machine from the bottom. In this method, the pumped concrete has less tendency to segregate than concrete falling through a trunk. Occasional surface imperfections can easily be smoothed over with spackle and paint.



The caisson of the floor foundation is constructed in the workshop and assembled on the building site by unskilled labour.
The floors are cast-in-place and forms are left in place a minimum of 8 days.
The ceiling of the rooms is perfectly smooth and does not require any plaster.



In order to industrialize the production of the technological installations of the building, they prefabricate complete units which are inserted into the floor foundation without delicate connections. This is one of the reasons why - at least in multi-storey houses - they lay the floor foundations on the building site rather than prefabricating them in the factory. The reinforcement of the floor foundations and the heating coils for two apartments are prepared on a special template on the building site.



Electrical wiring and outlet boxes are cast in the floor slab. The wiring is preassembled and inserted in plastic conduit and attached to the outlet boxes ready to be placed on the formwork.

The erection of multistory buildings is best with tower cranes moving on tracks. Each crane can assemble the complete shell of 1-2 dwellings per day. The box structure formed by exterior and interior wall panels connected by various types of joints, according to structural requirements, insures an even distribution of vertical stresses while providing maximum inertia against horizontal stress even in areas subject to seismic shock. Brackets fastened to plastic inserts in slab and panels support the panels temporarily.

Concrete slabs are either precast or site-cast. Site-casting is preferable for multistory buildings for it permits greater design flexibility, produces monolithic structures, and permits integration of pre-assembled electric wiring and radiant heating. In this case the form-work is easily assembled and produces perfectly smooth ceilings that require no finishing.

Installation of stairs.

Façade panel ready for shipment

SICOP COIGNET s.p.a.

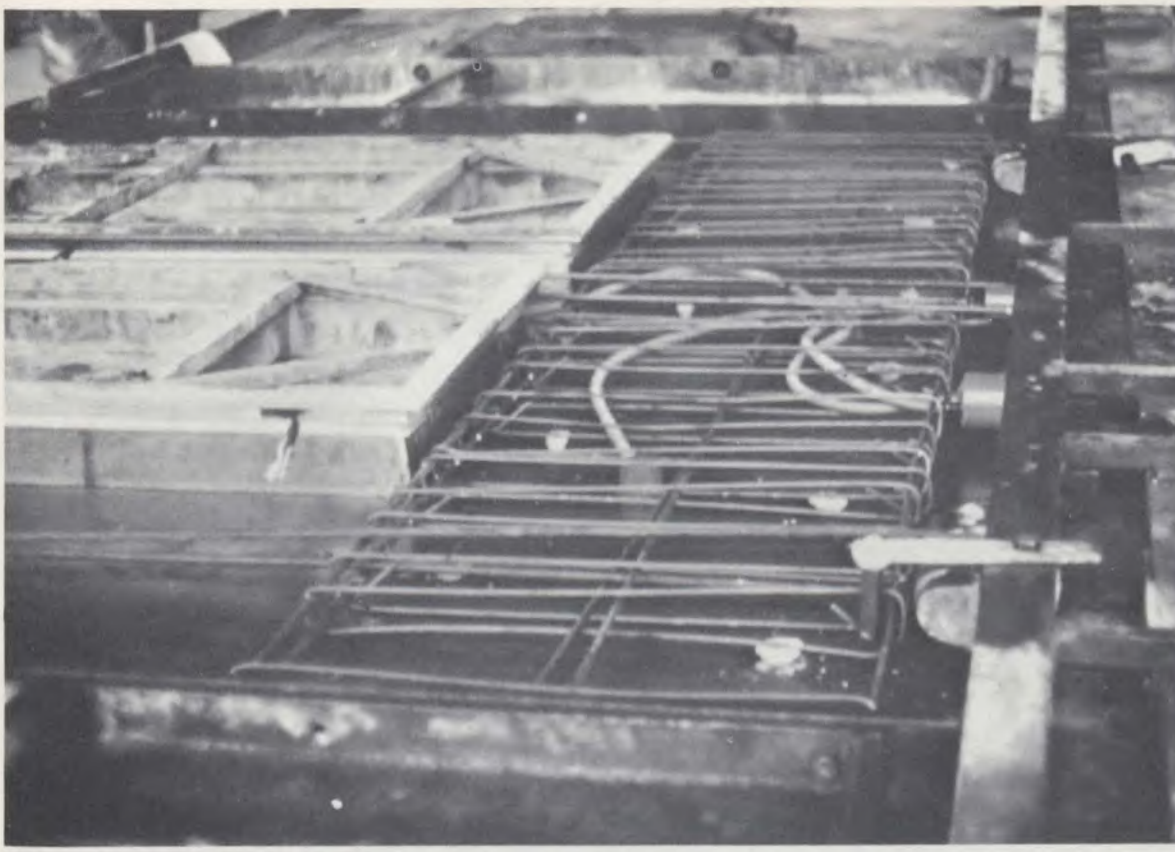
Sicop-Coignet s.p.a.
Bubbiano, Italy

SICOP COIGNET s.p.a.

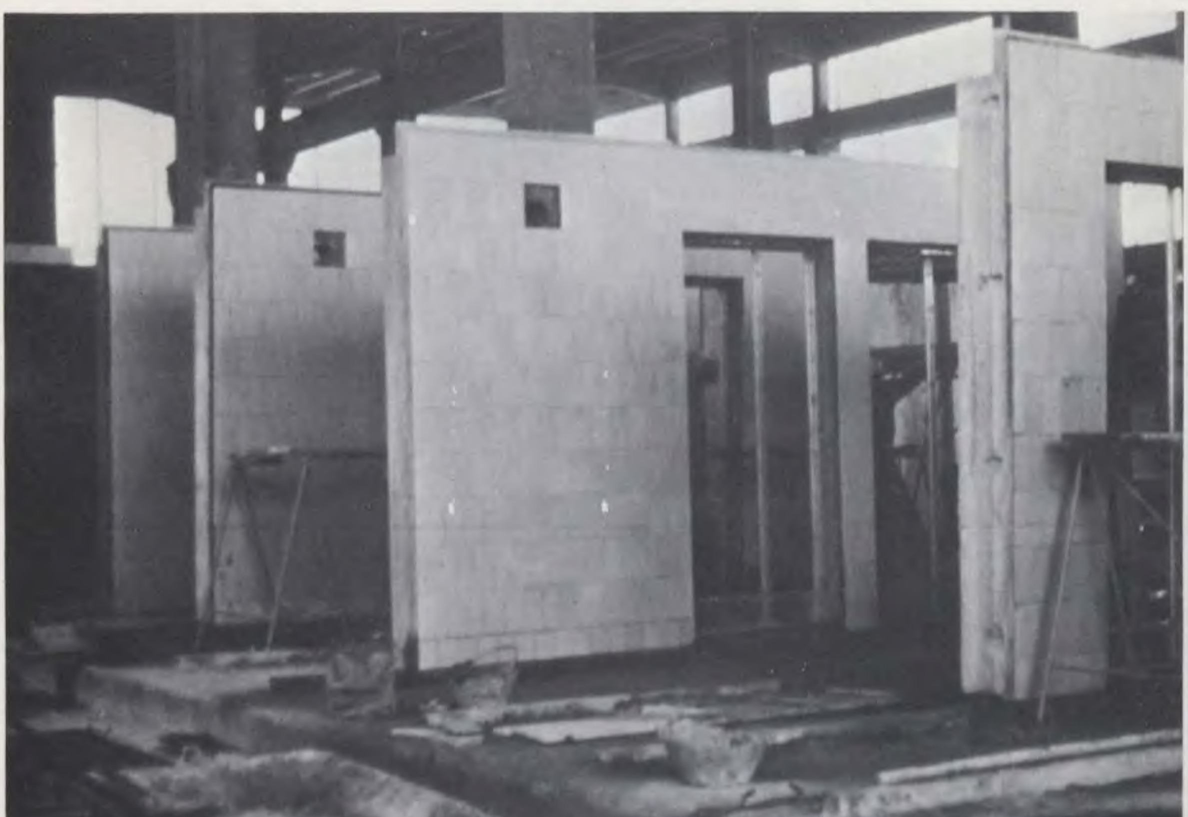
On the morning of September 20, the Mission visited the factory and one of the construction sites of the Italian licensee of the Coignet System - Sicop Coignet s.p.a. at Bubbiano, near Milan.

