Structural Prefabrication in Reinforced Concrete and Hollow Brick in Italy [1])

Préfabrication des ouvrages en béton armé et en briques creuses en Italie

Vorfabrikation von Bauten aus Stahlbeton und Backsteinen in Italien

1 - Foreword

The construction industry, which is both a factor and an index of human welfare and also an invaluable economic and financial activity within the framework of the national economy, is at the present stage of development of our Society called upon in Italy to solve an unprecedented great number of new problems and duties.

In fact, Italian building techniques have to a large extent remained anchored to conventional procedures and have but to a small degree followed the impressive technical progress in other fields of engineering. Their backwardness and, hence, necessity to catch up with that progress, are therefore felt today as never before, particularly in view of the great demand in the housing, industrial, bridge-and-viaduct and hydraulic sectors.

Prefabrication today in Italy, as yesterday in other countries (whose economic and social structure causes certain problems to be felt there somewhat earlier than in our country) is a necessary and undeferrable phase in the development of the construction technology. Due to the present-day shortage and very high cost of labor, it is imperative to rationalize and industrialize this sector of activity by prevalently using mechanical means and industrial procedures.

In what follows we shall briefly outline the present state of *structural*

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[1]) The present Report was prepared at the Structural Prefabrication Research Center, Bridge and Structural Engineering Department, Turin Polytechnic Institute, Turin, and at the Experimental Institute for Models and Structures (I.S.M.E.S.), Bergamo, under the chairmanship of Prof. G. Oberti, by the following group of collaborators: G. Arosio (Soc. Mantelli), Prof. C. Castiglia, Prof. F. Levi, M. Mariani (Soc. Vianini), Prof. R. Morandi, C. Muttoni (Soc. Valdadige), Prof. P. L. Nervi, F. Tomasi (Soc. SCAC), Prof. G. Tournon, G. Volpe (Soc. R.D.B.), L. Goffi (editor and Secretary General of the Research Center).

prefabrication in ordinary and prestressed concrete within the Italian construction industry, i.e., of prefabrication of structural members having a statical function in the edifice or structure. It therefore seems appropriate at

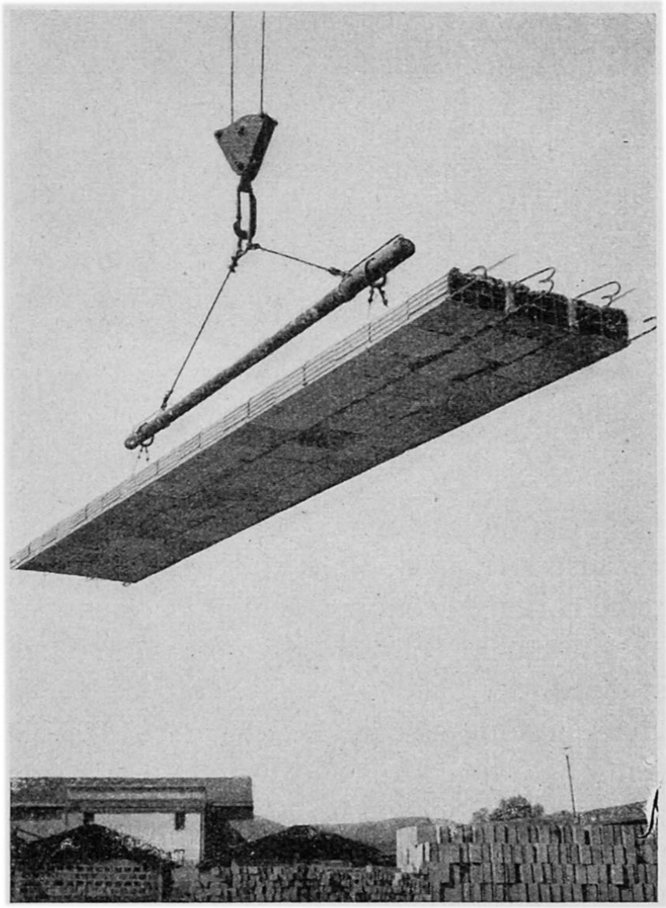

Fig. 1 - Reinforced hollow brick panel for flooring (Soc. Fornaci Valdadige).

first to distinguish between housing, industrial (workshops, warehouses), bridge-and-viaduct and hydraulic (canalization, water storage, maritime, etc.) types of constructions.

This distinction appears necessary because of the present different degrees of constructional development in these various sectors owing to the diverse tasks and problems that are related to them.

2 - Housing

The housing construction industry has for a long time now adopted some principles of the prefabrication technique. These principles are at present well generalized, as, for instance, construction of reinforced concrete and hollow brick floors. However, the further evolution has not yet produced substantial changes in the technology of this sector as regards a major trend towards technical development and industrialization.

In fact, the most remarkable progress in the housing construction-site technology mainly concerns horizontal elements and roofs. It may essentially be summarized as follows:

a) there is a tendency, at the building site, to dispense with some operations, such as, for instance, the construction of prefabricated beams. These beams now generally arrive already made from the prefabricating sites which are mostly connected with the hollow brick factories;

b) individual beams in flooring and roofs are now being replaced by panels which essentially consist of several beams joined together in the prefabrication yard. This reduces manual labor in placing the members and in concreting the spaces between the individual beams (Figs. 1 and 2). This concept is now also applied to thin shells;

c) since structural elements are usually prefabricated in specially equipped workshops, there is a general tendency to prestress floor beams and panels by pretensioning them on strongback benches and curing by means of steam.

Even though some undeniable progress did take place in the building-site technology, in an effort to achieve a more rigorous organization and a greater mechanization of the construction site itself, it cannot be stated that the physiognomy of this sector has greatly changed from what it was some 25 or 30 years ago, i.e., it has essentially remained of the manual or artisan type.

The reason for this lies mainly in the intrinsic features of the housing

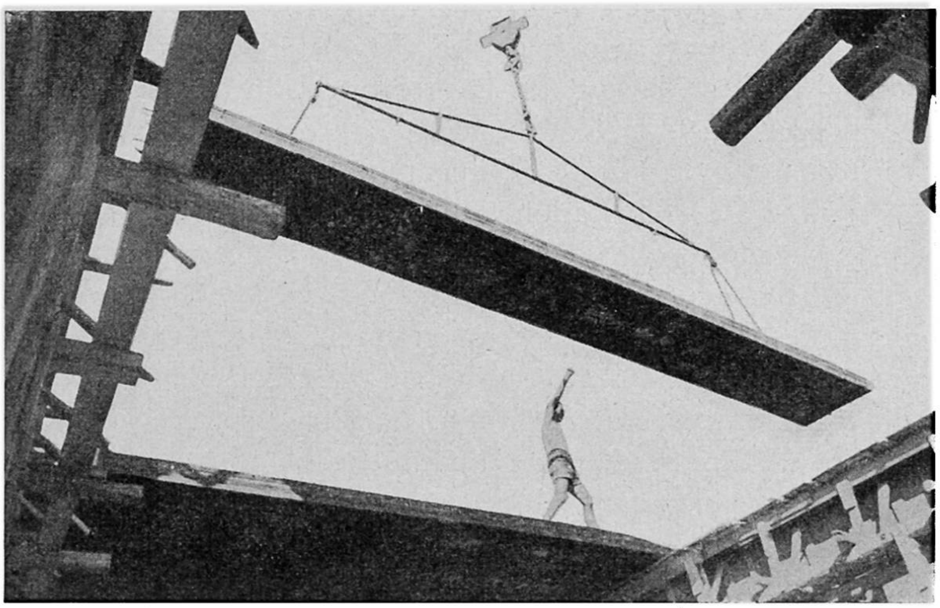

Fig. 2 - Reinforced hollow brick panel for large spans (Soc. R.D.B.).

industry which is somewhat reluctant to undergo an industrial type organization; moreover, at least until some time ago, labor has been greatly available compared to a high cost of mechanical equipment.

The appreciable change which recently occurred in the Italian labor situation has caused many workers to switch to the more qualified, comfortable and stable industrial type of employment.

The consequences of all this can clearly be seen in the present critical situation of Italian housing as regards both the cost of edifices and the strictly technical aspect of the possibility of carrying out certain housing projects because of the limited labor now available and the shortage of time.

It would be easy to quote statistical data showing that in Italy the incidence rate of working hours per dwelling room nowadays built is not much inferior to the corresponding incidence rate per room built some decades ago. Naturally, the increased labor cost incidence, which reaches up to about 40% of the total cost of the edifice, makes this cost almost prohibitive.

Therefore, whereas industrial type consumer goods have marked a large cost decrease compared to the customers, average purchasing power, living quarters have tended to become inaccessible because of their increasing cost. At the same time there is a steadily growing demand for this type of goods which is rightly considered as basic for the well-being of a society.

This situation, which can neither be deferred nor otherwise solved, will in the next few years necessitate, in Italy, the advent of large scale complete prefabrication. This is particularly true with reference to the housing projects now being planned by some large centers in the North and to the development programs of our underdeveloped provinces in the South.

The reference to Italian public housing projects is not casual, since it is well known that complete prefabrication in housing is possible only in the case of large projects which justify the installation ad amortization of the costly fixed facilities required in a prefabrication factory.

