

Architecture and Technology

Renzo Piano

Translated by Thomas and Mary Stevens

Renzo Piano is a well known young Italian architect who held an impressive and popular exhibition of his work last year at the AA. This article is an attempt to put his work into perspective and includes descriptions of a number of the projects shown in the exhibition.

In our century cities have undergone a process of degradation from which only the precise and systematic application of restructuring instruments can rescue them. With few exceptions, and in few quarters of the greater urban areas, our settlements seem clearly enough to be suffering from a deep imbalance in their constituent elements. They have enlarged without regard for the spontaneous and organic laws which relate their spaces: those occupied by residential, productive and communal service facilities.

These relations have been skipped, whether at a social or functional level, at that of the conduct of life, or at a spatial level – the structure which defines the civic spaces.

As a result of this, entire cities and vast districts are being ever more and more transformed into ghettos, simplified and impoverished in their relations and completely degraded in their structure (for example, the greater part of the historical Italian centres, especially where intensive programmes of rehabilitation have not been undertaken).

Heavy destructive intervention cannot substantially modify the situation. For example, the poly-functional megastructure, although architecturally very interesting, can conceal an inability to analyse the organic relations which govern the services of cities old and new, and to provide a design sufficiently complex and flexible to represent an answer.

A fair hypothesis is probably to concern ourselves as architects more with what goes on in the city than with its form; more with the existing relationships between the facilities of the city than with the optimal definition of each one separately.

Cities need revitalizing inter-

ventions, capable of renewing their meaning as instruments of change. They need the truly catalytic interventions, extremely flexible and adaptable in time, of organisms capable of continual upgrading to the changing functional and circumstantial conditions of the city.

Thus in the formal and structural definition of these organisms, there enter so heavily into play the functional, experimental and temporal variables as to supersede any customary approach to the planning problem, and to concentrate all the attention of the design on their characteristics of effective flexibility, adaptability, mobility and openness.

In the functional definition, the problem is substantially to single out the activities of major change and most evident communal interest in order to dimension on them a complex network of facilities. These are facilities which, whether in new examples or in reconstruction, are those of communication, education, leisure and sport, sanitary, social and commercial services, and which individualize a network strictly connected to service areas.

It is necessary to individualize a law of development and right relationship of such facilities for the modification of the conditions of cities.

We are not handling closed organisms but schemes flexible and enlargeable in time, which can be integrated with existing constructions.

The basic problem in defining these laws of dependence is obviously the type of social organization in the community. Interesting examples of community organization can be recalled in which the educational facilities are backed up by the active presence of the population in the conduct of the school.

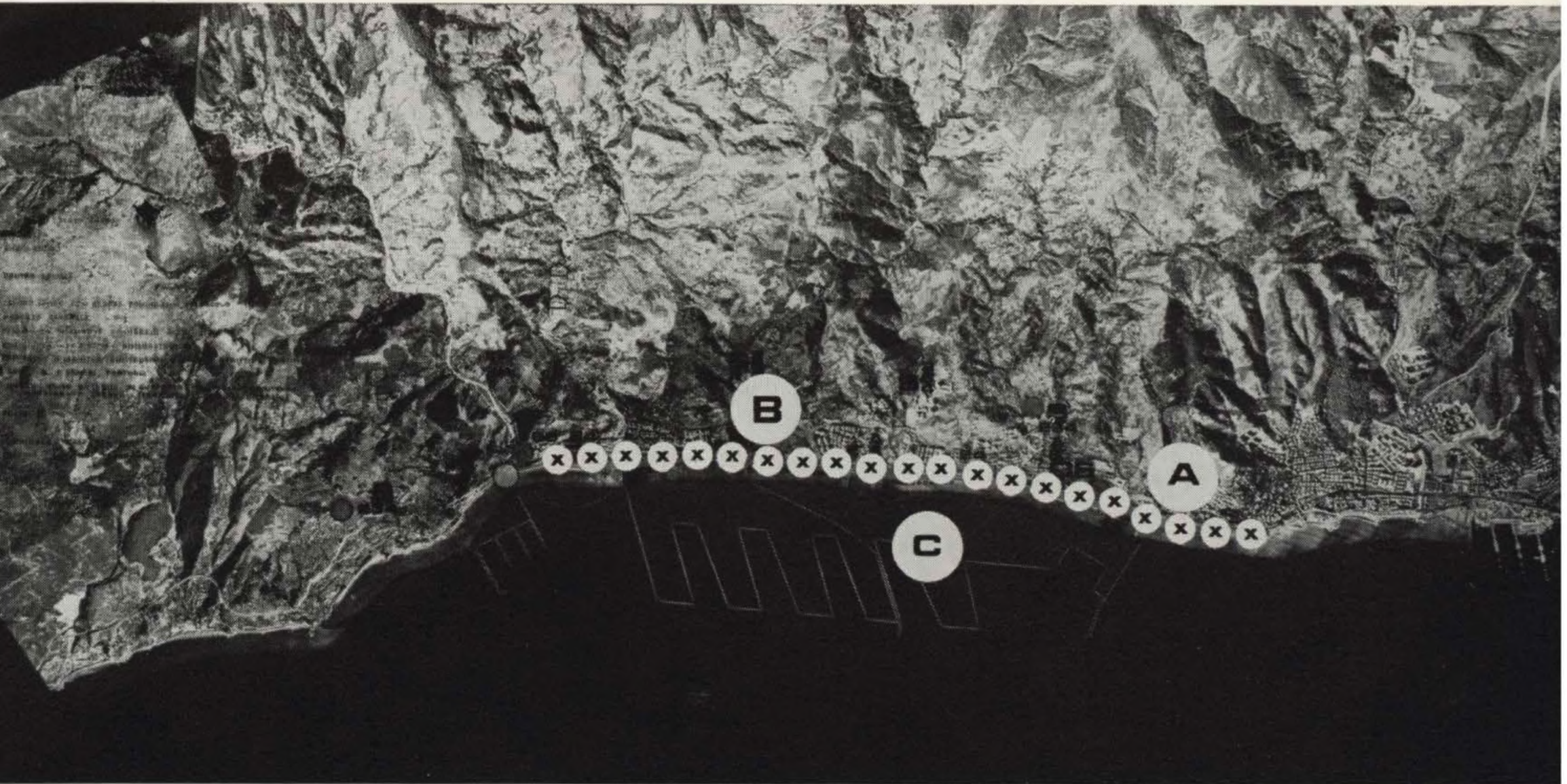
But on the level of the structures, the aim is to arrive at plans integrated in themselves and closely linked to the urban territory. It is a discourse which signifies substantially the introduction of freer and more dynamic schemes, schemes more capable of interpreting the need for complexity in the facilities.

On the technological level, it means substantially basing the organisms on less restricted, constructive criteria, more interpretative of the needs of organized production.

The role of technology is in its most general aspect of structural and constructional research, if research into materials and methods of production is evidently of primary importance in singling out the concrete modes of response to the organizational requirements of the environment (which is clearly still the basic problem of architecture).

It is not only an instrumental role, but one which establishes the extent to which technological values intervene in modifying and defining the requirements of the project, for in every projective process which is sufficiently dynamic, it is founded in continuous verifications of assumptions. In a projective process the level of complexity of the end product is heavily conditioned, even in its functional aspects, by the profundity of the so-called technological aspect of the problem – structure, apparatus, materials, production techniques.