They follow the Coignet system and are equipped with the same type of heavy machinery that the Mission members saw in Paris. The plant layout is very good and the batching plant is one of the most modern seen to date. They use belt conveyors to deliver the cement to the concrete buckets. The plant is four years old and cost over $1,500,000 to build. Floor slabs require one-half hour to prepare and two and one half hours to cure. They use electrical curing to accelerate production and the wages at the factory are from $1.50 to $2.00 per hour.

We visited the construction site near Milan which they are sharing, on a large project, with other systems builders (M.B.M., Italcamus, Camus, Fiorio and Costamagna). The smallest apartment rents for $40 per month including heating and water. Kitchen floors are made with terrazzo while vinyl tile is used elsewhere. The quality of finish of the apartments visited was very good.



Horizontal casting table showing window frame, steel reinforcement and plastic electrical outlets and conduits in place prior to pouring concrete.



Façade panels in inspection area.

Large panels for use below grade.

Experimental apartment made of brick panels precast in plant.

Low rent apartment project near Milano.

FINTECH ITALCAMUS s.p.a.

Fintech Italcamus s.p.a.
Settala
Milan, Italy

FINTECH-ITALCAMUS s.p.a.

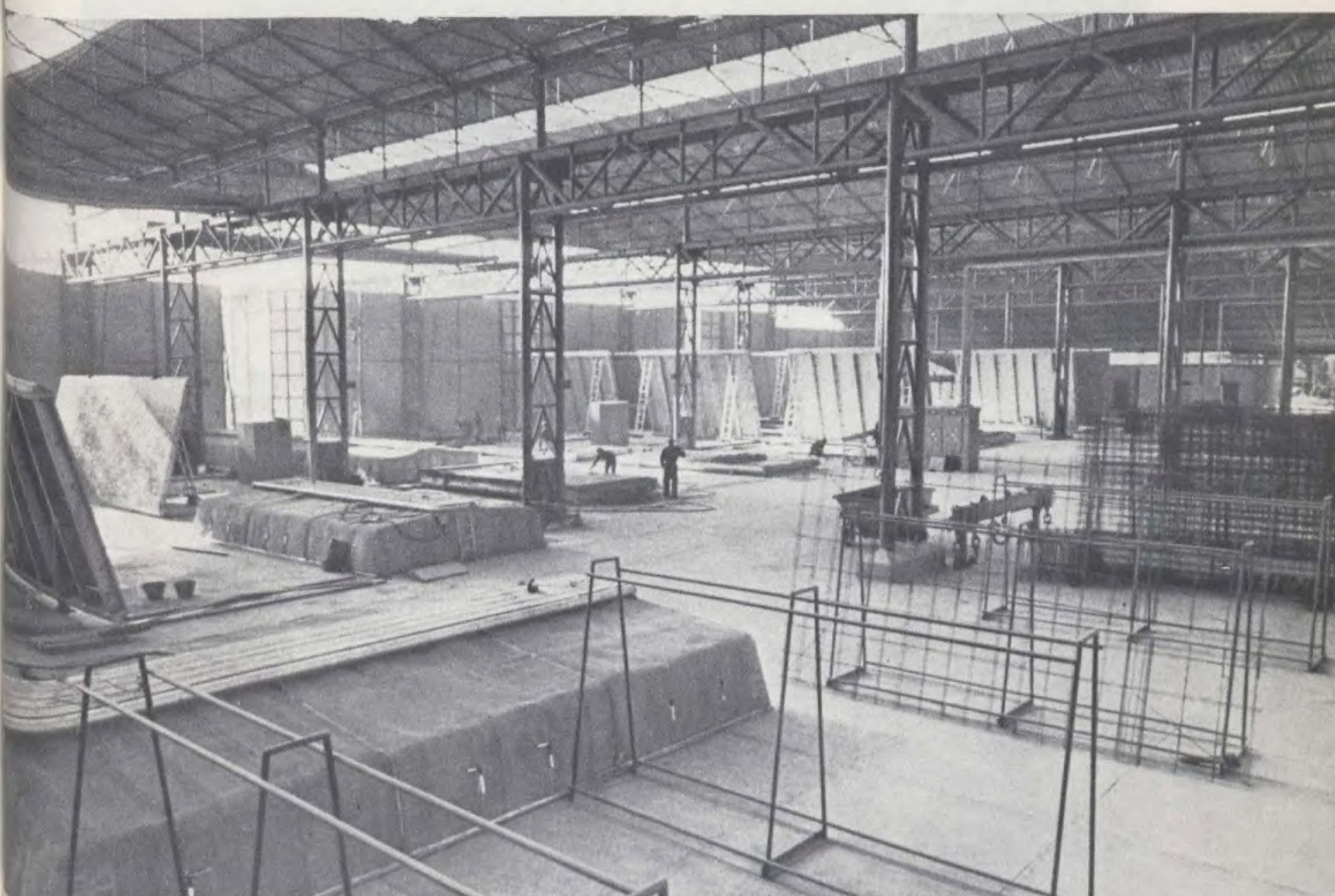
During the afternoon of September 20, we visited the large construction site near Milan where Camus and a group of four other system builders are erecting large blocks of apartments.

The project is for low rent housing and the quality of the finished product is very good. Following the visit at the site, the Mission visited the plant which was designed by the Camus engineers of Paris. The plant was built in 1963 at a cost of $1,500,000 including equipment, trucks, cranes, etc. Two months after the plant was opened, it was in full production. They use electrical curing, and thermostats control all the electrical heating.

They claim that this type of curing represents a saving in electrical costs and improves the quality of the finished product. The plant is very functional, the equipment is up-to-date and well kept and the workmanship is very good. The plant has 30 casting tables. The average cost of a horizontal mould is approximately $5,000. The capacity of the plant is 1,500 apartments per annum with a shift and a half.

Since the plant was built they have produced 2,000 apartments per annum. They produce four apartments per day per shift. They employ 150 men per shift and the minimum wage is $1.70 per hour including all charges.

They work 45 hours per week. It requires 13 man hours to produce one panel.



Fintech Italcamus plant at Settala near Milano, Italy.

10 storey low rent apartment buildings near Milano.

THE JOHN LAING CONSTRUCTION LIMITED

John Laing Construction Limited
14 Lower Regent Street
London, England

THE JOHN LAING CONSTRUCTION LIMITED

The Mission visited the John Laing group of companies on September 21 and 22.

The Laing group of companies is an international organization engaged in building, civil engineering, property development, investment, and manufacturing in various parts of the world. They have adopted some European systems and have designed their own system to meet conditions in Great Britain.

During our visit, all members of the Mission had an opportunity to discuss the Sectra System, the 12M Jespersen System, the Easyform System, the Laingwall System and the Laingspan II System, and to visit their research establishment and product development companies.

1. The Sectra System is described as a concept of building in a logical manner, involving the use of high precision heated formwork, (thermo-coffrage) combined with mechanical handling, prefabrication and a systemized allocation of labour which brings factory speed and precision to the building site.

The John Laing Construction Limited has acquired the sole rights in Great Britain for the Sectra patented system of rapid, multi-storey flat construction developed by M. Lucien Quentin, a French consulting engineer. The system is designed for buildings of up to 25 storeys and has already been used extensively in Europe.

Sectra is basically a method of using precision-made steel formwork in rectangular 'tunnel' sections, in room or two-room widths and ceiling heights, for the placing of in situ structural concrete. The main feature of this formwork, which is rapidly lifted into position by tower crane, is that it is internally heated, to accelerate the hardening of the concrete. In this way it is possible to reduce the time during which the concrete must be supported by the formwork from several days to only 13 hours. In addition, the heated formwork considerably reduces unproductive time when work is normally brought to a halt in cold weather. Extensive use is made of prefabrication for partition walls, staircases and plumbing. Substantial economies in labour and transport are achieved by Sectra, compared with the manufacture of large precast structural components at a central factory. By bringing factory methods of production direct to the site, Sectra increases productivity and reduces the overall labour content. This method of precision in situ construction is not dependent on the proximity to the site of a precasting factory, and locally obtained materials can be used.