Since, in practice, only large-scale private or subsidized public housing projects can offer opportunities of this type, it is to be expected that in these cases complete prefabrication will be resorted to. On the other hand, private housing projects will generally find it more convenient to follow conventional methods of construction, which will be improved and made increasingly more efficient by a better planning of the construction phases.

It is not easy to define the present state of Italian housing prefabrication. This is due to the fact that the large housing projects (briefly outlined above), which will represent an experiment of great import capable of defining the physiognomy and future trends in this sector, are still in a preliminary formulation stage.

As was mentioned above, Italian housing prefabrication is almost without precedents. For this reason, the present most important Italian prefabrication initiatives have recourse to French patents. In fact, these patents concern construction systems which have ten or more years of successful experience behind them, i.e., ever since France, considerably ahead of us, felt the necessity of rationalizing the building sites, mainly because of an acute shortage of labor.

It is to be expected that foreign experience will lend an appreciable assistance to our housing industry. Nevertheless, much will still remain to be accomplished as regards studies and direct experience, especially with respect to local requirements, which differ in each country because of the diverse climatic, traditional, social and psychological conditions.

One of the initial most important heavy prefabrication uses based on French patents has been the use of the Costamagna system of load-bearing concrete and hollow brick panels for a housing project by the Istituto Case Popolari, Milan, and the Barets method of load-bearing concrete panels for INA CASA, Turin (4,500 rooms to be completed within two years).

Other French prefabrication patents (Balency, Camus, Coignet, Fiorio) have been taken over by Italian construction companies and are now being used in important projects, especially in Milan.

Of the original Italian methods we shall mention that of the Structurapid Company (Gaburri), Milan. This method consists of a modulated prefabrication of the load-bearing structural members (columns, beams, floors), all of which are of reinforced concrete.

According to Mr. Messina's patent, Turin, front walls, partitions and floors are prefabricated, whereas columns and beams are cast in situ leaving spaces for the conjunction of the prefabricated members. The inside walls are of hollow bricks reinforced with steel mesh, and the outside walls are of lightweight reinforced concrete containing expanded polystyryl. Prefabricated also are the bathroom walls, and in them are installed, during the casting, all the feed, discharge and ventilation ducts for the sanitary fixtures and the ducts for the electric power installation. A low-priced housing project, consisting of four eight-story buildings containing about 200 apartments (i.e., 6 apartments per story), was begun in Turin in August, 1962, using the Messina method.

Of interest also is the Grassetto system (Padua) which essentially concerns prefabricated concrete wall panels in whose hollows columns and beams are later cast.

The materials used in the above-mentioned housing projects are generally ordinary concrete and hollow brick employed in traditional housing construction.

It is, however, obvious that in this sector prefabrication will have to devise and use materials batter meeting its own requirements.

In this connection it should be mentioned that a factory is at present being built and almost completed at Caiazzo, near Naples, for the manufacture of a new construction material called " silicalcite ". This material essentially consists of sand and lime, and its mechanical strength progressively increases up to reaching at compression 900 kg per sq. cm in relation to the specific gravity of the material which ranges from 450 to 1,900 kg per cu.m.

The silicalcite makes it possible to produce commonly reinforced structural members; its heat insulation is also good, as its coefficient of conductivity may reach 0.09 kcal (m, h, °C).

Meanwhile, a testing laboratory is in operation in Milan since August 1963, carrying out systematic research. It will later be of assistance in the manufacture of the silicalcite.

3 - Industrial building

Industrial type building (workshops, warehouses, etc.) is governed by laws differing from those controlling housing building.

Prefabrication in this sector in Italy is well advanced because of the greater possibility of formulating the pertinent problems in the industrial mass production field. However, in this branch, too, much still remains to be accomplished owing to the ever growing necessities and requirements and, above all, in view of the increasing competition from steel structures.

Prefabrication in situ of the main load-bearing beams and other secondary members (trusses, floors, etc.) is by now of common use in any construction yard for the erection of a factory or an industrial building. Quite often the construction company purchases the main beams and other load-bearing members directly from specialized firms expressly equipped for an industrial type production. This tendency is mentioned here because it is probably destined to assert itself even more in the presumable development of the building industry which will convert the construction companies into concerns for the assembly of industrially prefabricated structural elements.

A great number of Italian firms (R.D.B., Valdadige, Cementi Rossi, etc.) manufacture on their premises a large variety of main beams and other structural members to meet the various requirements of the customers.

Quite obviously, the reduced weights required for these elements to permit them to be transported even great distances demands that these elements be almost always prestressed.

Transportation requirements, moreover, impose limitations on the sizes of the individual members. This, however, does not interfere with the capacity of these structures to meet most of the requirements set forth by ordinary industrial building.

In want of conditions justifying the employment of industrially prepared parts, a prefabrication scheme for an industrial building may in most cases be set up directly at the construction site.

A typical construction yard equipped for complete prefabrication is now being used for building the Alfa Romeo factory in Arese (Milan) (Figs. 3 and 4).

The structure of the factory consists of thin cylindrical shells resting on box beams which, in turn, are supported by columns arranged like a 16 m square mesh.

All the structural members are prefabricated on site by means of steel formwork, and their placement is plain, with no additional completion work.

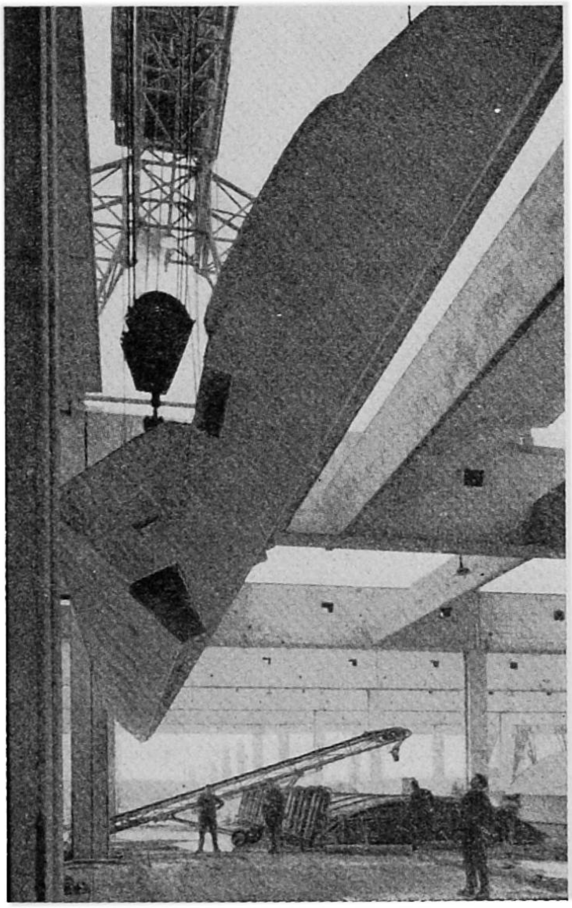

Fig. 3 - Alfa-Romeo factory, Arese (Impresa ICIS). Placement of a precast thin shell.

The columns supporting the structure, each weighing about 15 tons and with a cross-section that was especially studied to accommodate the ducts and outlets, are all prefabricated; after curing they are raised and set into plinths cast in situ by means of movable steel forms. The prefabricated and prestressed box beams (weighing 33 tons each) are then placed on the columns, and upon every beam rest the ends of the thin cylindrical shell having a 14 m span and a width of about 5 m.

The thin shells (weighing 33 tons each) are of concrete 6 cm thick, cast as one sole piece with edge beams and stiffening elements at the ends;

they are prestressed at the valley by means of 2 Tecnicavi cables, one consisting of six 7 mm wires and the other of nine 7 mm wires, and at the upper edge beam by a cable of nine 7 mm wires.

This cable arrangement practically forms the reinforcement of the shell, since the task of taking the transverse moments and the other secondary actions has simply been entrusted to a double mesh of steel rods.

The cylindrical shells and the other prefabricated members are prepared in movable steel forms at the base of the structure so as to avoid the cost

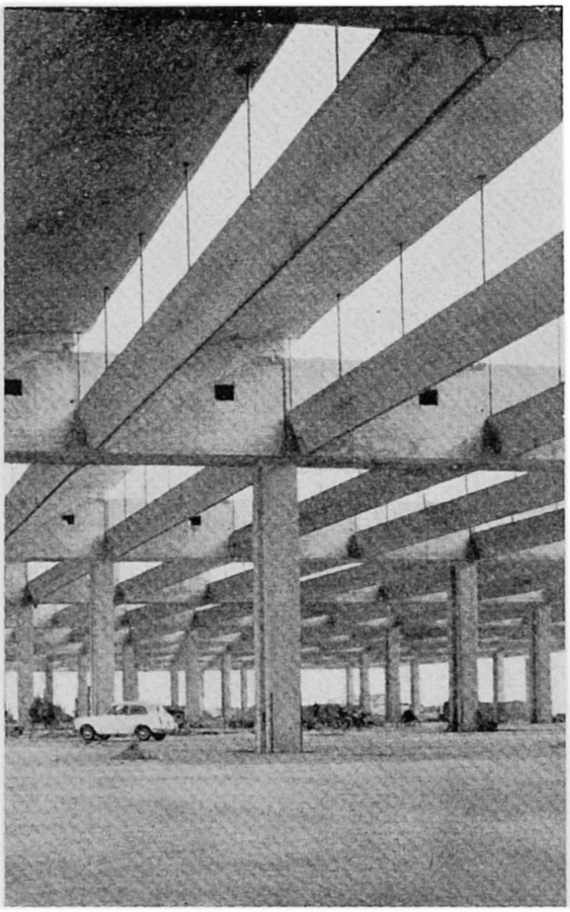

Fig. 4 - Alfa Romeo factory, Arese. Interior of buildings upon completion of civil-engineering work.

and the difficulties involved in transporting such heavy elements and to reduce their placement to mere hoisting.