This is intended to be the critical basis of the work presented here, realized experimentally through a diverse set of opportunities, provided solely on the level of technological research and on the basis of the aims.



Works and projects

Study scheme for the Port area of development, Genoa 1970

9 (1) Along the axis of communication are distributed the facilities of the areas included in the plan of reconstruction.

The educational facilities are provided for in A, to be carried out with structural schemes of the type indicated in the experimental projects in the illustrations 9, 10, 11, 12, 13.

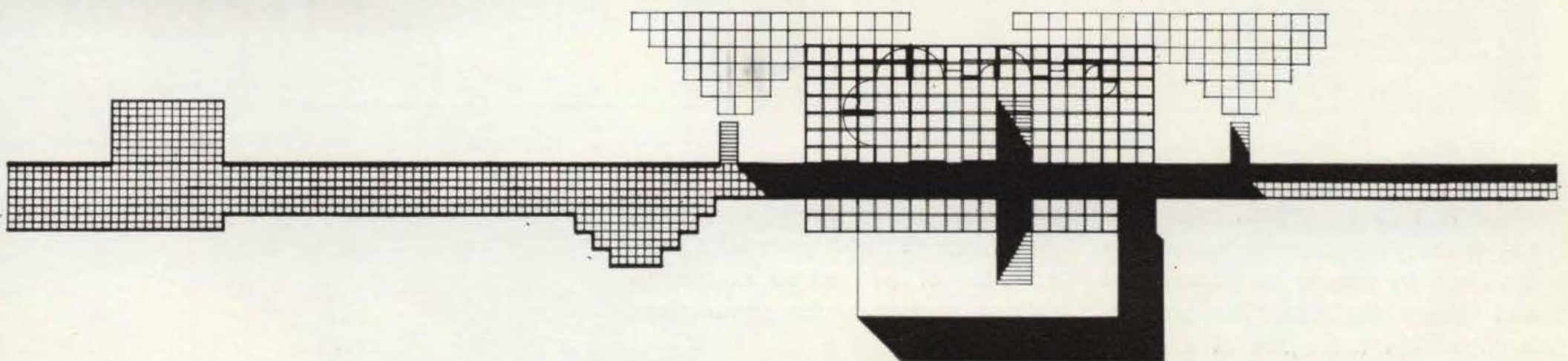
Sports facilities, large covered areas, leisure and markets are provided for in B, to be executed with the structural schemes of the type shown in illustrations, 14, 15, 16, 17, 18.

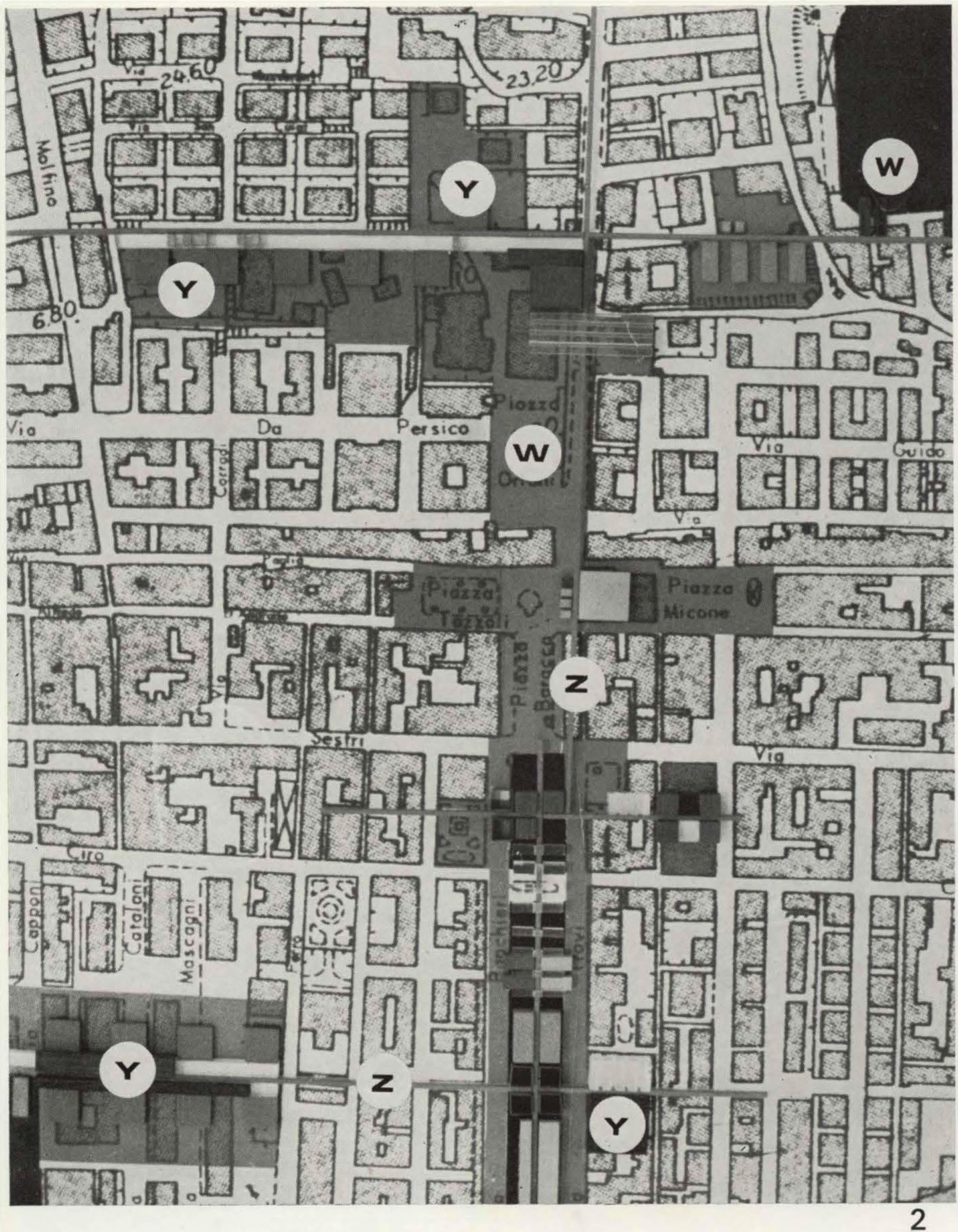
In C, port facilities, mobile and capable of enlargement, are provided for, shown in 19, 20.

The relation between the effective requirements of the project and the examples described is to be understood in a wide sense, excluding choice of details and limiting the retention of the structural and spatial characteristics of the examples. These are all *suggested*, not so much as architectural concepts complete in themselves, but as fields open to more complex developments.