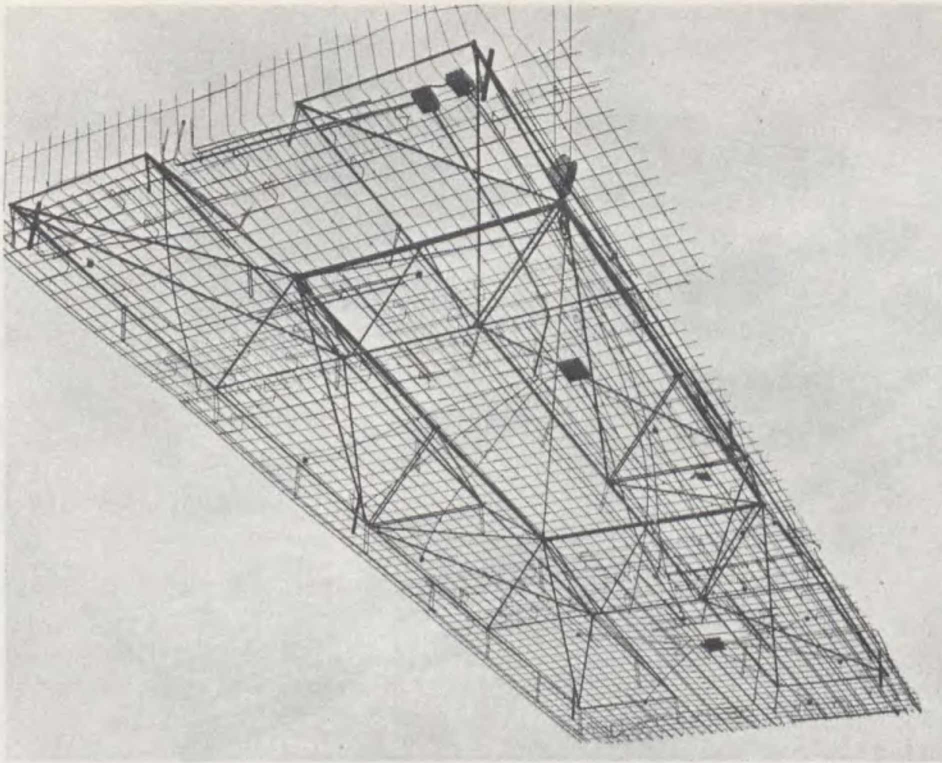
It is possible by using the Sectra method of construction to complete the structure of a typical single floor of a multi-storey building, comprising five flats, in a two-day cycle--and the entire structure of a 15-storey block in 20 working days.

Walls and floors are cast in situ at the same time and the heating of the concrete is a logical step taken to complete the structure in the shortest possible time. The whole of the reinforcement for floor slabs is prefabricated on site and lifted into position by the crane. Any services required can be incorporated in this prefabricated assembly. An important advantage of the system is that in the construction of a slab block whole sections of the building can be completed and occupied while work proceeds on the remainder.

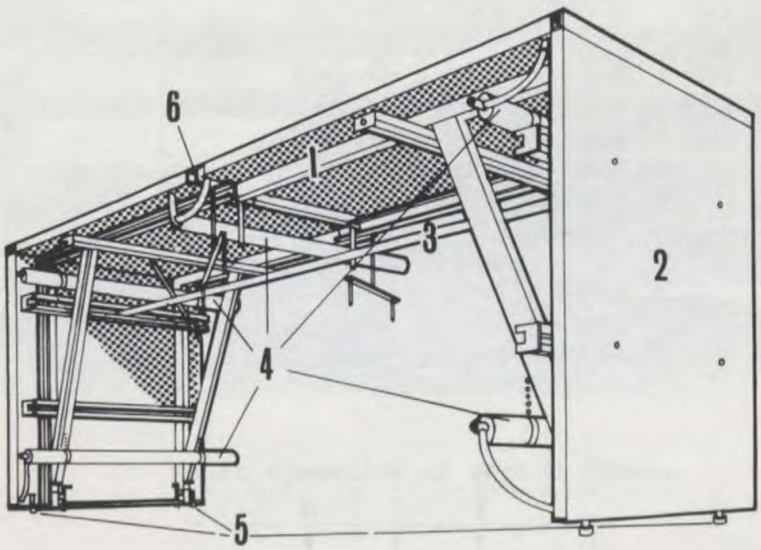
The precision of the Sectra system results in high-quality concrete surfaces which can be decorated, with a minimum of preparation.

By use of various combinations of the steel formwork units, variations in floor planning are achieved. There is also wide scope in elevational treatment through the use of large prefabricated cladding panels in a variety of materials and designs.

The Sectra system is an in situ system. It is an intermediate step between traditional building and industrialized building. It is well suited for many types of construction. The system is especially suited for medium size projects spreading over large areas. The typical 24-hour cycle is; five hours forming six hours concreting and 13 hours curing. They can produce 25 apartments in five days and have completed 13 storeys in 13 weeks using eight sets of forms. A set of forms costs approximately $11,200.



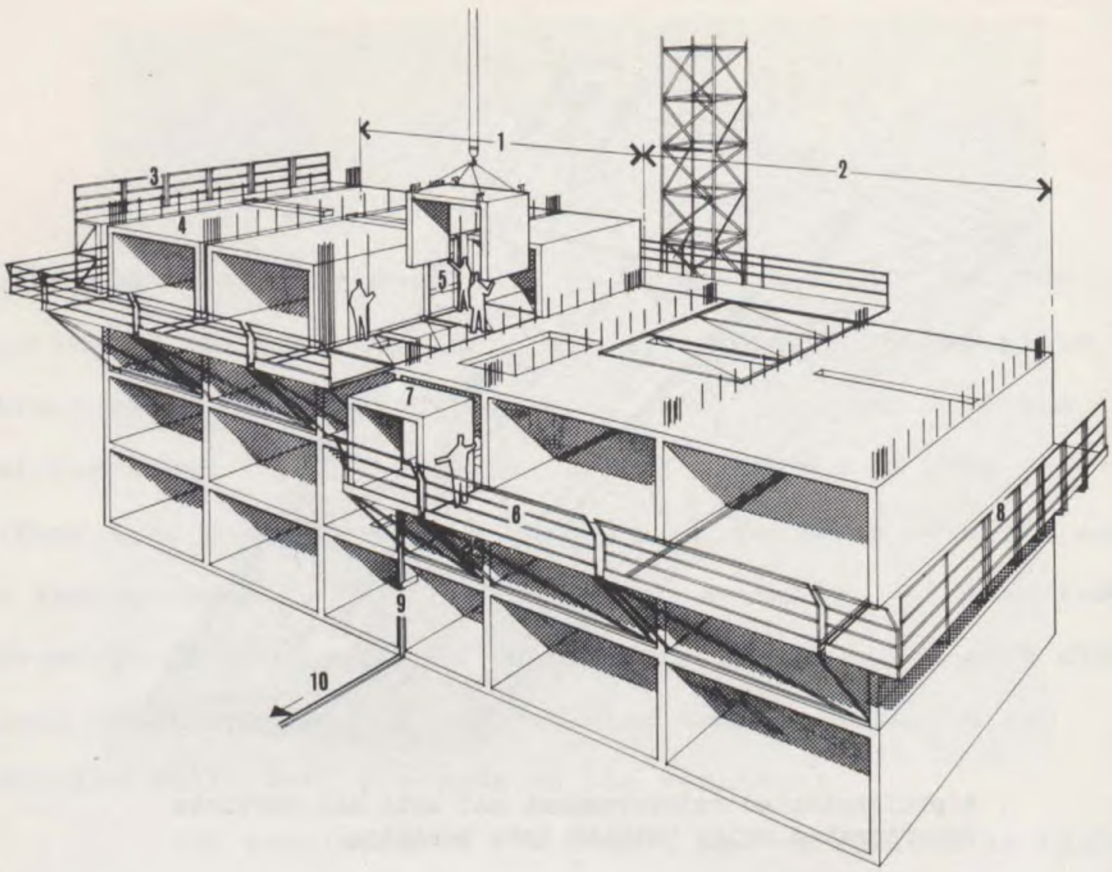
A prefabricated reinforcement mat with all services incorporated being hoisted into position.