The steam curing is done by means of movable equipment (a kind of a tent on wheels) which is successively transferred to the various shells in situ; the steam (at 75°C) is applied for 12 to 15 hours, depending on the ambient temperature. The production of the shells could reach the rate of one shell a day per each available form, so that with the 8 forms available it was practically possible to manufacture 8 shells every 24 hours. The monthly production at the site was thus capable of covering an area of 12,000 sq. m, and this rate was kept up also in the severe winter months of 1962-63.

The rigorous and thorough study of all the constructional details was justified by the importance of the job (60,000 covered sq. m), which has doubtless contributed to the development of the high technical level of this construction.

Attention, therefore, must be drawn to the simplicity of the building site setup which does not involve particularly expensive fixed installations. It is therefore presumable that a similar setup may economically be convenient for a more modest construction employing a proportionally smaller quantity of facilities (forms, hoisting and steam curing equipment, etc.).

Of the numerous other examples of prefabricated industrial structures, the following (of which we give photographs and some general data) are particularly worthy of mention.

Fig. 5 shows 40-ton arches in the process of being hoisted (the placement plane is 25 m above the ground level).

These are parts of the thermal power plant of S.A.D.E. (Adriatic Power Company) in Porto Marghera, built by S.A.C.A.I.M., Venice, of the Mantelli Group.

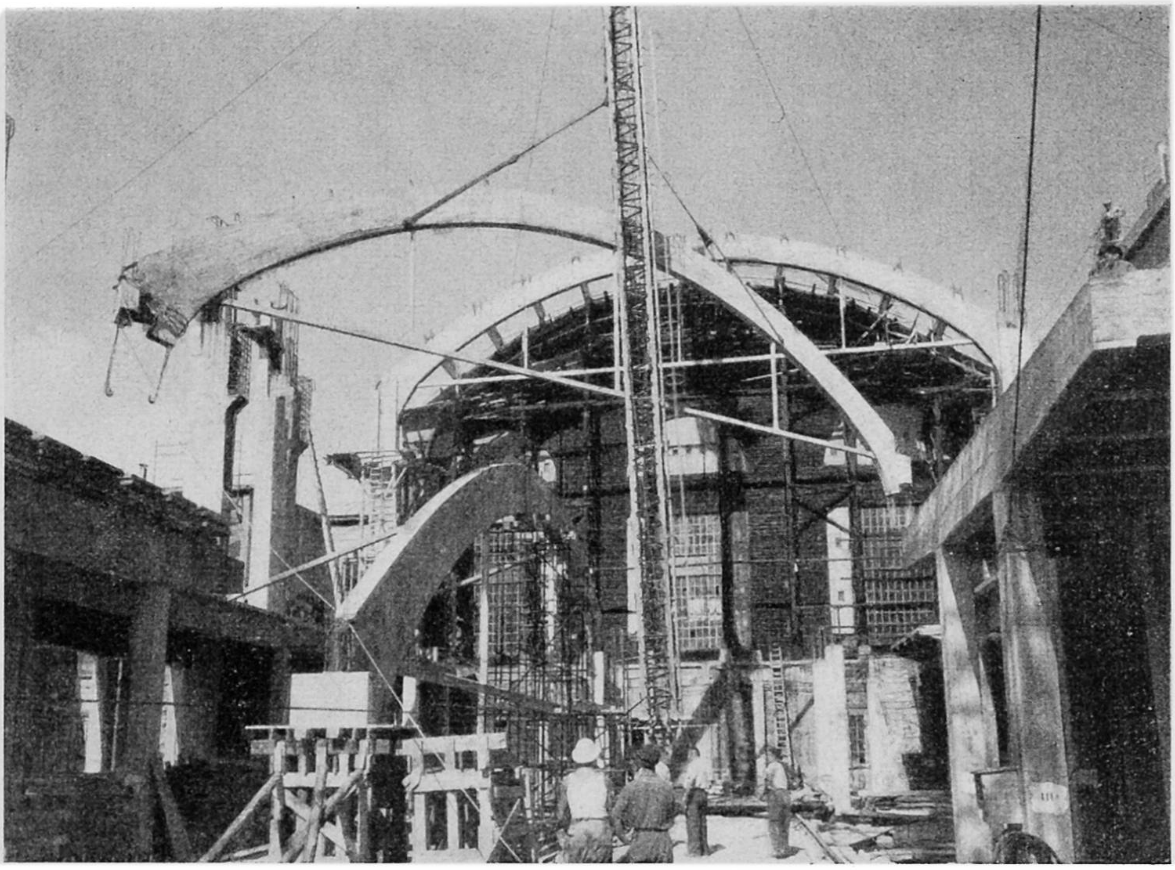

Fig. 5 - Thermal power plant, Porto Marghera (Impresa SACAIM, Venice). Hoisting of the prestressed precast thrust-relieved arches.

Worthy of note are also the parabolically-shaped buildings for raw materials and finished products of the SINCAT factory at Priolo, Syracuse, constructed by the Soc. Ing. Mantelli of Genoa, of the same Group (Fig. 6). The structures consist of precast three-hinged arches, of which each half-arch weighs 11 tons and is 22 m long.

Special mention should be made of the structures which are considered in this paragraph even though they enter only in a marginal way into the category of industrial buildings, i.e., hangars, exhibition halls, garages, markets and stadia. These constructions, remarkable for their large spans, frequently present first-class constructional and building-site problems which have been, for some time now, solved by total prefabrication. In fact, it may be said that total prefabrication significantly affirmed itself first in this building sector.

In this field of activity Italy offers examples that are unsurpassed even when compared with similar works abroad. Some of these constructions, built using advanced prefabrication techniques, are rightly considered as fundamental within the framework of modern architecture. Such, for instance, are the constructions designed by P. L. Nervi (Orbetello hangars, 1935-41; Exhibition Palace, Turin, 1948).

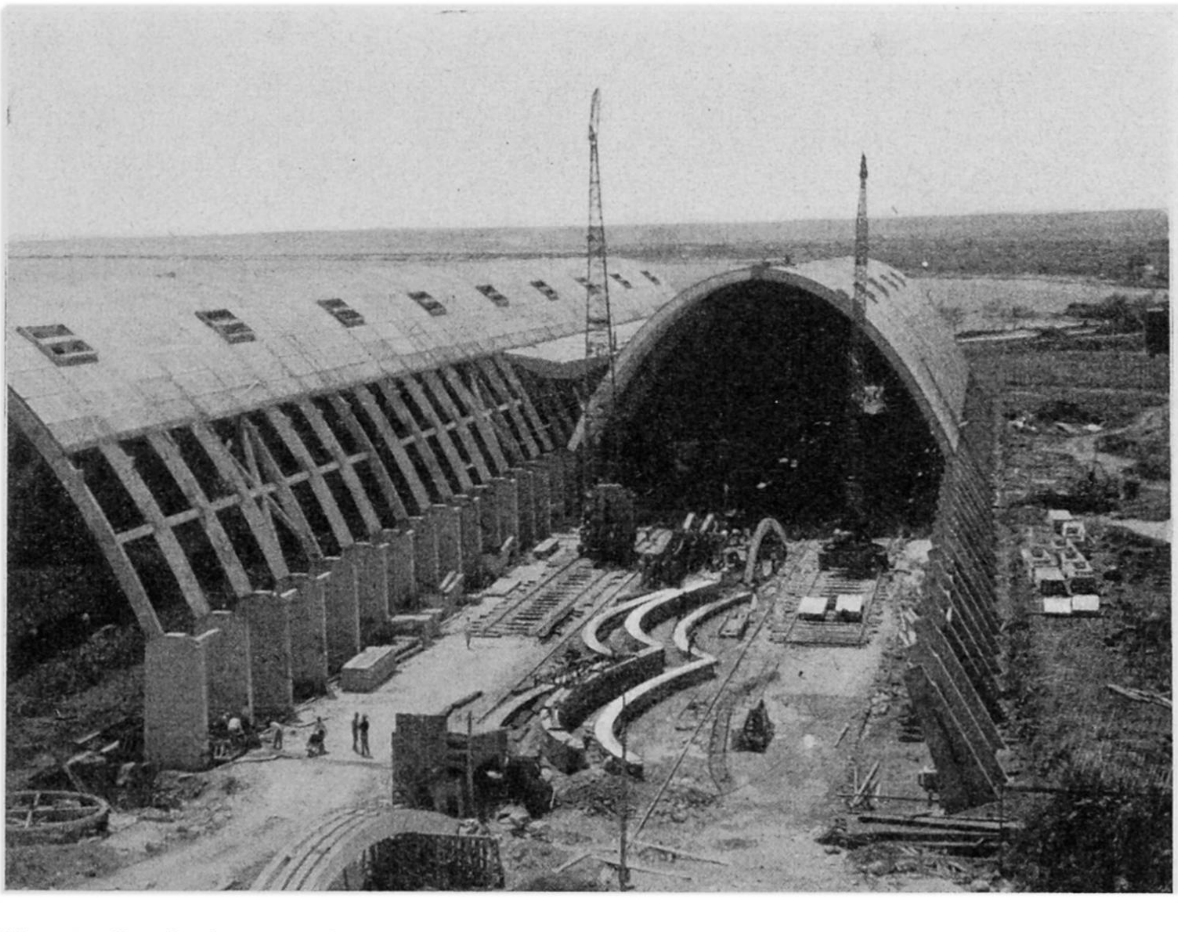

Fig. 6 - Priolo factory (Syracuse). Parabolic roofs consisting of three-hinged arches and reinforced hollow brick slabs.