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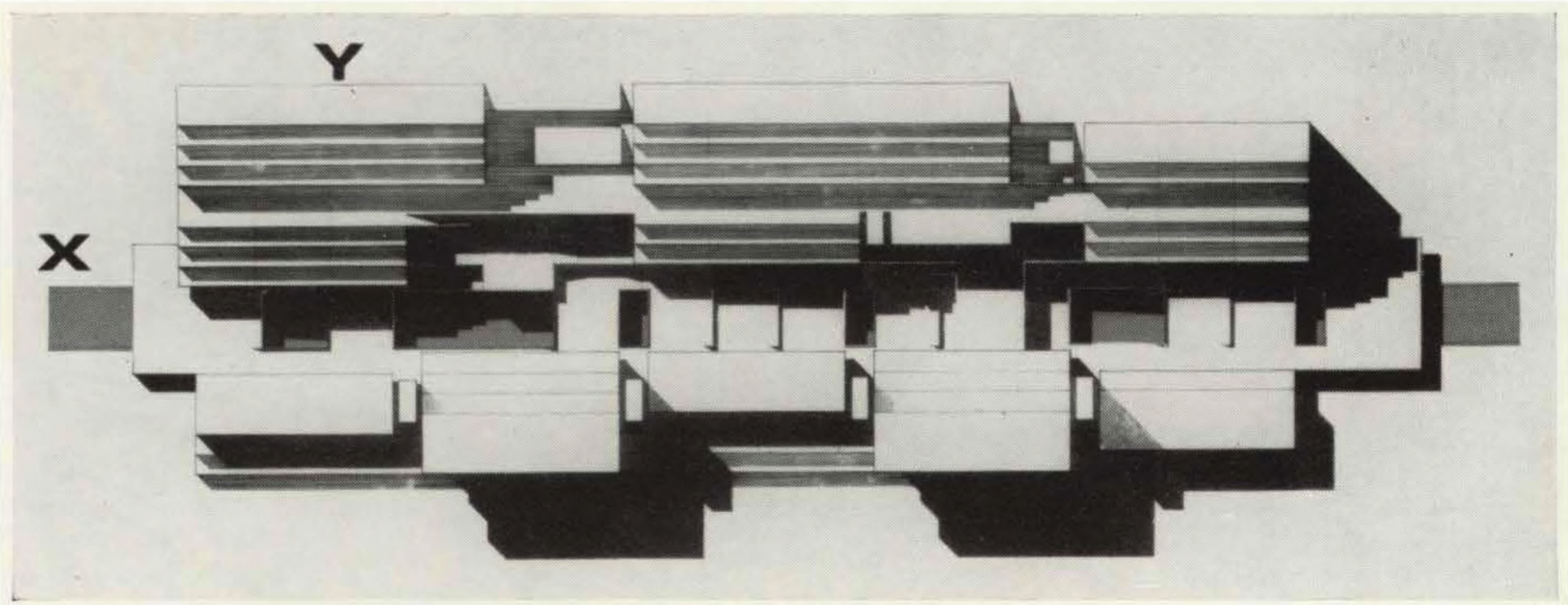




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Study scheme for the reconstruction of an urban area
 (2) A programme for urban reconstruction by means of educational and leisure facilities. The scheme includes the salvaging of existing

facilities (W) by the insertion of new organisms with improved potential for change (Y) and the creation of a network of pedestrian communications, and of service connections (Z).



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Housing – Genoa 1969

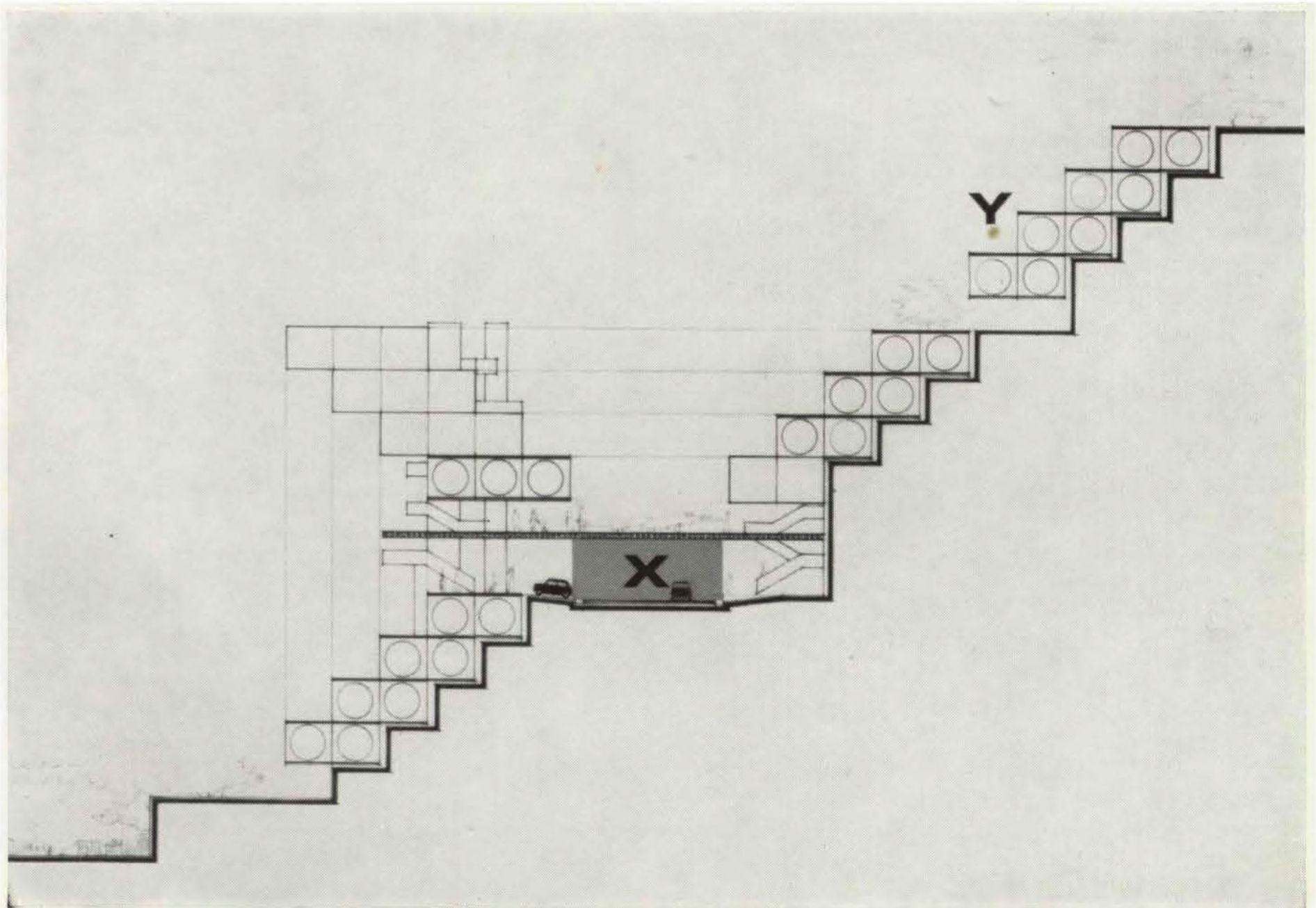
This is a study for a residential settlement to be developed in successive stages (3).