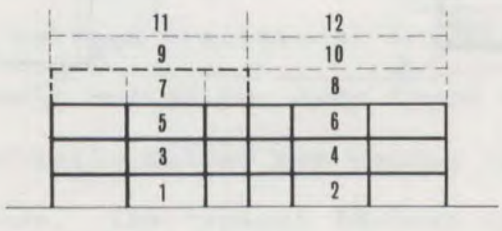
KEY

1 Sliding framework
2 Shutter panels
3 Strut
4 Heating mains
5 Vertical jacks
6 Central coupling

A unit of heated formwork (Thermo-coffrage).

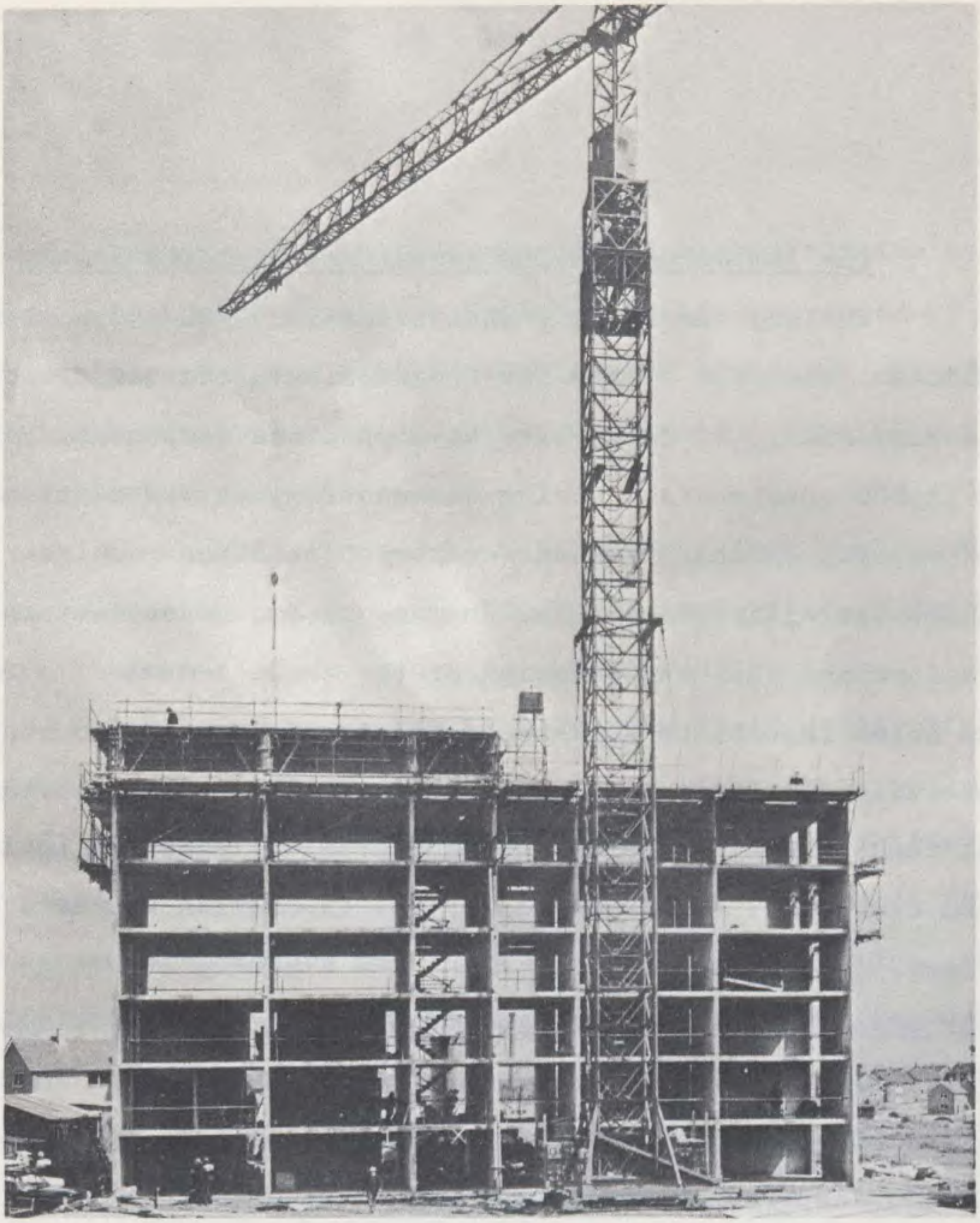


1 Phase 7 being shuttered
2 Phase 8 shutter track being placed
3 Gable shuttering in position
4 Tunnel shutter
5 Formwork to opening
6 Platform for withdrawn shutters
7 Shutter being withdrawn
8 Platform for supporting gable shuttering
9 Heating mains
10 To heating unit



Shuttering phases

Diagram showing the Sectra system of construction



Front elevation of Sectra frame.

2. The 12M Jespersen Industrialized Building System

In 1963 the Laing organization acquired the right to the Danish Jespersen System for Great Britain and has established three factories. To date, they have produced components for over 12,000 apartments. During our meeting, it was mentioned that adapting systems from one country to another requires complete assimilation to local company needs, practices and operations and that the question of the trade unions' jurisdiction is of prime importance and should be clarified prior to starting up operations. They recommended that unions should be brought in at the planning stage so that all problems relating to labour can be clarified. Their own operation in England was held up for one year.

Labour comparison for Structures of Same Size

(a) Traditional construction - 1500 man hours at site

(b) Sectra Systems - 900 man hours at site

(c) Jespersen System - 600 man hours at site

12M System is a modular system based on 4" or 10cm module.

3. The Easyform System

The Easyform System of house construction was pioneered by the Laing organization nearly 50 years ago. It is a patented system of in situ concrete construction, for houses and blocks of flats of up to five storeys in height. It incorporates advanced techniques of industrialized building in order to achieve rapid construction.

Features of the system include the use of high-precision steel formwork, designed to achieve rationalization and speed of construction, combined with flexibility of planning. Easyform has all the advantages of on site construction, carried out to a comprehensive planned program.

Since 1945 alone, about 75,000 Easyform dwellings have been constructed for over 130 local authorities throughout Great Britain -- and many more are under construction.

The Easyform system achieves the rapid construction of the superstructure of permanent dwellings with cavity walls for external and party walling by unskilled labour with skilled supervision. External cavity wall construction prevents the penetration of moisture and increases thermal insulation, which is also enhanced by the use of lightweight aggregate concrete for the inner leaf, providing a warm inner surface and preventing condensation. Comparative figures show the superior thermal insulation of Easyform construction:

The external cavity wall of a typical Easyform two-storey dwelling comprises a $3\frac{1}{2}$" outer leaf of natural aggregate concrete, a 2" cavity and a $3\frac{1}{2}$" inner leaf of lightweight aggregate concrete secured by galvanized wall ties. In higher buildings the loadbearing walls are increased in thickness where necessary for added structural stability.

Both leaves of the external and party walls are reinforced above and below the ground and at the first-floor window openings. The chimney breast is also reinforced for stability and to resist temperature stresses.

The high speed of construction achieved by the Easyform system is particularly apparent on the large contract. The larger the contract, in fact, the <u>greater</u> the speed and the <u>lower</u> the relative cost. A typical project for the building of an estate of 500 dwellings complete with roads and sewers on a reasonably level site would normally be completed within $2\frac{1}{2}$ years. From the handing over of the first house until completion, this represents the construction of more than one house per day.

In order to combine minimum cost with maximum speed of construction, it is desirable that an <u>Easyform</u> housing project should comprise 200 or more dwellings. Initial contracts of smaller size can however be undertaken by arrangement, in circumstances where reasonable continuity of work can be envisaged.