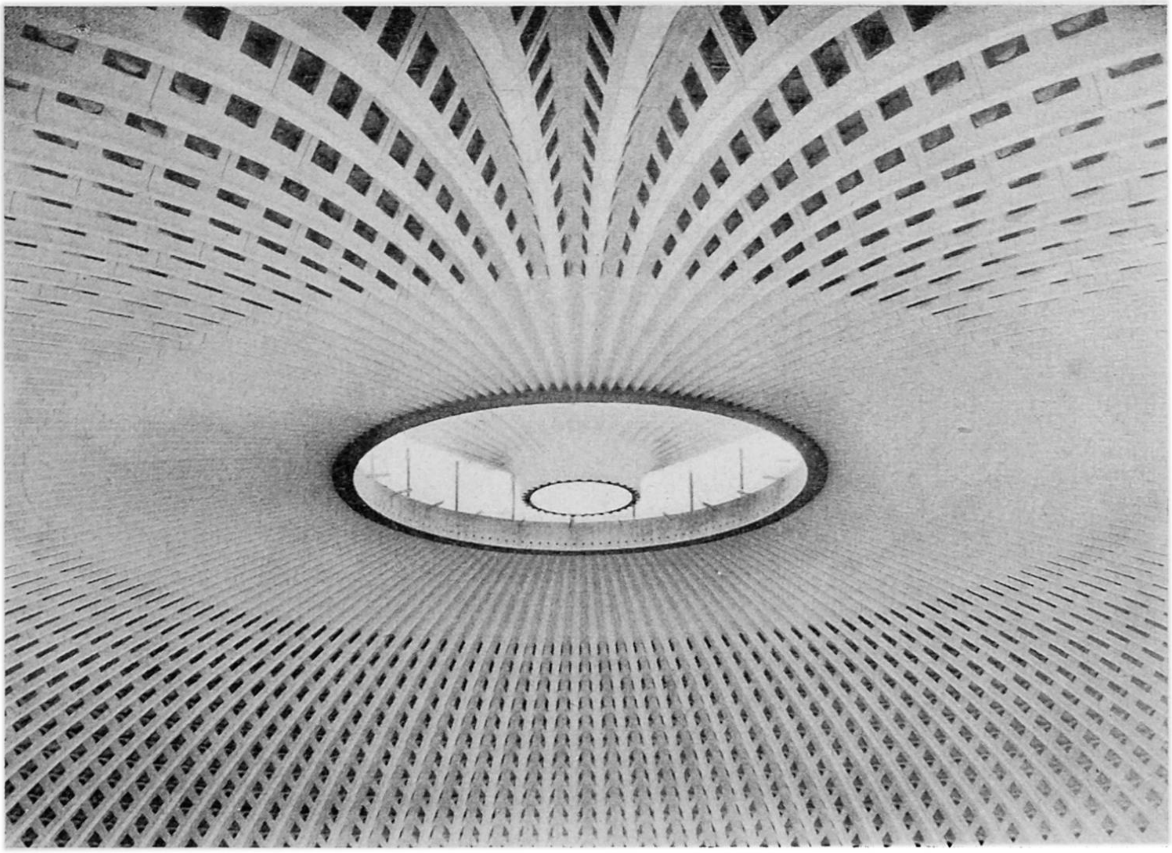

Fig. 7 - Dome of Sport Palace, Rome (designed by P. L. Nervi).

A constant concern of the most qualified designers in this branch of construction has been the necessity of overcoming some limitations which are inherent in the nature of reinforced concrete.

The solutions found are truly original. They tend to make the employment of reinforced concrete highly flexible and easy, capable of competing with steel structures whose use in this sector frequently offers rational and brilliant solutions.

Such is the case of using precast « ferrocemented » elements (i.e., precast thin concrete elements abundantly reinforced with steel mesh), as was done by P. L. Nervi in designing the above-cited and other structures, among which are some sport buildings in Rome for the Olympic Games in 1960.

Outstanding among those buildings is the Sport Palace, circular in plan and covered by a dome roof consisting of a corrugated structure with an overlying continuous slab 9 cm thick (Fig. 7).

The corrugated parts are precast elements (7 in a radial direction) connected to one another and to the upper slab by steel bars placed in the troughs and ridges of the waves and subsequent concreting in situ.

Prefabrication of the various elements began soon after the site opened,

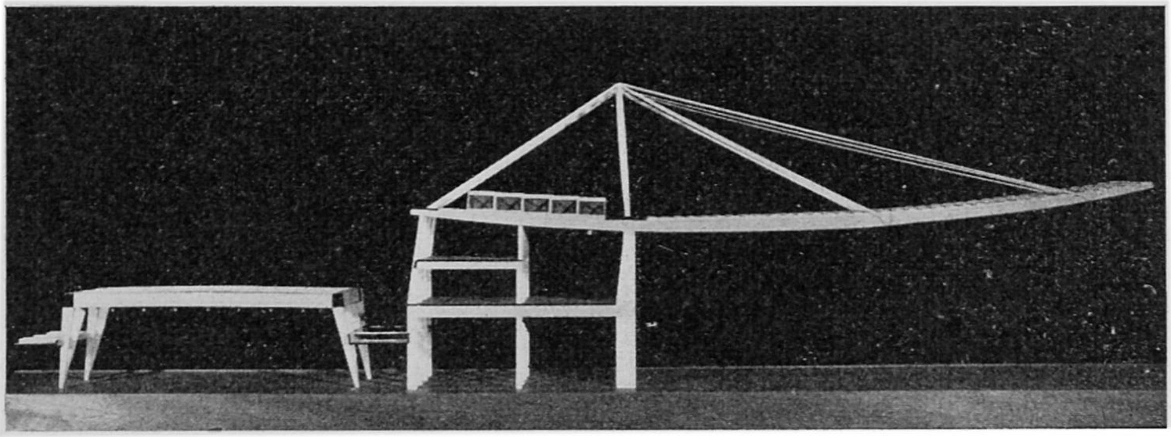

Fig. 8 - Fiumicino hangar. Longitudinal section of the roof (designed by R. Morandi).

so that when the supporting structure was made ready the dome could be installed and completed in less than 3 months.

Considerable speed and execution advantages, with particular regard to the complex shape of many structural elements, were also achieved by prefabricating the stairflights, the perimetral columns supporting the annular roof, etc.

Direct competition between reinforced concrete and steel construction is illustrated by the two recently-constructed Fiumicino airport hangars having the overall dimensions of 200 × 85 m, designed by R. Morandi (Figs. 8, 9 and 10).

Each hangar is divided in two parts, one of which, 200 × 60 m in

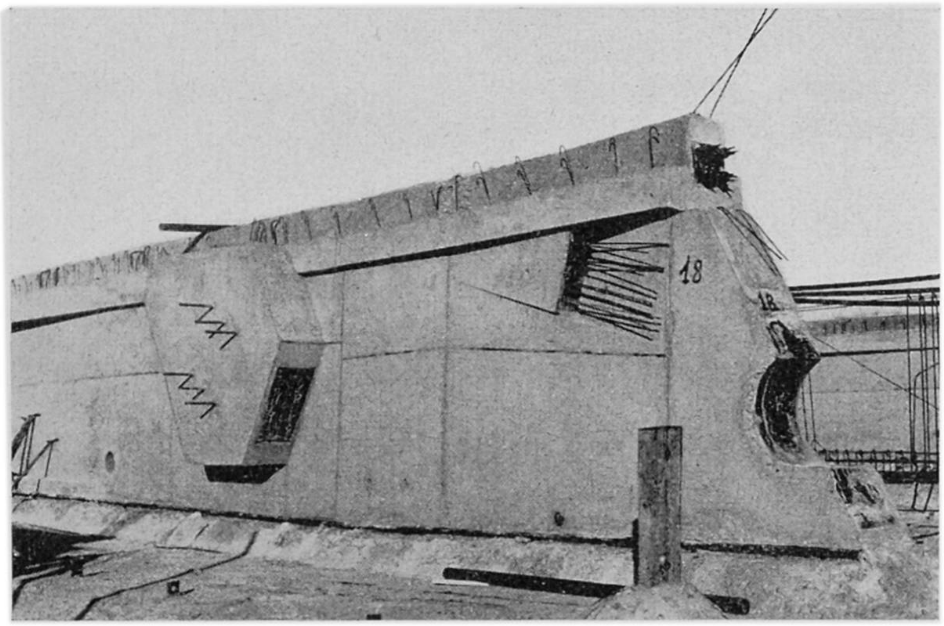

Fig. 9 - Fiumicino hangar. Main load-bearing ribs of the roof. Detail of a hinge.

plan and with no intermediate supports, is the aircraft shelter proper and the other serves for various uses.