Axis X is intended to be the basic infrastructure of the settlement, and functions as the tie with the city. This principal axis represents the first phase of the settlement and combines, besides the chief communal facilities, all the service ducts, parking, loading and unloading areas. The axis only contains the facilities for commerce, education

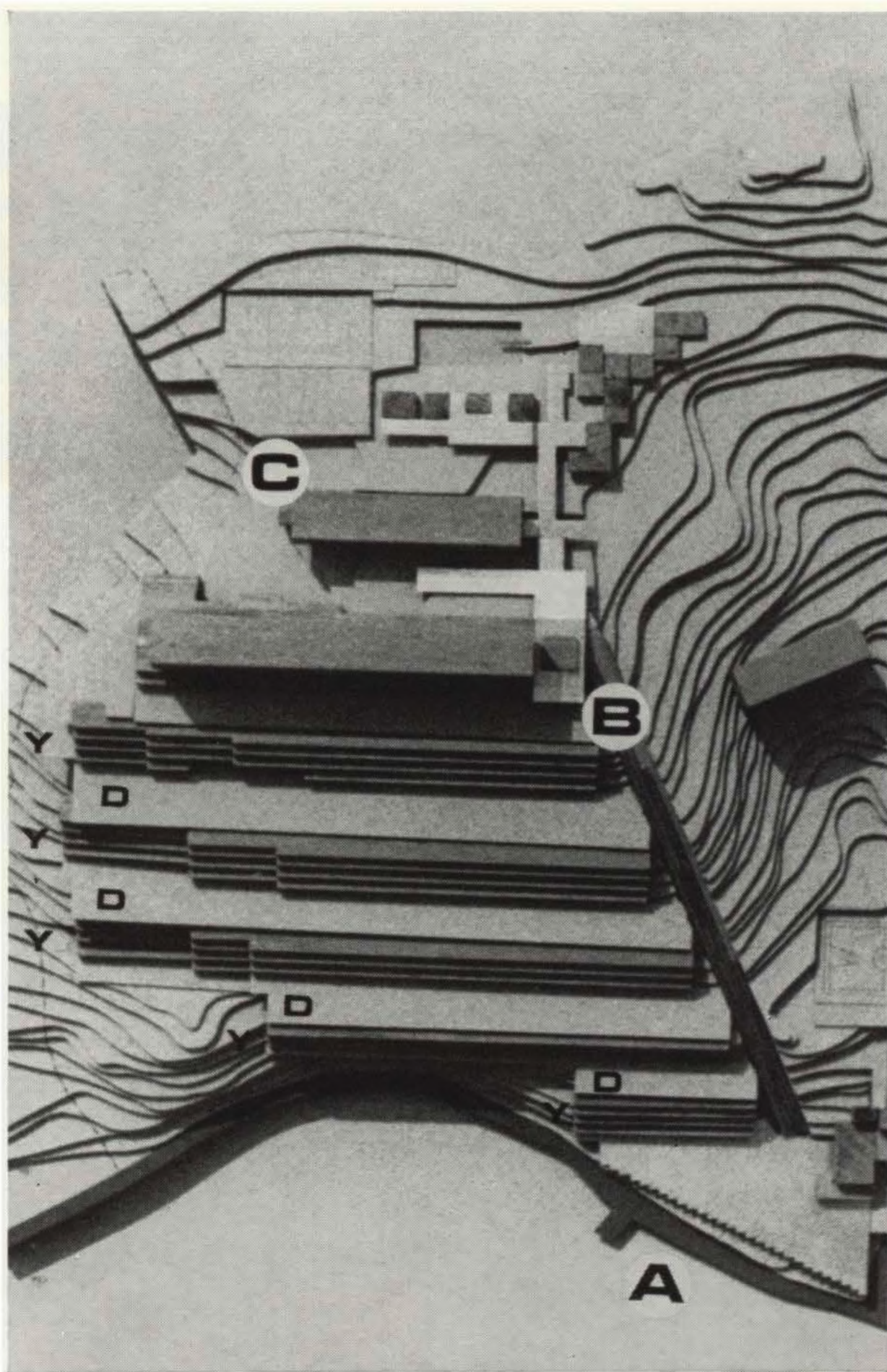
and recreational facilities. On this functional spine are inserted in successive phases – in precise relationship to the dimensions of the settlement and the development of the facilities – containers for the individual living spaces. These containers are executed in large elements of prestressed concrete, fixed on site and tensioned by means of a system of cables. The connection between the primary axis (X) and the habitation cells (Y) is envisaged

not only in a structural and functional sense but also in relation to the development of the organism in time.

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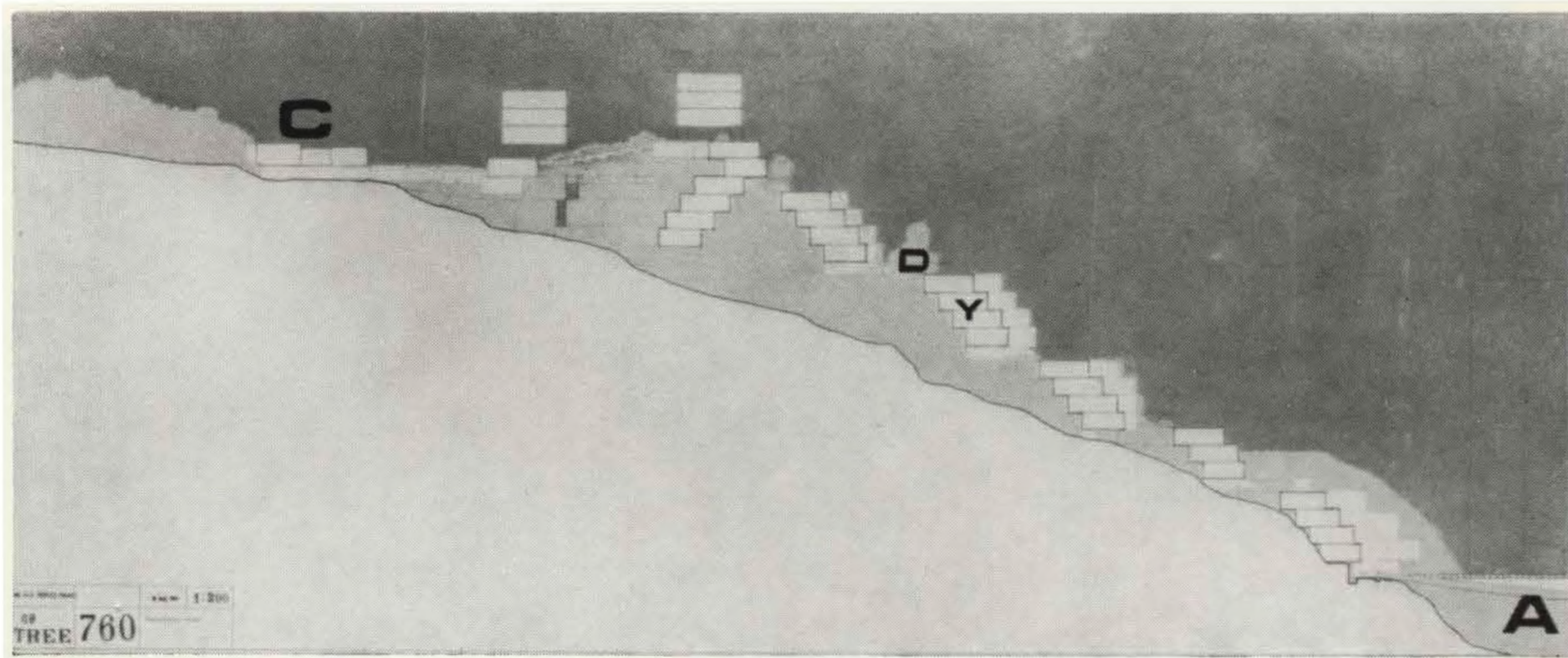