4. <u>The Laingwall System</u>

The Laingwall System provides a quickly erected yet permanent structure for office, laboratory, school, hospital and many other types of building.

The key feature of the system and its principal point of departure from existing systems is its technique of construction for load-bearing external walling.

This consists of large, storey-height prefabricated units which provide an entire wall, finished externally and in many cases internally. The design allows for freedom of choice in internal structure to provide flexibility over a large range of building types.

Floor construction can be of a variety of types but a precast floor is preferable, with a precast spine beam where necessary. The external finish to spandrel panels and solid units can be of exposed aggregate, mosaic, profiled concrete or any special finish.

The Laingwall units are erected by crane and, depending on circumstances, windows can be fixed into the unit at the casting yard.

Laingwall standard units can be delivered from a stock or cast economically at short notice and are suitable for buildings up to ten storeys. Special Laingwall units can be designed by the client's architect, thus giving scope for individuality where the size or type of project make this an economic proposition.

5. Laingspan II System

This is a system of industrialized building designed to reconcile the economic advantages of standardization and the discipline inherent in prefabricated systems with a high degree of flexibility.

Laingspan II has been introduced to satisfy the planning and structural requirements of a wider range of building types and to meet the differing performances demanded today. The system is particularly suitable for schools, hospitals, laboratories, offices and small factories.

It is based on a 4" modular grid.

The fundamental idea of the Laingspan II system is the joint between structural members, which is of a metal-to-metal type, giving a speed of frame erection, equal to that of a structural steel frame, without the disadvantages of concrete casting of structural members on the site. (The joint itself is grouted for fire protection later, when convenient.)

The development of the system is a continuous process, providing components for a kit of parts to give the greatest degree of choice and flexibility. To fully exploit the potential qualities of the system, its evolution will link with other Laing systems to widen the scope of building types to which it can be applied.

Laingspan II therefore offers a fully integrated system of construction with the characteristics of a maximum flexibility and unrivalled speed of erection. It is a system capable of meeting the needs of almost all types of building.

6. Product Development

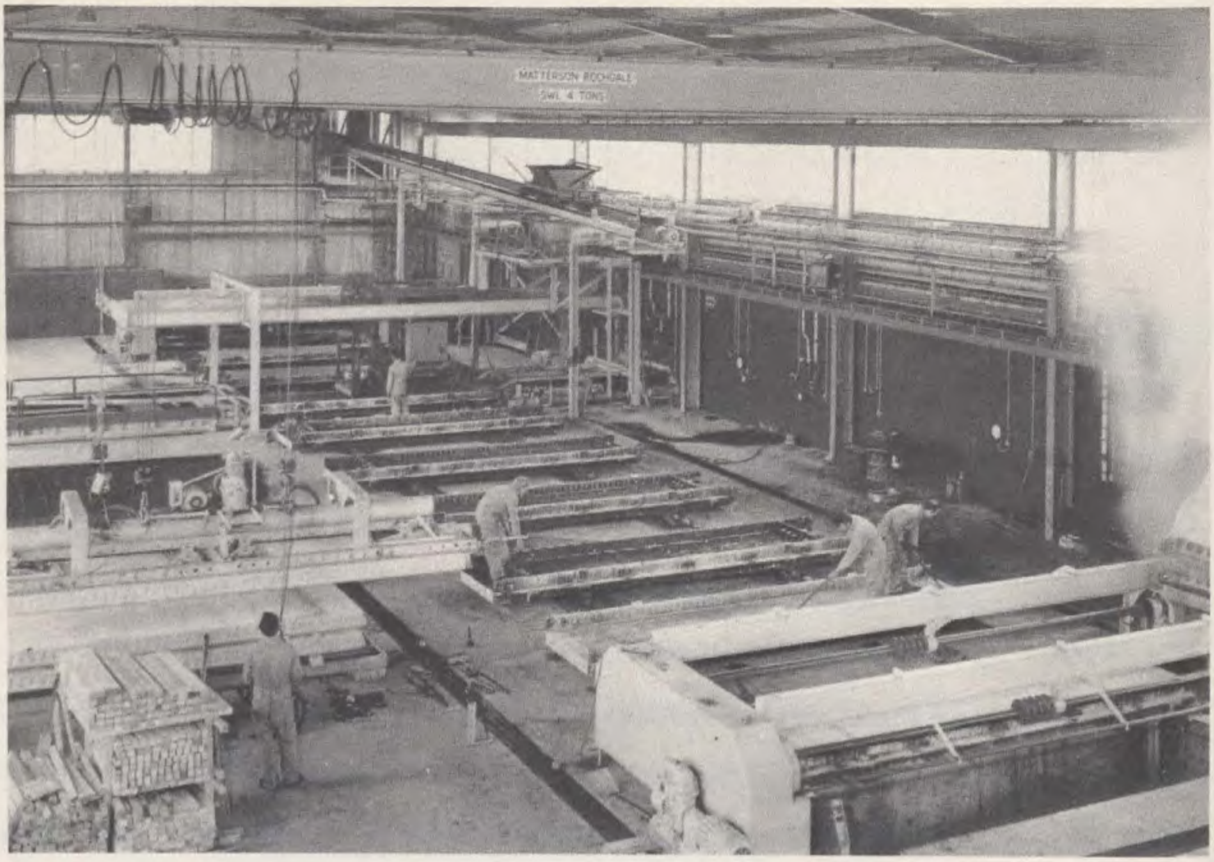
The company have developed from sintered pulverized fuel ash a lightweight aggregate for concrete called Lytag, for use in structural precast, insulating, fire resistant and refractory concrete.

They manufacture lightweight building blocks called Thermalite Ytong. They are today Britain's largest manufacturers of aerated concrete, operating four factories. Through other subsidiaries, they manufacture chemical products for the building industry, floor coverings, sand lime products, etc.

7. Research and Development

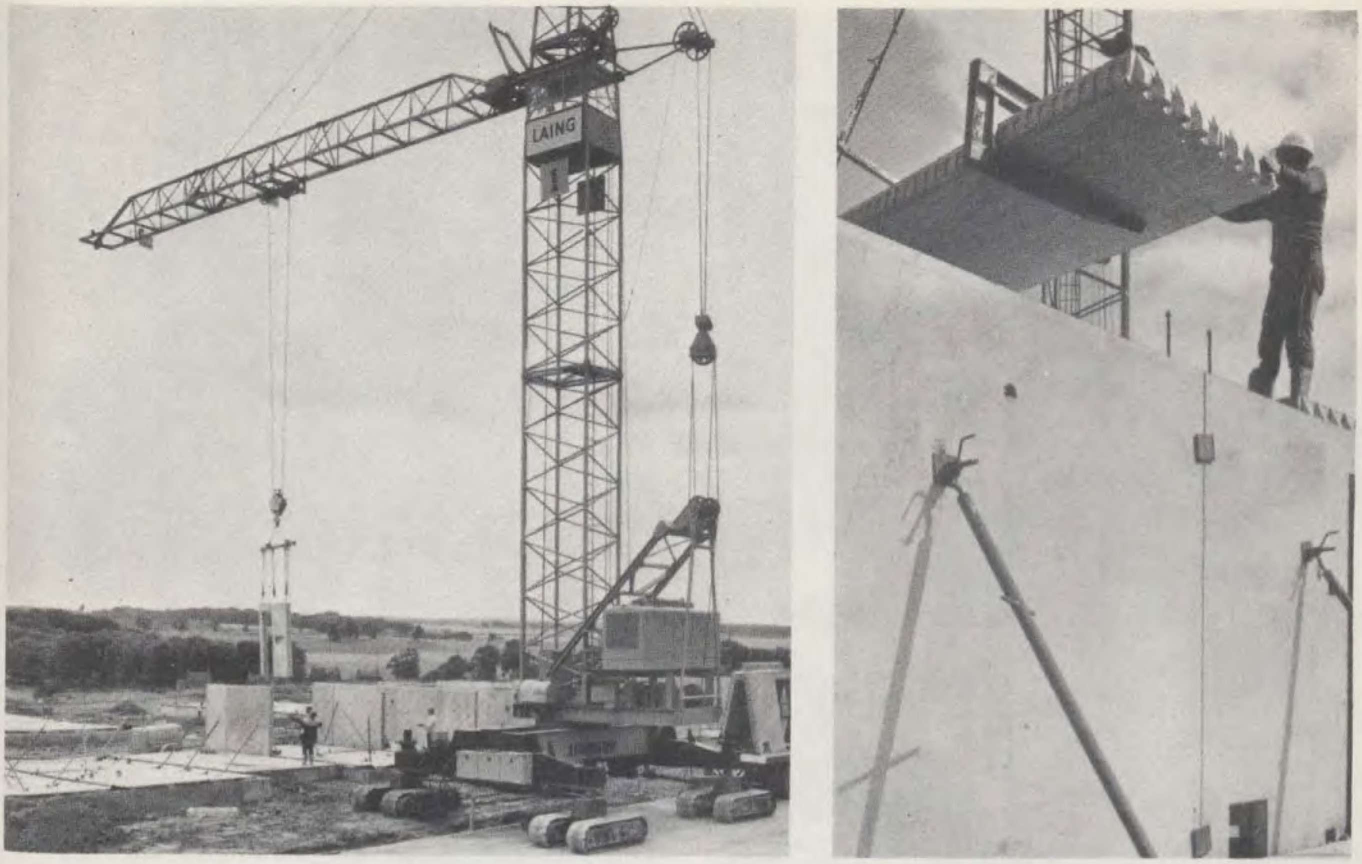
Through the John Laing Research and Development Limited, research and development is carried out in construction techniques material, plant and equipment design, etc.