The necessity of having a continuous front wall opening in order to allow a free entrance of airplanes from the runways has practically imposed the adoption of a cantilever type roof spanning the entire 60 m width.

The roof of the building is prefabricated, i.e., the large scythe-shaped girder, which forms the main load-bearing member, was divided into three parts, 28, 29.75 and 21.55 m long respectively. These parts, mutually connected by hinges, are supported by oblique prestressed concrete tie-rods to reduce their deformability.

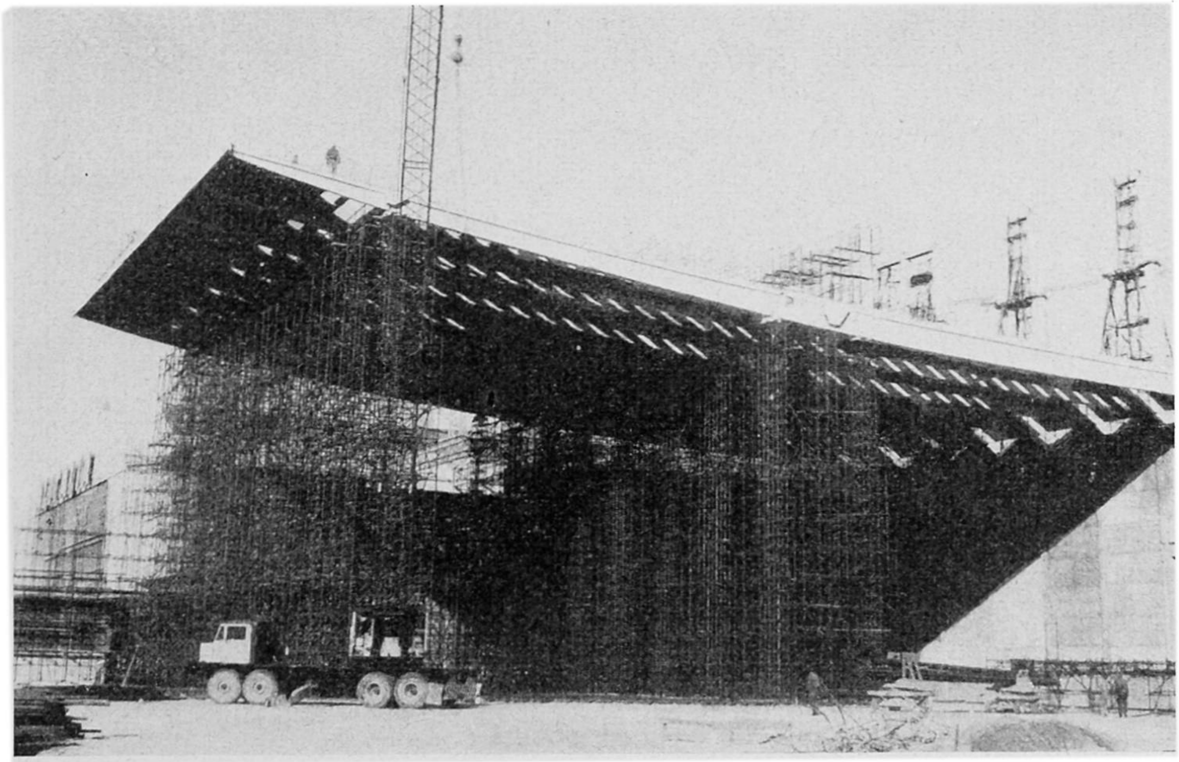

Fig. 10 - Fiumicino hangar. Assembled roof. The suspension tie-rods are still to be installed.

Because of the tie-rods, each composed part is automatically prestressed, so that its high strength steel reinforcement is very moderate, being only 6 kg m^{-2}.

4 - Bridges and viaducts

As in the case of industrial buildings, prefabrication in the bridge and viaduct sector has long since made it possible in Italy to carry out important works. It can be said that the prefabrication technique in this field is by now quite generalized, especially since the advent of prestressed concrete has considerably reduced the weight of the individual prefabricated elements and made them easier to handle.

For girder bridges, even of great spans, the transverse placing of beams is now of common usage. An appropriate centering is installed at the placement level to support the formwork of the beams. These are cast in the forms and, after being cured and prestressed, they are moved sidewise and brought into their final positions. Each form and centering make it thus possible to cast the longitudinal beams of an entire deck placed between two supports.

Widely used is also the longitudinal placement of the beams by means of a provisional steel centering supporting one end of the concrete beams, or by special bridge cranes.

In the case of small spans and weights, the beams are cast at the ground level and are then placed at the required elevation and position by means of appropriate hoisting apparatus.

Of this type of structures it is worth mentioning the viaduct of Corso Francia, Rome, designed by P. L. Nervi.

Prefabricated are the V-shaped beams, the slabs and the sidewalks; the piers and the cantilevers were cast in situ (Fig. 11).

The 16 m beams, each weighing 16 tons, were cast in cement-finished masonry forms. The daily output was of 4 beams, and no artificial curing was used.

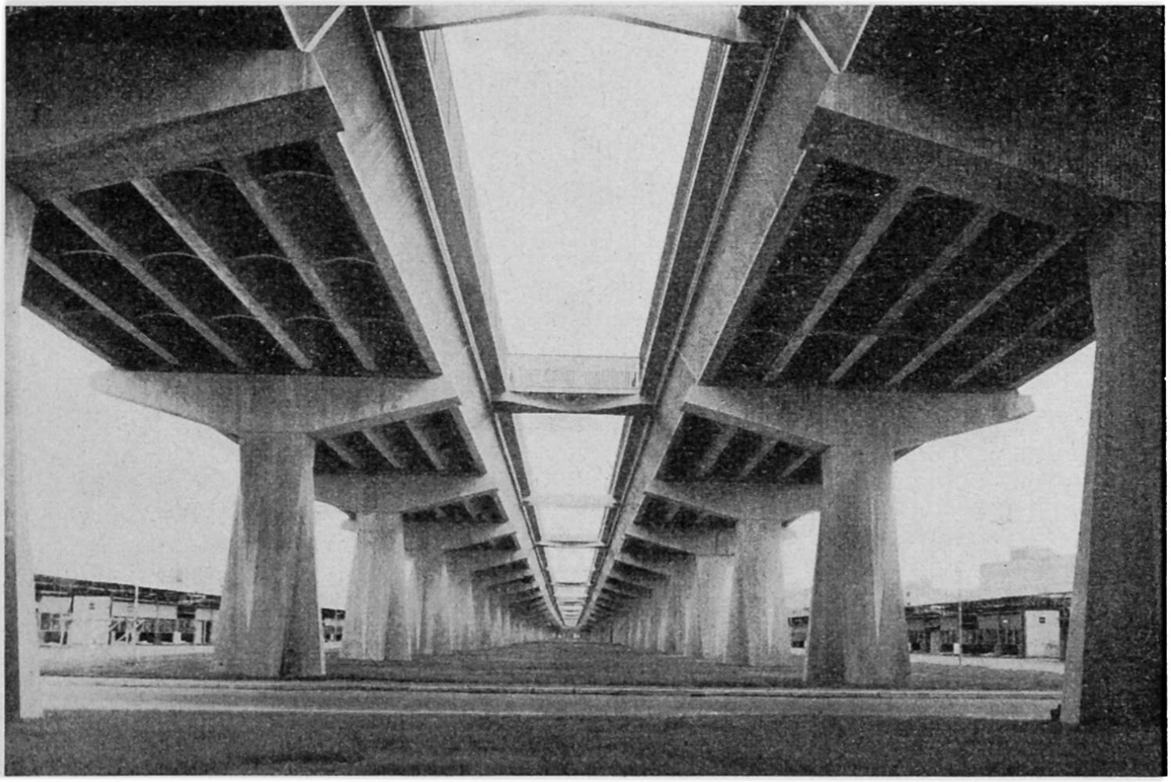

Fig. 11 - Corso Francia viaduct at the Olympic Village, Rome (designed by P. L. Nervi).

The output of the slabs and sidewalks corresponded to that of the beams.

In this sector, too, there is a growing trend toward industrialized prefabrication, similar to the one described for industrial constructions. Namely, there is a tendency to prefabricate, in special building sites, standard type beams and floors capable of forming decks even for large-span viaducts.

For instance, the Ferrocemento Company of Rome (Mantelli Group) has recently perfected typical expressway decks for spans of 24, 28, 32, 36 and 40 m, entirely made of ordinary and prestressed concrete elements. They essentially consist of:

a) main beams, in various quantities in accordance with the planned roadway width;

b) intermediate transverse beams (usually two);

c) continuous flooring slabs.

The beams are pretensioned. The layout of the prestressing wires is not straight from end to end but like a broken line in order to permit the wires to take the shearing stresses besides the bending moments.

The strongbacks for tensioning the beams are given by the steel forms, and the broken-line layout of the wires is achieved by means of appropriate stirrups which remain permanently embedded in the concrete.