Housing – Genoa 1969

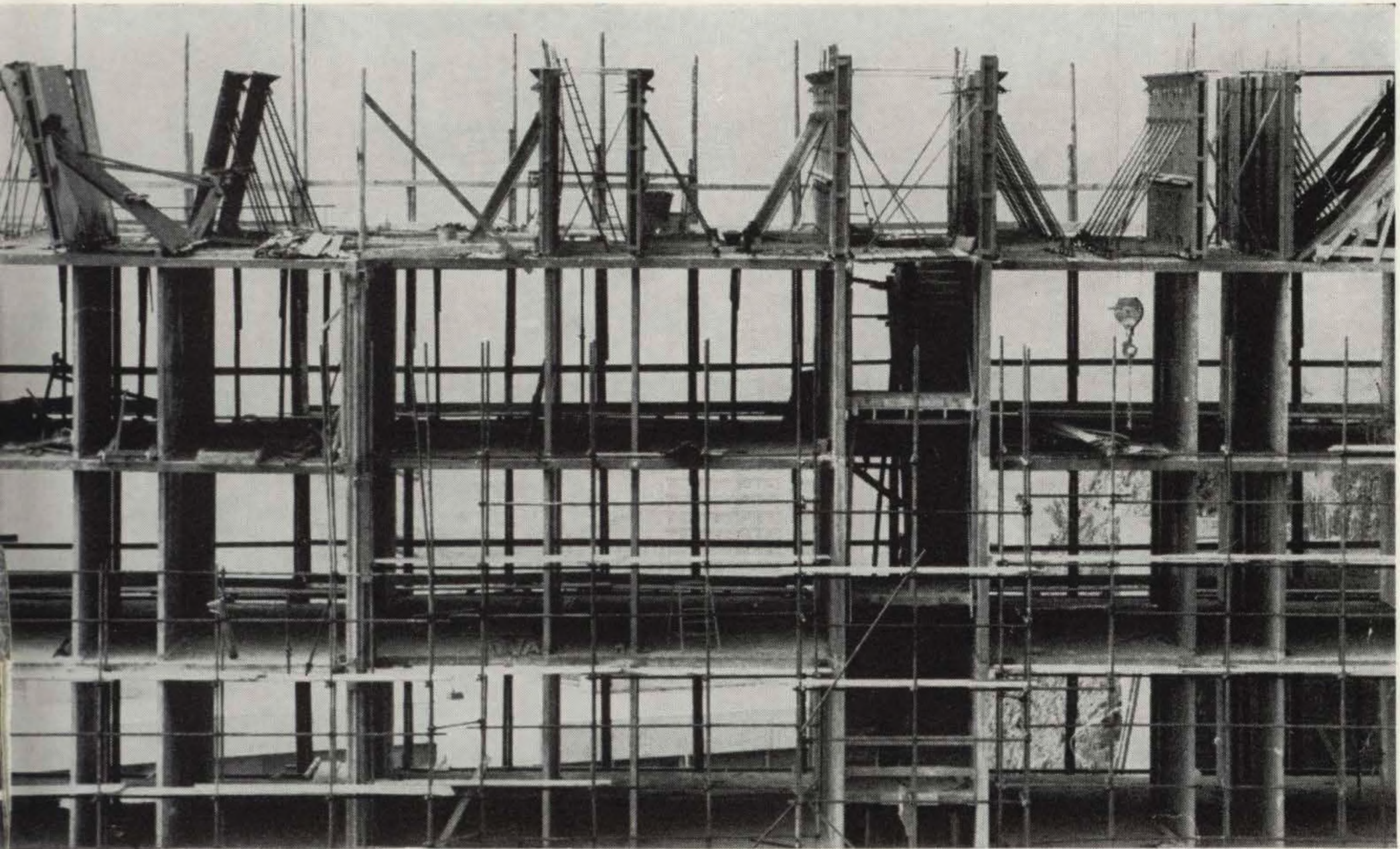
Designs 5–6 show the scheme for a residential complex planned beneath a hill.

In A are grouped the general amenities, parking, shopping centre, and services; B represents a complex of lifts and inclined hoists, able to transport up the hillside all the persons and materials foreseen in the organism. At the summit of the hill in C the sports grounds, schools and leisure facilities are located. The arms (D) represent the structurally primary spines, in which are concentrated the horizontal routes, and on which are inserted at various times and even with very different characters, the dwelling units (Y).

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OF TREE 760



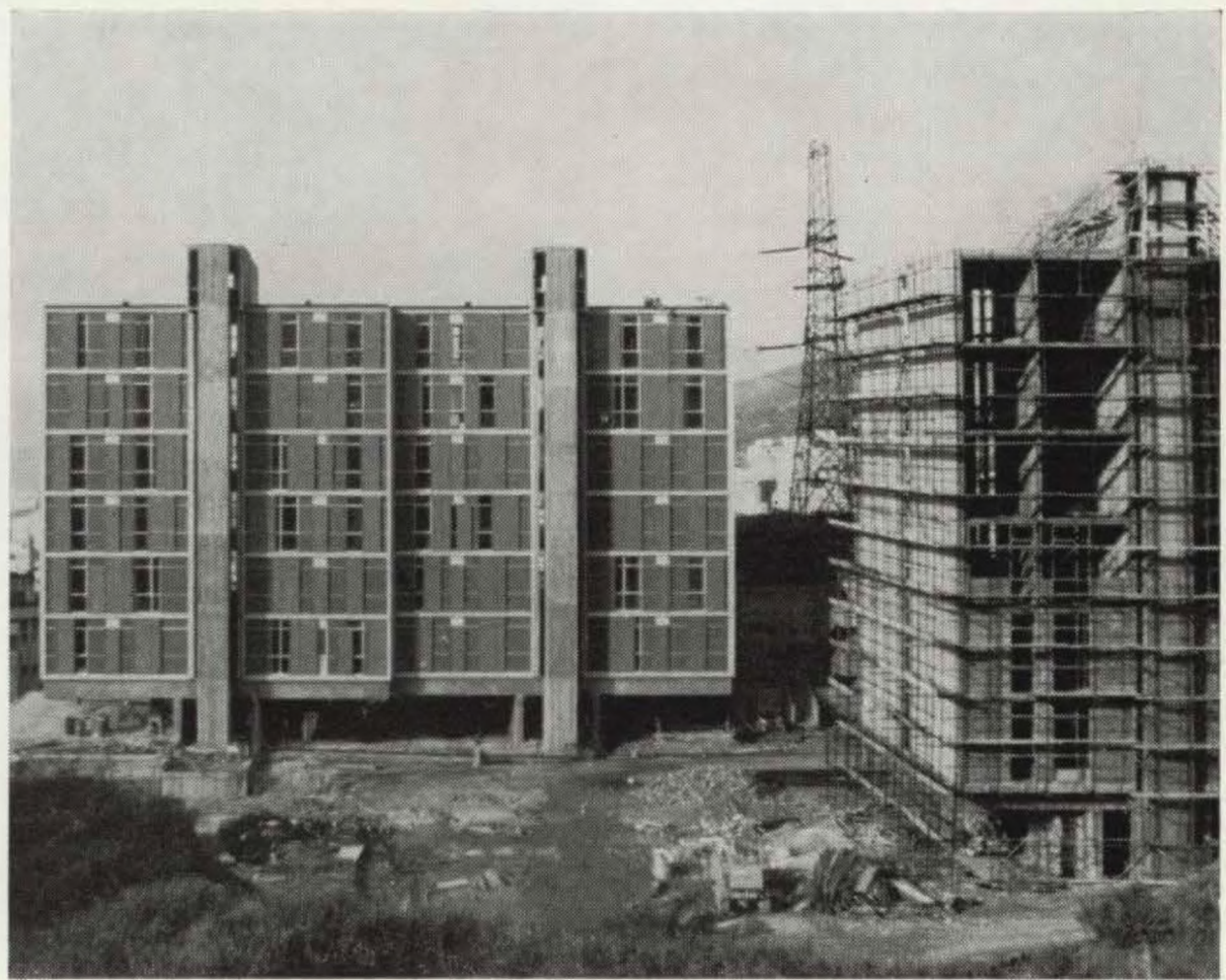
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Apartment blocks – Genoa 1968