They spend annually $1,500,000 on technical services within their organization and approximately one-half of this amount is devoted to research and development.

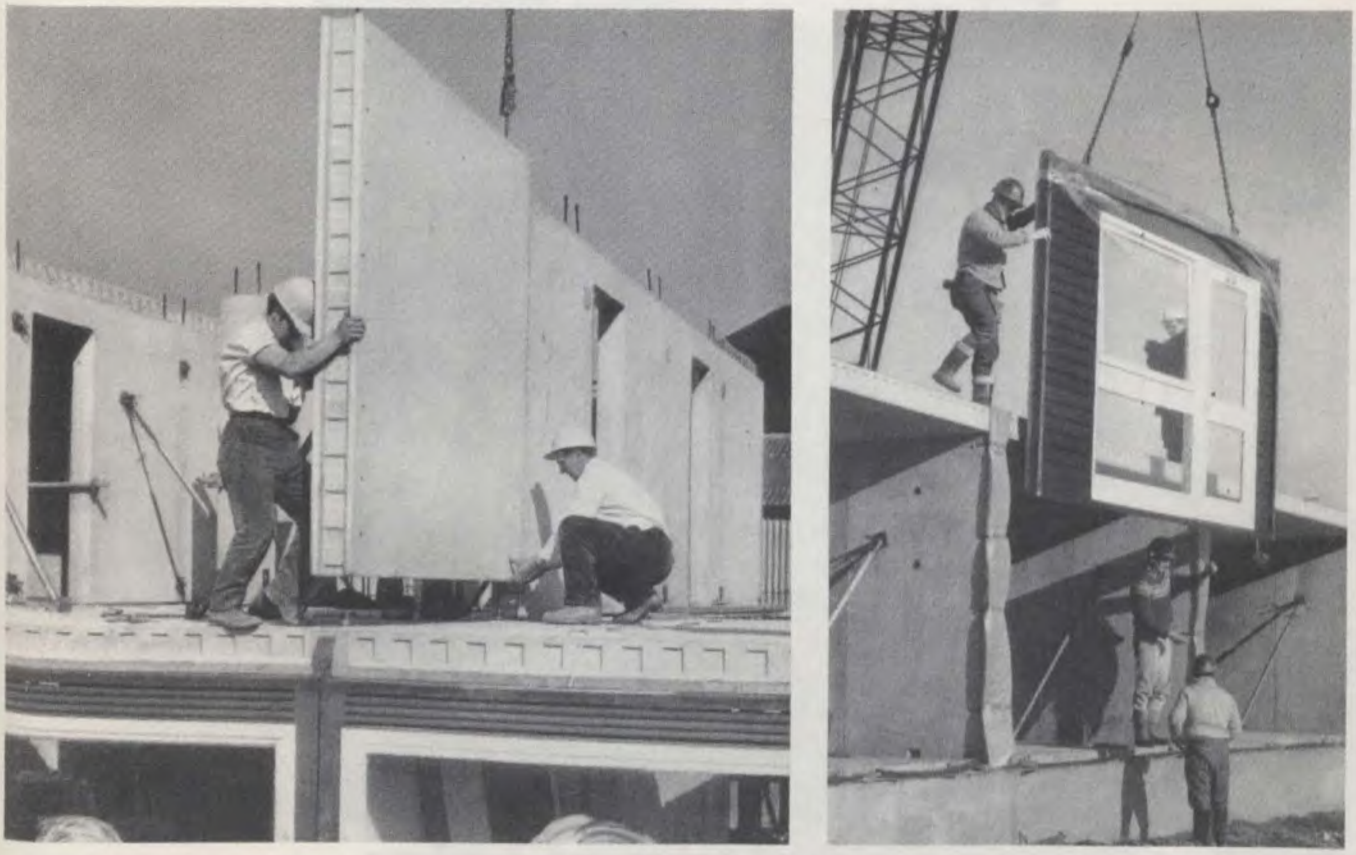


Floor element production.

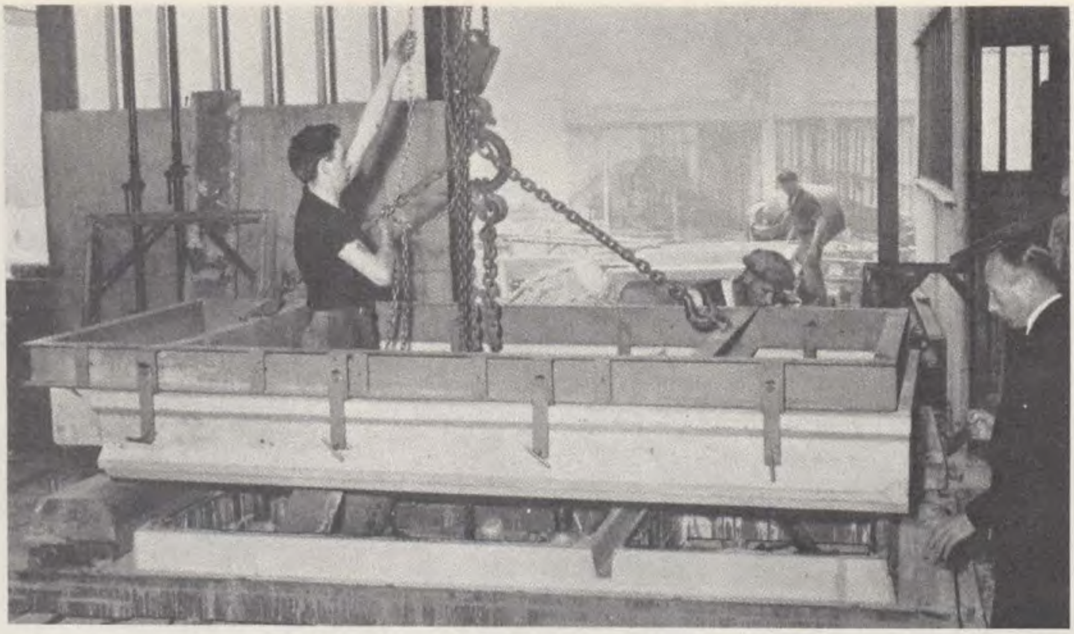
Factory stockyard.



Site erection.



Placing of wall elements.