The transverse beams consist of precast elements which are prestressed in situ by sliding cables.

The roadway is formed of continuous slabs over the entire width of the structure. They are pretensioned and provided with special holes to allow their connection in situ to the beams.

The conventional building-site operations for this type of viaduct are confined to setting up the supports and casting in situ small quantities of concrete for connecting the individual parts.

5 - Hydraulic structures

The usual considerations about the benefits generally resulting from the use of prefabrication, such as rationalization of the building site, reduction of labor and cost, etc., must, in the case of hydraulic structures, be supplemented by still others. These are of a technical nature and frequently of decisive importance for an unequivocal choice of this construction technique.

What we mean are mainly environmental conditions (concreting under water or in particular circumstances, etc.), the necessity of reducing to a minimum the construction time (lining of operating canals when they are empty, erection of structures during low-water time), and so on.

The hydraulic works here dealt with comprise water-conveying structures (free-flowing channels, pressure pipelines), general works (for water storage, inlet, outlet, etc.), and maritime structures (piers, landings, protective works, and so forth).

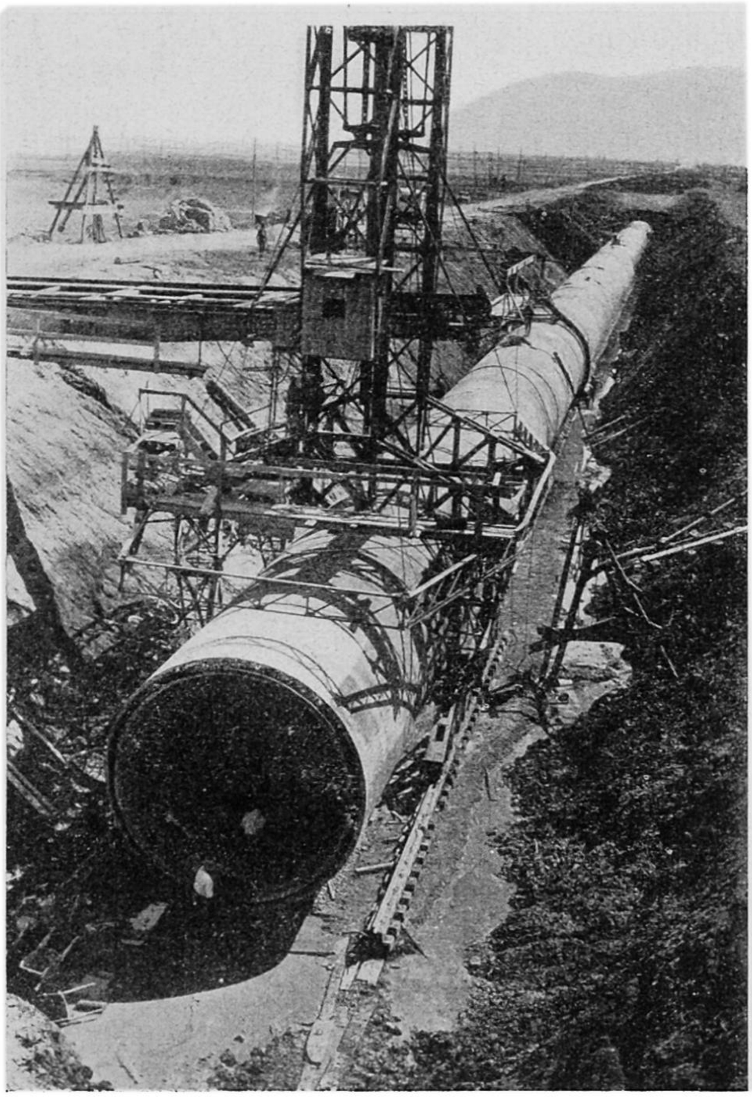

Fig. 12 - Volturno pipeline (S.M.E.). Plain reinforced concrete pipes, diam. 4.20 m (Impresa Ferrocemento).

Prefabrication at the present time is largely used in the first-mentioned sector, i.e., open channels and pressure pipelines, where prestressing increases the watertightness of the reinforced concrete structures.

Of interest in the free-flowing sector are the Vianini-built canal systems and the Tarquinia Plain irrigation flumes where the Vacuum Concrete method was used.

Of the pressure pipelines we shall mention those used for supplying water to the city of Rome (A.C.E.A.) by means of prestressed pipes having diameters of 1.40-2.02 m and suitable for pressures up to 14 atm, also built by the Vianini Company. Another remarkable example are the 4.20 m diameter plain reinforced concrete pipelines constructed for the Volturno hydroelectric power scheme (S.M.E.) by Ferrocemento Ing. Mantelli and Co. (Fig. 12).

Increasingly growing is the use of prefabrication in the other hydraulic structures. Of special interest are the accomplishments in the general works sector, i.e., the lining of canals, river regulation and protection works as well as irrigation and reclamation projects.

Canal lining, long based on employing non-reinforced concrete tiles so sized as to make it possible to place them by hand or by means of modest mechanical devices, now tends to adopt large-sized prefabricated elements.

Such elements, for instance, are the lightly reinforced 4 m square and 8 cm thick slabs used by Ferrocemento-Ing. Mantelli & Co. for lining the Recentino Canal.

Such may also be the highly flexible and very long prestressed concrete slabs designed by Zorzi for the Farsura Construction Company and destined to line the power canal of the Pontecorvo hydroelectric power plant.

The slabs are 25 to 30 m long, 1.25 m wide and 3 cm thick. They are

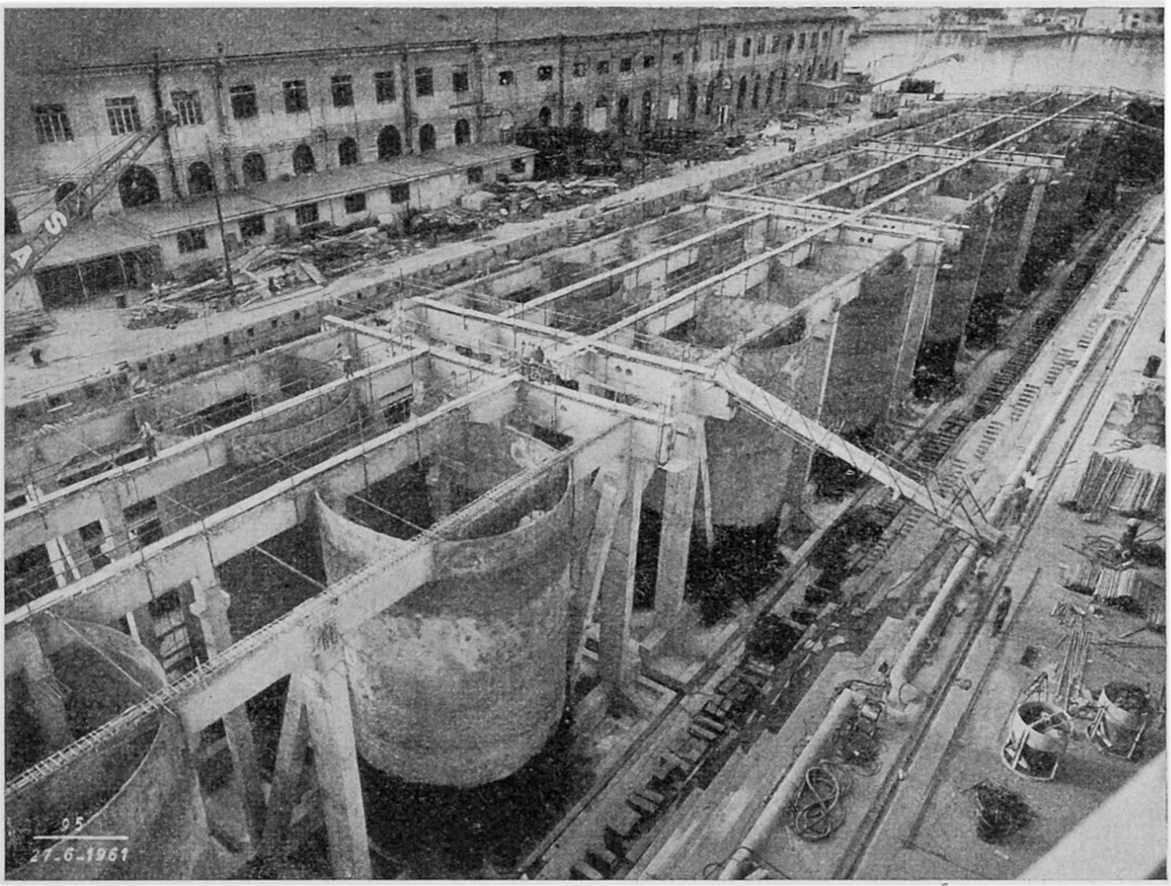

Fig. 13 - Edisonvolta thermal power plant, La Spezia. In-situ prefabrication of the fuel discharging wharf (Impresa SALCI).

reinforced with steel mesh and prestressed longitudinally (10 ∅ 3 mm per slab). They were produced in 10 to 12 superimposed layers, using special vibrating and finishing machinery.