In the illustrations 7–8 a residential complex is illustrated, using techniques of partial prefabrication, starting from the principle of assigning to a solid primary structure of post-tensioned concrete the role of a primary structural element; the secondary structural role is assigned to the light prefabricated elements connected to it.

The whole is composed of five constructions each of six floors, and an ensemble of communal facilities beneath the ground-floor columns.

The primary structure and the staircases are *in situ* post-tensioned reinforced concrete. The structure consists of a horizontal beam raised above the ground and a tower for vertical services such as staircases, lifts and plant. Such a structure guarantees the embedding of the building in the ground and defines an absolutely stable platform for assembling the successive elements, also it is not shackled by the toler-



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ances due to eventual differences in the load-bearing capacity of the foundations. The secondary structure is represented by prefabricated elements in lightweight concrete.

At the structural level, this

differentiation between elements, service ducts and dwelling units represents the possibility of separating the functions of the various parts, and assigning to each element and material the most appropriate task.

Laboratory building – Genoa 1969

One aspect of technology I regard as basic may be the tendency to define ever more precise functional architectural roles for the various available materials, according to their specific mechanical characteristics, but also according to their availability in relation to the various techniques of transformation.

In 1969 an experimental laboratory building (9–10) was erected at Genoa composed of four fundamental constructional elements, made of four different materials. The construction provided a square plan of 20 m, with an additional concrete element containing the plant. The entire complex is hermetically sealed and completely air-conditioned. The basic constructional elements are represented by the foundation beams in prestressed concrete, the pyramidal constructional element in steel, the wall element in light concrete and expanded polyurethane, and the translucent roof element in glass fibre. These elements are enough to cover a very wide range of possibilities for servicing, and each one represents an attempt at technological optimization.

The foundation element in prestressed concrete is so dimensioned as to fall within the weight limit manageable by a mobile lorry-mounted crane; the cavities in the element are intended to facilitate the efficient ventilation of the foundations, and an easy positioning of plant such as air-conditioning, water and under-floor electrical supply.

The pyramidal structural element in steel measures 2 m square on base and 1 m high. The particular use of the same element to carry the walls has allowed a considerable reduction of the maximum loading stress, thanks to the erection of an effective and very efficient mortise along the edge. The elements can also be transported, perfectly dowelled into one another, with the minimum of encumbrance. They house the equipment for air-conditioning, lighting, automatic sprinklers, etc.

The wall element measures 2 × 2 m, and is made of lightweight concrete and expanded polyurethane. The total thickness is 10 cm made up



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of two thicknesses of light reinforced concrete each of 3 cm, enclosing a 4 cm layer of expanded polyurethane. The thermal insulation is considerable, although the thermal inertia is low.

The panel is mechanically fixed to the load-bearing structure, and all the elements can easily be interchanged. Finally, the translucent roof element is made of glass fibre, and is in two layers, with an air-space between them against condensation.

The external polyester membrane forms a separate section and is discontinuous, with opaque material to the south and translucent material to the north. Thus the panel, although transparent to indirect light, prevents direct sunlight from penetrating the building.

This characteristic, besides evening out the luminosity between the limits (sun-rain, summer-winter) considerably reduces the heat gain to the building from irradiation.

Experimental houses – 1968–69

The characterization of the parts of a polyfunctional organism according to the priority of the services in time, the laws of growth and development, and specific structural function is accompanied by the need to qualify the architectural space according to a very intense flexibility of use.

An experiment of this sort has been tried out in a series of constructions in the neighbourhood of Genoa (11, 12, 13). It consists of week-end houses and is made of an *in situ* part, comprising the foundations, the service connections and the ground floor, and a prefabricated part, consisting of the vertical load-bearing structure, the walls and the roof.

The principal aim of the project was to obtain the possibility of characterizing the internal and external space in a very different way, generating them with a series of standard elements of construction.

In reality, although the vertical load-bearing structure had a single basic element, it allowed completion with very various secondary elements such as lightweight concrete, wood, glass, fastenings, movable walls, and although the horizontal supporting structure was executed in standard wood elements, they permitted the closure of the inside space with a great variety of secondary elements (an opaque element, a transparent element, and a shed element). The plan of one of the buildings can be seen (11), in which the various functional zones of the

house, sleeping, eating, cooking, washing, living, are characterized by the various secondary elements.

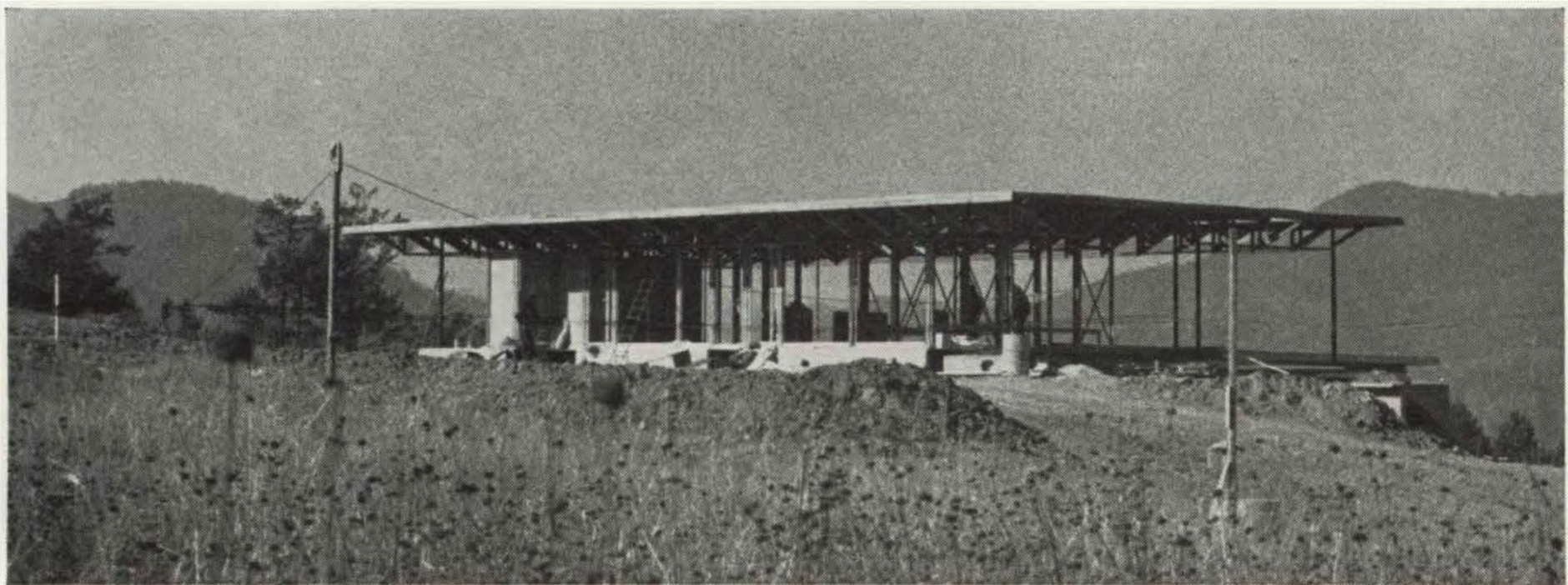
The entire useful space of the house, internal and external, is protected by a large structure in plates, made of standard elements, whose composition creates a structure of crossed beams, of considerable rigidity.