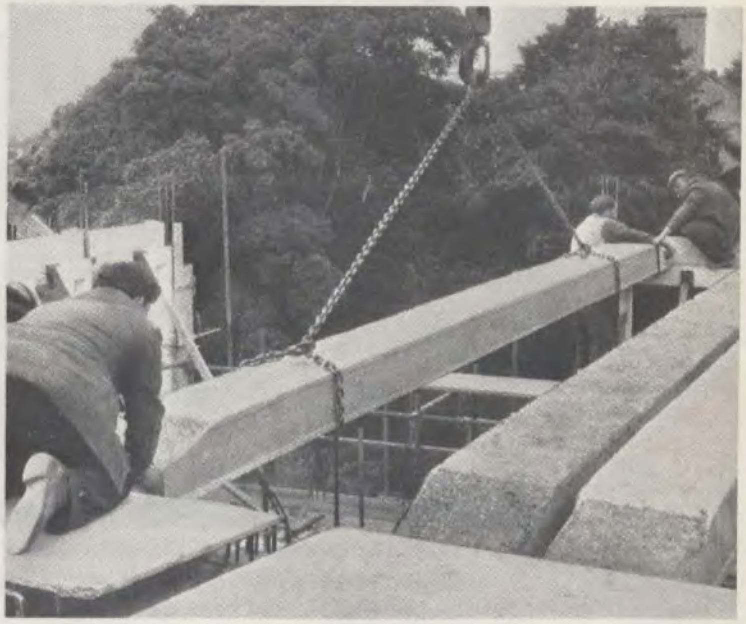


Lifting a Laingwall unit from mould.

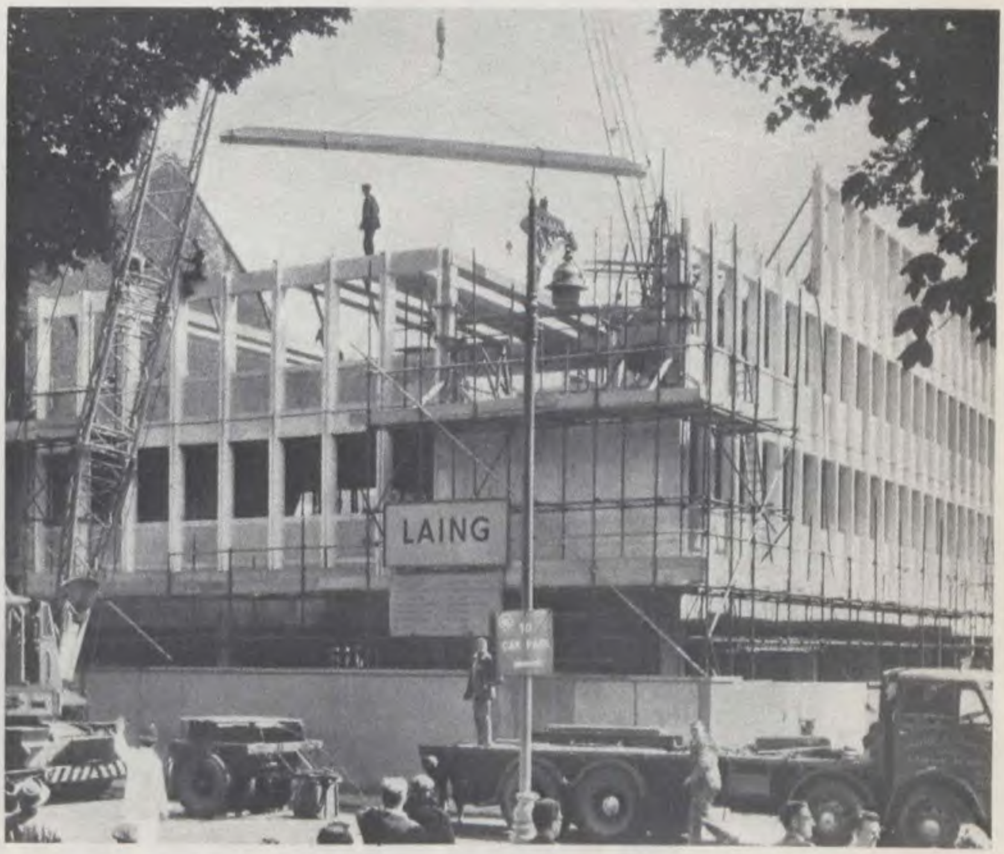
Laingwall unit lifted by crane from lorry direct into final position. Precast floors provide working platform.

With unit still held by crane, strut is fixed and unit plumbed.

Precast floor units being placed, spanning between Laingwall units and spine beams running down centre of building.

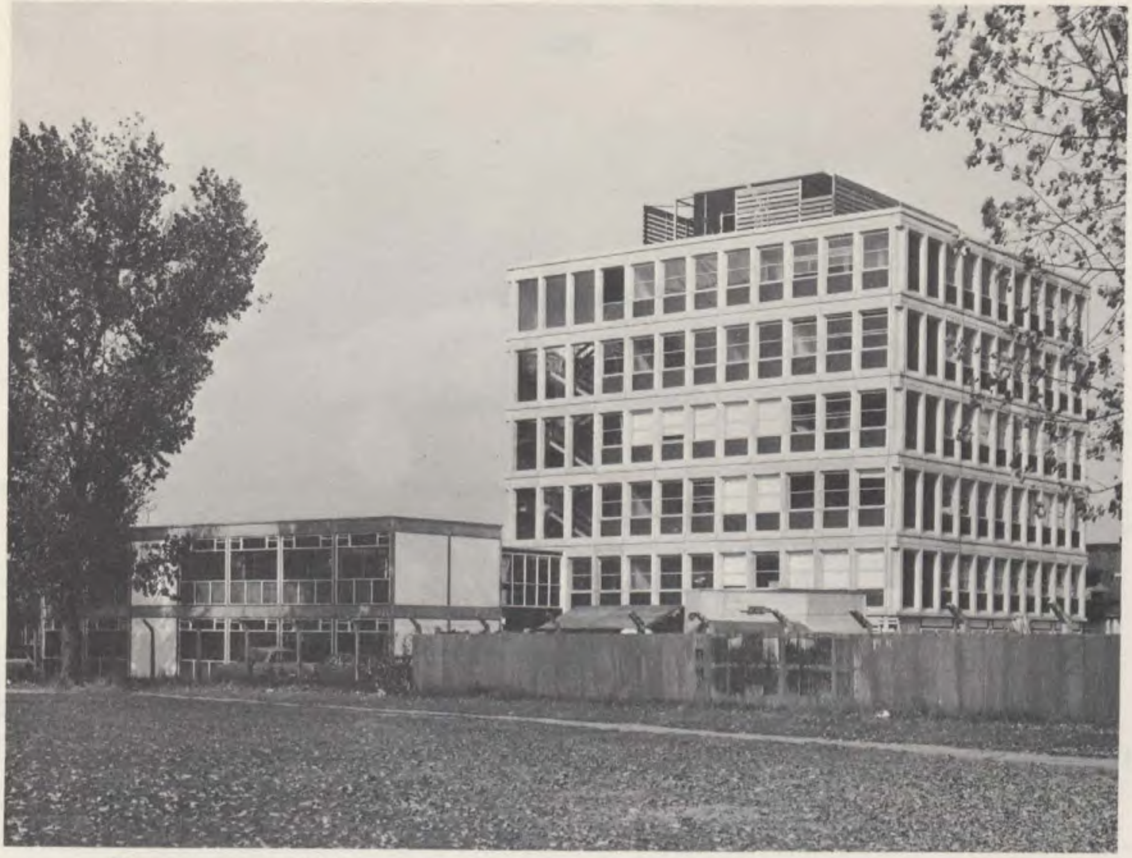


General view of half completed building.