The slabs were transported in situ in batches by Decauville wagons. On arrival to destination, each slab was picked up at the edges and hoisted by means

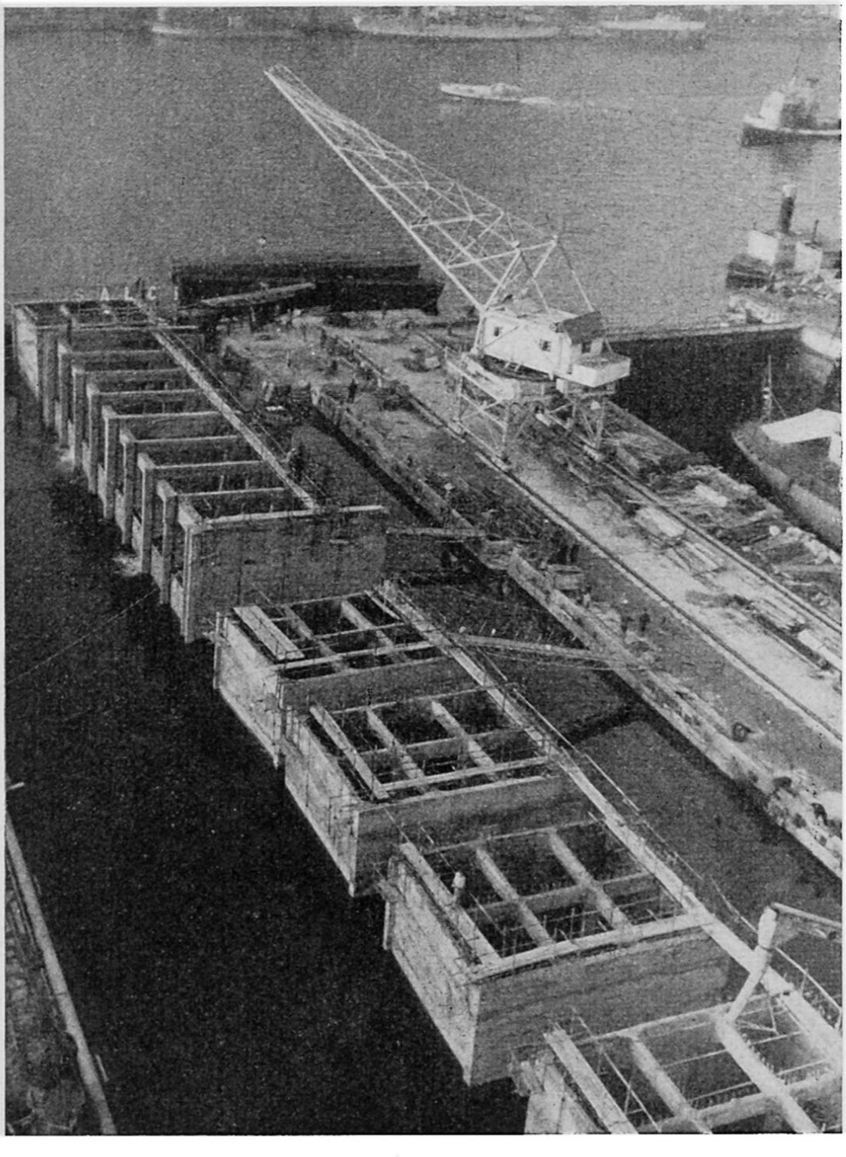

Fig. 14 - Edisonvolta thermal power plant, La Spezia. Precast wharf elements floating and ready to be trailed to destination.

of a bridge crane. It was then placed across the axis of the canal on a loose stone bed which had been sprayed with cement mortar.

Worthy of special mention in the field of canal lining is the Ghiselli type which also acts as a retaining wall since it makes a prism of ground behind the lining cooperate in the stability. The prism of ground is fastened to the lining by anchorages.

In river regulation and protection works, including transverse structures such as for water control, use may profitably be made of dry masonry framed by prefabricated reinforced concrete elements such as beams equipped at the ends with specially installed hooks for mutual connection.

Using appropriately connected hooked « I » beams (patented by G. Boni-

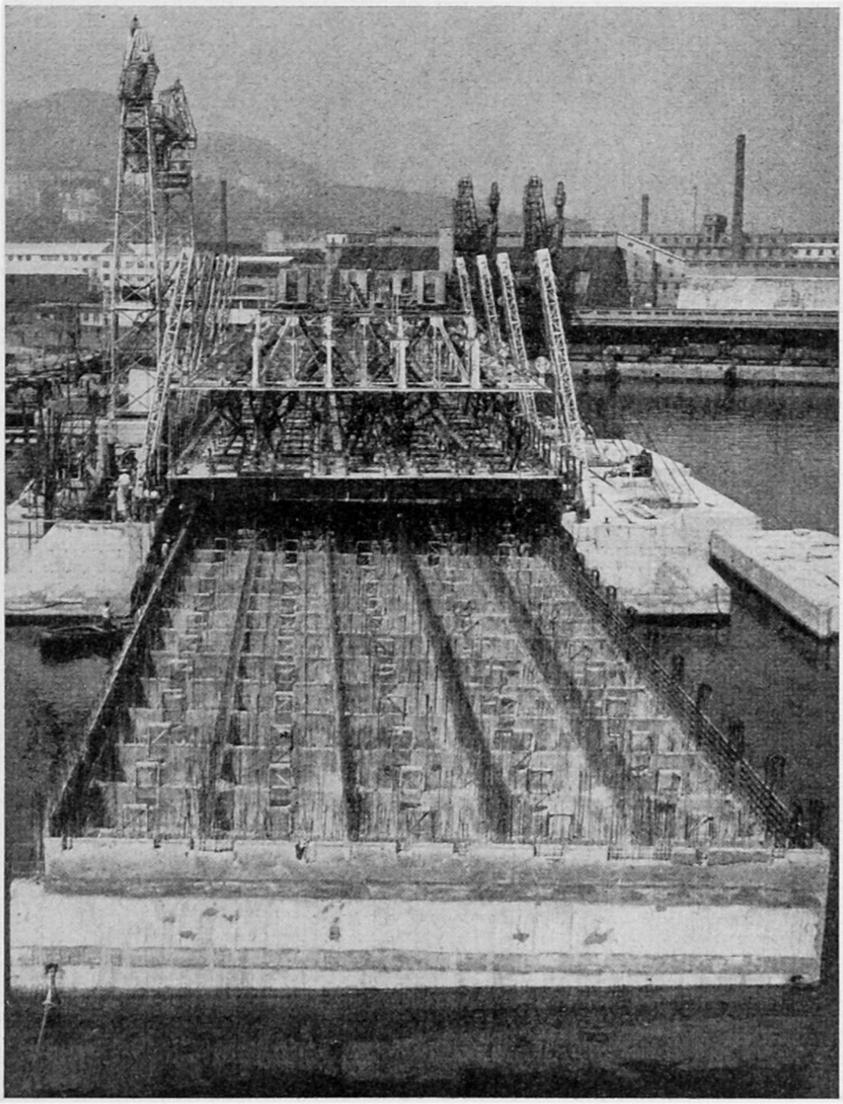

Fig. 15 - Dry dock no. 5, port of Genoa. Cellular caissons connected by prestressing (Impresa Fincosit).

celli), linked cellular structures may be obtained which, when stone filled, form a kind of comparatively deformable composite dry masonry possessing a high draining capacity and great tensile and shear strengths.

The weight of the prefabricated members in this structure is relatively small (200 to 300 kg per cu. m), and the filling material for the cellular structure may be obtained in situ even if it is of mediocre quality.

For maritime works, prefabrication mostly furnishes structures of extraordinary size and weight, whose transfer to the place of employment is possible only by means of special transportation facilities or by utilizing the floating capacity of the structures.

The prefabricated members to be conveyed by floating may be manufactured in three different ways: on a slip, in a dry dock or under a carrying and launching structure.

The slip-produced members are launched in the classic way used for ships. However, this method is about to be abandoned because of the numerous hazards it involves and also because of the high cost of the launching ramp which has only a gentle slope and is therefore long in order to reach the great depths that are always required for having such heavy elements float.

The members manufactured in a dry dock are obviously floated by merely flooding the dock. A conspicuous example of this technique is given in Figs. 13 and 14. The advantages of this system are obvious. However, it demands that a dry dock be available close to the site and, furthermore, the rent of the dry dock is always high.

More convenient under many aspects is the method of construction « under a carrying and launching structure ».