The effective rigidity of the

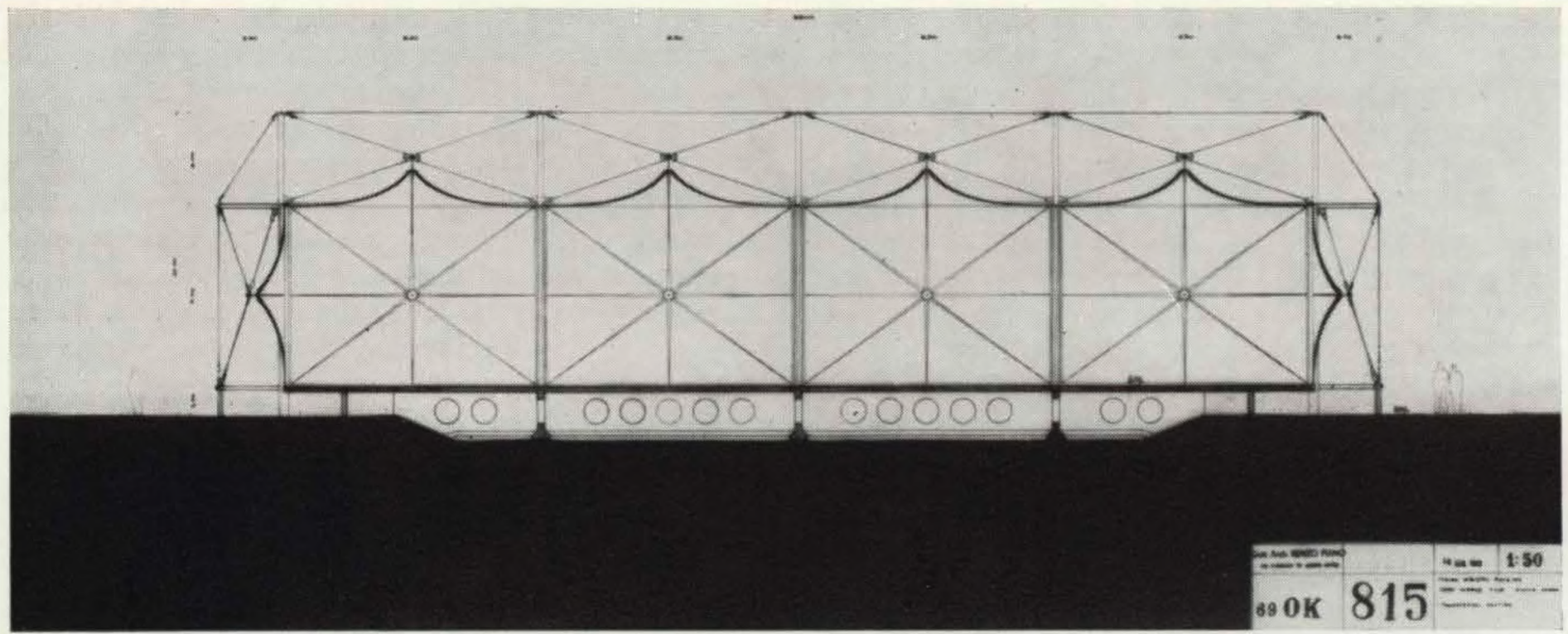
structural part, the primary element of spatial definition, allows the supports to be moved at will, and quite complex systems of movable walls to be carried out.

In the examples shown certain screens were removable or displaceable in tracks so as to modify the internal spaces when the house was in use and introduce a dynamic factor of spatial modification.

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Italian Industry Pavilion – Osaka 1969–70

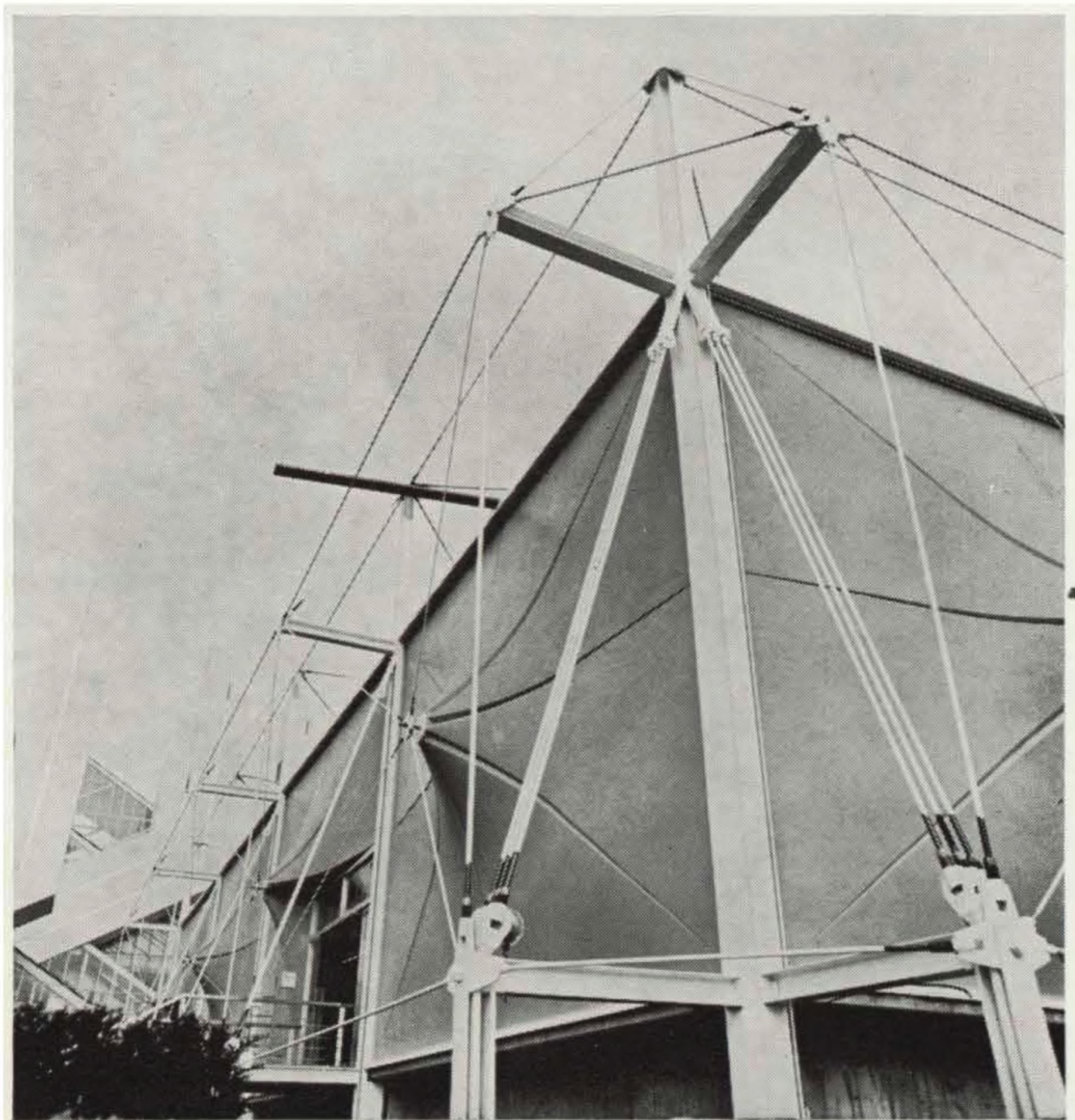
This pavilion, erected at Osaka for the 1970 World Fair, represents yet another development in the field of tensile structures.