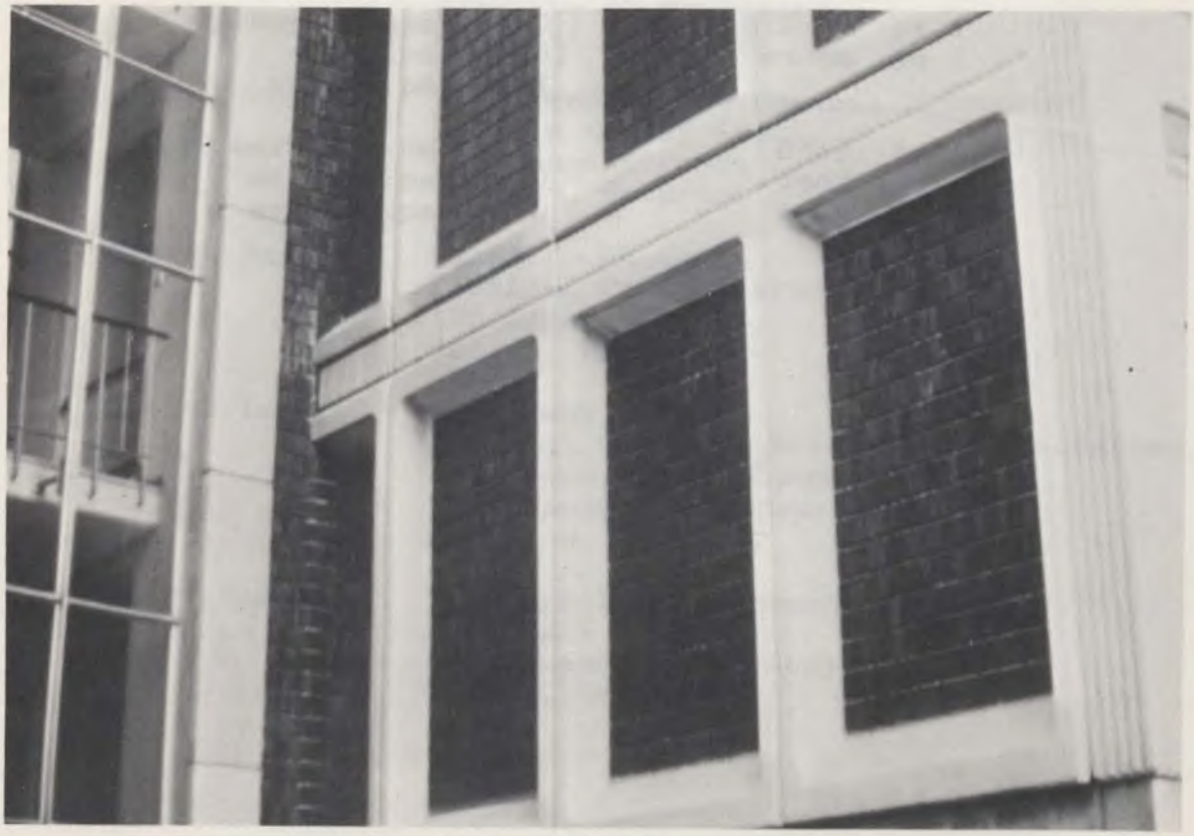


The North Western Gas Board's new headquarters at Altrincham, Cheshire, erected in the Laingwall system of industrialized building.

Head offices of John Laing and Son Limited at Mill Hill, London, N.W.7, erected in the Laingwall system of industrialized building.



Six storey office building erected in the Laingwall system at Boreham Wood, Hertfordshire, for the Research and Development division of John Laing Construction Limited.



Laingwall panels with brick facing.

APPENDIX 1

CONVERSION TABLES

LENGTH

1 metre	= 39.370 inches	1 inch	= 0.0254 metres
	= 3.281 feet	1 foot	= 0.3048 metres
	= 1.093 yards	1 yard	= 0.9144 metres

AREA

1 sq. centimetre	=	0.155 sq. inches
1 sq. metre	=	10.764 sq. feet
	=	1.196 sq. yards
1 sq. inch	=	6.45 sq. centimetres
1 sq. foot	=	0.092 sq. metres
1 sq. yard	=	0.836 sq. metres

APPENDIX 2

LIST OF MEMBERS

Mr. George Adam	President, Canadian Prestressed Concrete Institute, Manager of Sales and Engineering, Con-Force Products Ltd., P.O. Box 398, Calgary, Alberta.
Mr. Hector Asselin	Asselin, Benoit, Boucher, Ducharme et Lapointe, Consulting Engineers, 4200 Dorchester Street W., Montreal, P. Q.
Mr. Kenneth Bruce	Vice-President & General Manager, Prestressed Concrete Division, Francon (1966) Limited, 8300 Pie IX Boulevard, Montreal 38, P. Q.
Mr. George Escott	Vice-President & General Manager, Pre-Con Murray Ltd., 980 Yonge Street, Toronto, Ontario.
Mr. George Paris	Canadian Manager, Portland Cement Association, 116 Albert Street, Ottawa, Ontario.
Mr. H. Sceviour	President, National Concrete Producers' Association, President, Day & Campbell Ltd., 1074 Upper Wellington Street, Hamilton, Ontario.
Mr. P. E. Marchand	Industrial Development Officer, Materials Branch, Department of Industry, Ottawa, Ontario.

APPENDIX 3

ITINERARY

LIST OF EUROPEAN COMPANIES VISITED

	Persons visited
September 5th	
Byggnadsfirman Ohlsson & Skarne A.B., Sveavagen 153-155, Stockholm 23, Sweden.	Mr. Sven-Eric Norman Mr. Allan Naslund Mrs. B. Karlstrom
September 6th	
Larsen & Nielsen Constructor A/S, Frederiksberg Bredegade 11, Copenhagen F, Denmark.	Mr. Hans U. Bille Gram
September 7th and 8th	
P. E. Malmstrom, Consulting Engineers, Jagtveg 223, Copenhagen, Denmark.	Mr. Erik Anderson
The Jespersen System, c/o Modulbeton A/S, Postgiro 65747, Olstykke, Denmark.	Mr. J. C. Holm, Managing Director
September 9th	
A.B. Skanska Cementgjuteriet, Hjalmarekayen 3-5, Malmo, Sweden.	Mr. Lennart Nilsson
September 12th	
La Société Tracoba, 254,rue de Bercy, Paris 8e, France.	Mr. Louis Netter, Vice-President and General Manager; Mr. Jacques Coiffard, Asst. General Manager; Mr. Georges Paisnel, Technical Director; Mr. Marcel Tessier, Gérant; Mr. Gérard Chamberlant, Mr. Jean Bureau, Relations extérieures.

September 13th	Persons visited
Construction Edmond Coignet, 11 avenue Myron T Herrick, Paris 8e, France.	Mr. A. Pruzan, President and Managing Director; Mr. C. Hutin Mr. A. Gadenne
September 14th and 15th	
Société Raymond Camus & Cie, Ingénieurs-Constructeurs, 40 rue du Colisée, Paris 8e, France.	Mr. Henri Camus, Head of Equipment and Factory Department; Le Général de Villeplée, Director of External Business; Mr. André Voisin, Comptroller; Mr. François Camus, Architect.
September 16th	
Les Entreprises Balency & Schuhl, 14 rue Etex, Paris 18e, France.	Mr. A. Fontan, Plant Manager; Mr. Paul Andoly, Asst. Plant Manager.
September 19th	
Impresa Generale Construzioni MBM s.p.a., Trezzano sur Naviglio, Milano, Italy.	Mr. R. Meregaglia, President; Mrs. R. Tam Mr. Ubazir Mr. Ferdinand Mr. André Balency-BEARN, Président Balency & Schuhl; Mr. R. Cambon, Director, Balency & Schuhl
September 20th A.M.	
Sicop-Coignet s.p.a., Bubbiano, Italy.	Mr. Ferdinando Marsili, Technical Director.
September 20th P.M.	
Fintech Italcamus s.p.a., Settala, Milan, Italy.	Mr. R. Randolphi, Factory Director.

September 21st and 22nd	Persons visited
John Laing Construction Limited, 14 Lower Regent Street, London, England. OR Bennet House, 1 High Street, Edgware, Middlesex, England.	Mr. G. A. Britton, Director; Mr. J. Chappel, Marketing Manager; Mr. David A. Sawtell, Architect; Mr. A. Luxon Mr. Allan Nicol Mr. John Peters Mr. S. Faulds Mr. Henry Snead Mr. John Bathgate Mr. Leo Scott