It consists in setting up, in a fixed position or on a floating craft and at an adequate height above the water surface, a carrying structure, such that will

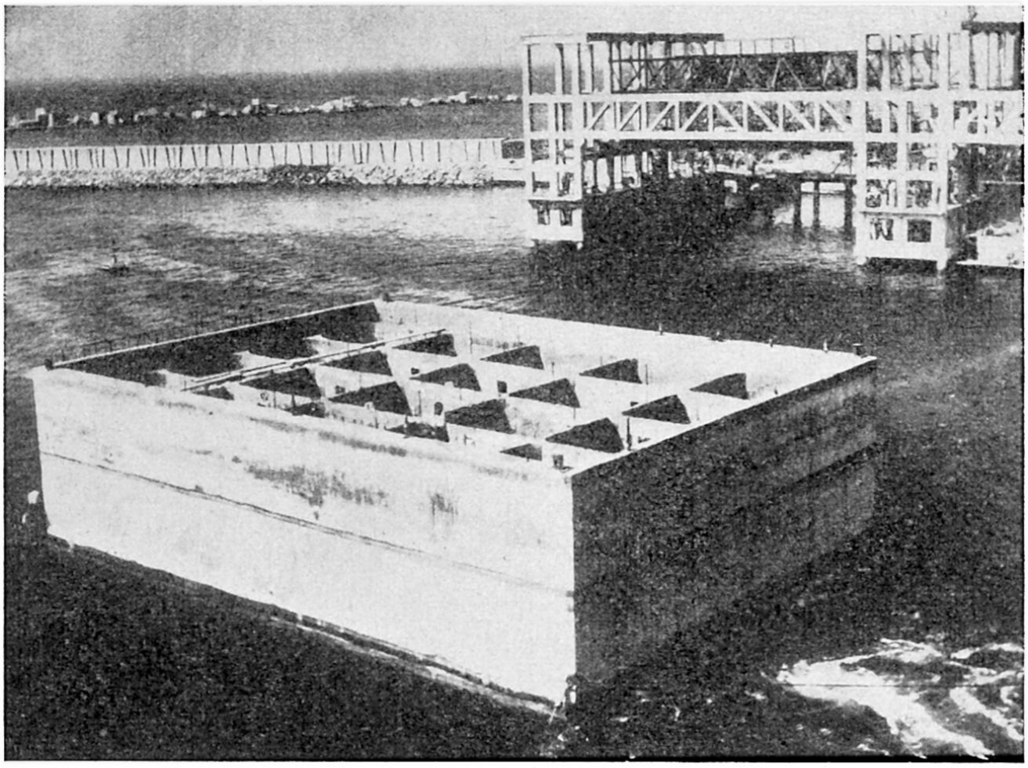

Fig. 16 - Airport dam and pier at Genoa. Floating caissons and precasting equipment (Impresa Fincosit).

make it possible to begin building the various elements. As these are constructed, they are lowered into the water up to the point where they float; the elements are then removed by floating, completed and transported to their final destination.

This system was employed in Italy in very important jobs. Foremost

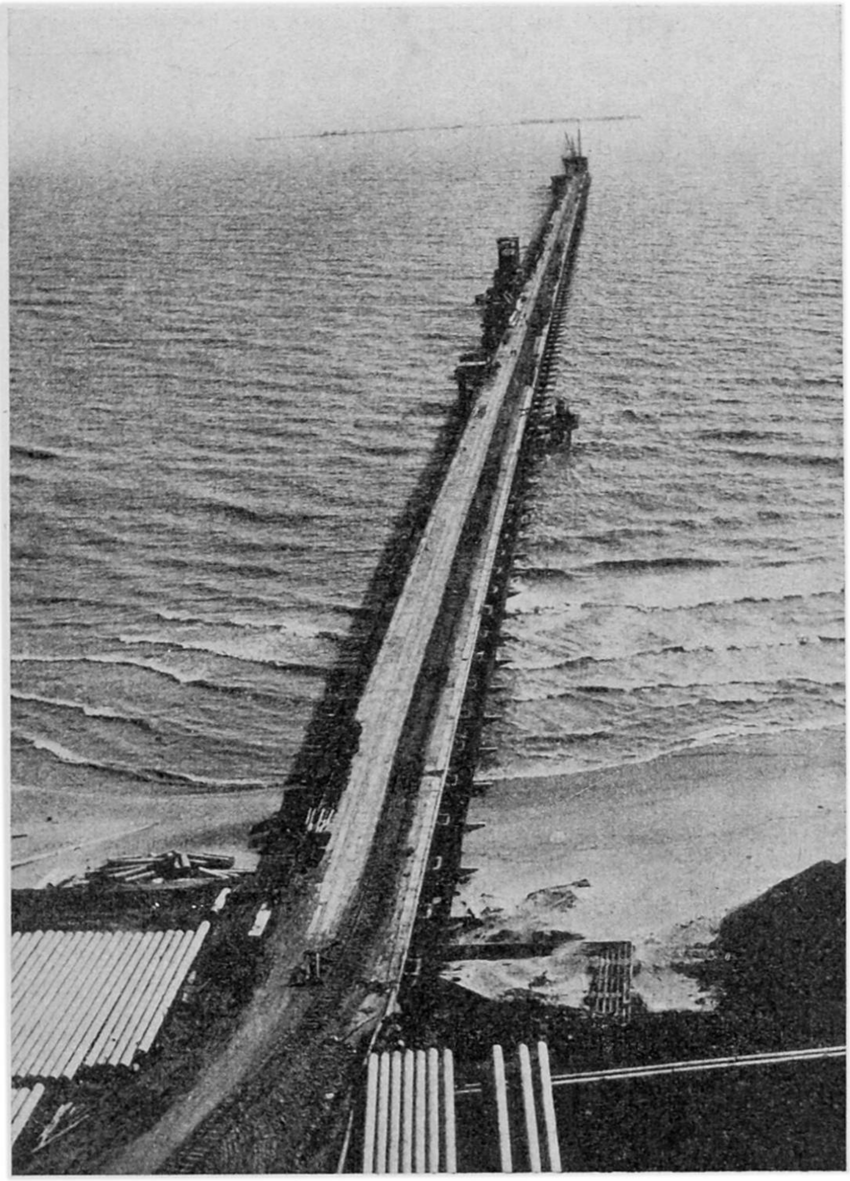

Fig. 17 - ANIC loading dock at Gela, Sicily. Prestressed foundation piles (Impresa Vianini).

among them are the imposing external and internal quays of the new port in Genoa and the structural members of the 5th dry dock, also in Genoa. Figs. 15 and 16 show some of the most significant works recently carried out (Fincosit Construction Company). Another striking example is the ANIC loading dock at Gela (Sicily) built by the Vianini Company on a prefabricated and prestressed pile foundation (Figs. 17 and 18).

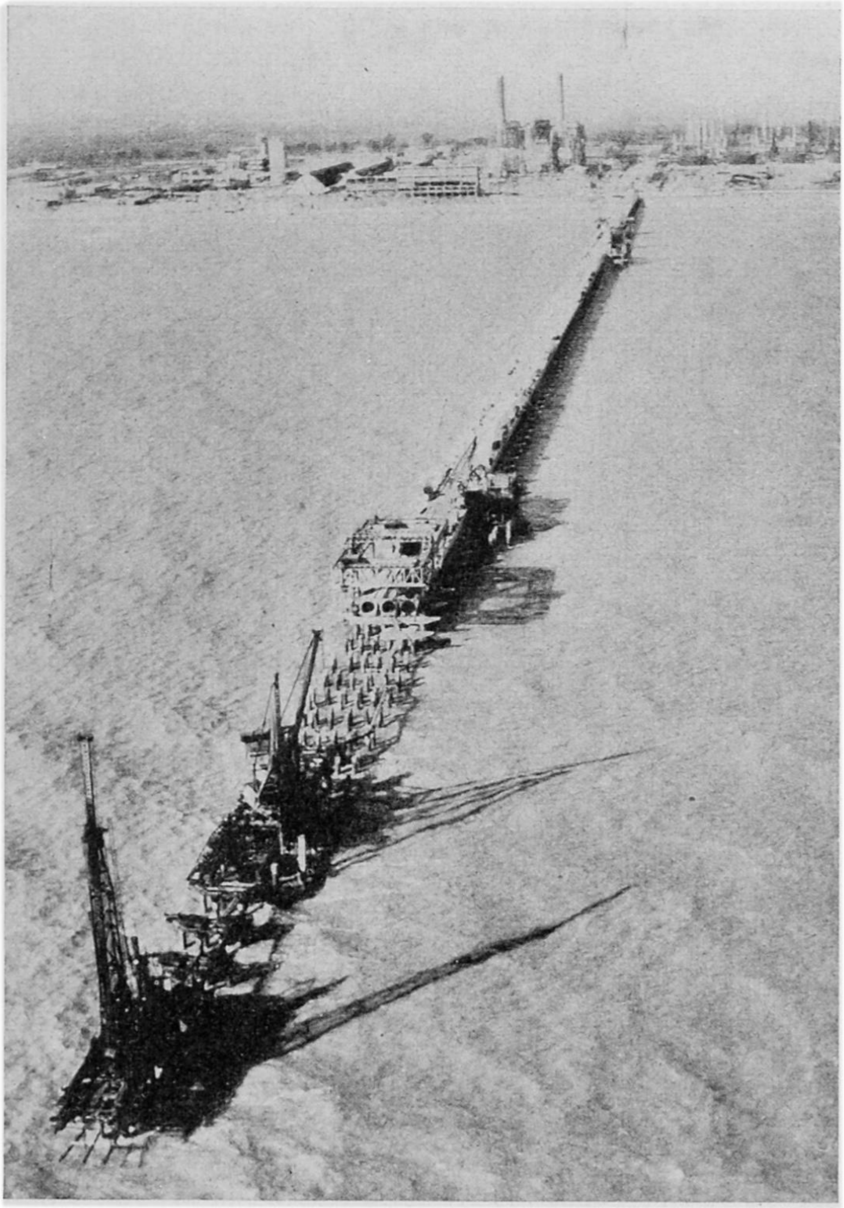

Fig. 18 - ANIC loading dock at Gela. Driving of prestressed foundation piles.