In the section (14) the structural plant can be seen: a closed system of rigid elements and prestressed cables puts under tension, and hence maintains rigid, a vast space of 7000 m³, executed in large elements of reinforced polyester resin. All the elements of the plastic membrane are in double-thickness glass fibre with an air space against condensation between them. The use of plastics in a tensile structure arouses particular interest because all these materials have low modules of elasticity and therefore tend to deform (although they are strong in tension).

For this reason every structure in such materials is subject to compression or flexure and tends to depart from its initial geometrical shape, involving its yielding not so much by fracture as by deformation. In this case the plastic used for the construction of the flat roof and wall membranes is maintained exclusively in a state of traction.

The tension, necessary to maintain the structure against wind flutter, is absorbed at ground level by a ring structure of steel in a foundation system of crossed beams in prestressed concrete.

The junctions between the panels making up the elastic membrane, whose behaviour under tensile



stress must be absolutely homogeneous, are formed by continuous profiles of steel included in the pressing of the elements themselves.

The illustration (15) shows some details of the building under construction.

The stresses in the structure were determined by computer in order to check the numerous conditions of asymmetrical loading, in particular, those due to wind and earthquakes. The erection of the elastic membrane

was accomplished by assembling the entire roof on the ground before raising it. At the head of each module of the membrane (8.50 × 8.50 m) a long filleted bar 7 m high was screwed on and tied at the top to the prestressed structure. By twisting simultaneously 16 filleted bars corresponding to the 16 modules of membrane, the ensemble was raised to the level of the roof, stopped and put into the intended condition of stress.

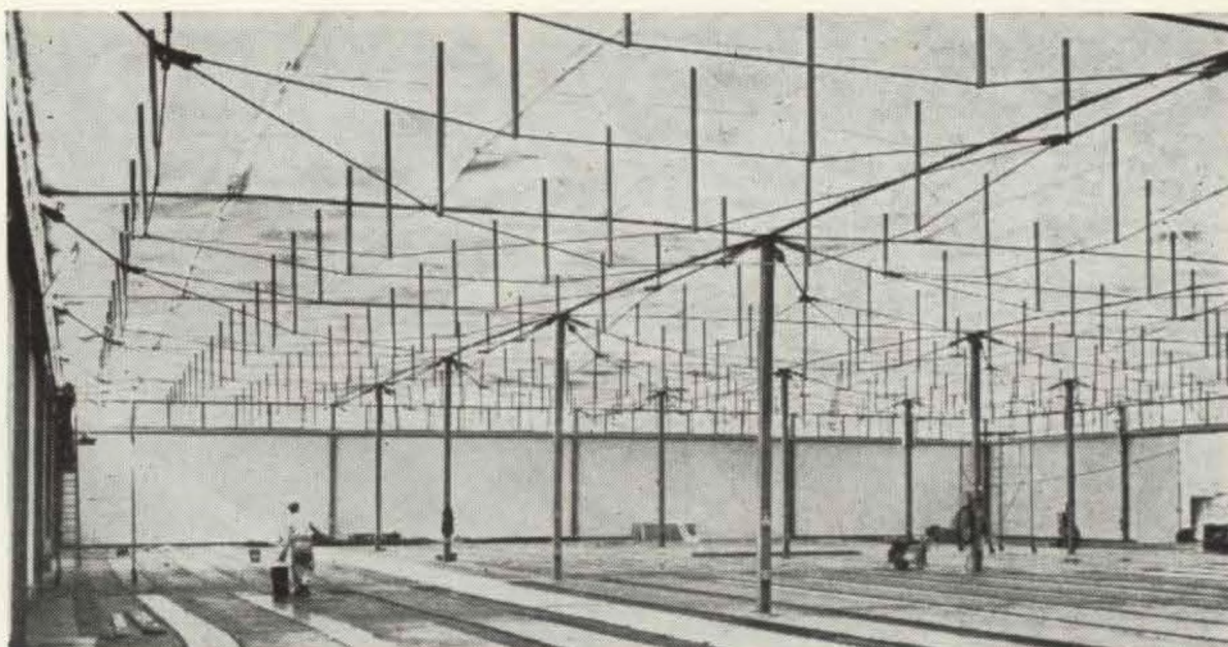
Factory building – Genoa 1969

The plan of this complex, the first 2,400 m² phase of which has already been executed, consists of modular units each 10 m². Each modular unit is made up of two membranes of polyester kept in tension by a system of steel cables. The tension is transferred from element to element and finally transferred to the ground perimeter by means of a system of counterweights in concrete. The basic element of the membrane is a square panel 2.50 m in reinforced polyester produced by pressing. The panels are joined by chemical welding along their edges. The entire roof membrane absorbs about 30 per cent of the light so that the luminosity of the inside space attains about 70 per cent of that outside. The mean dead load of the entire roof structure is in the region of 8.7 kg–m² and thus represents an advanced example of structural optimization.

The network of cables in tension (illus. 16) transmits the prestressing of the elastic roof membrane by means of the vertical steel pylons.

The regions of maximum stress in a membrane at the point of attachment of the pylon with the glass fibre panels are reinforced by means of a corrugation of the two surfaces of the panel so as to bring about an increase in the thickness from the edge towards the centre of the panel itself.

A structural problem of great importance was to determine the period of oscillation of the tensile structure in a wind (illus. 17). Such a phenomenon presents a particular danger when the oscillations of the



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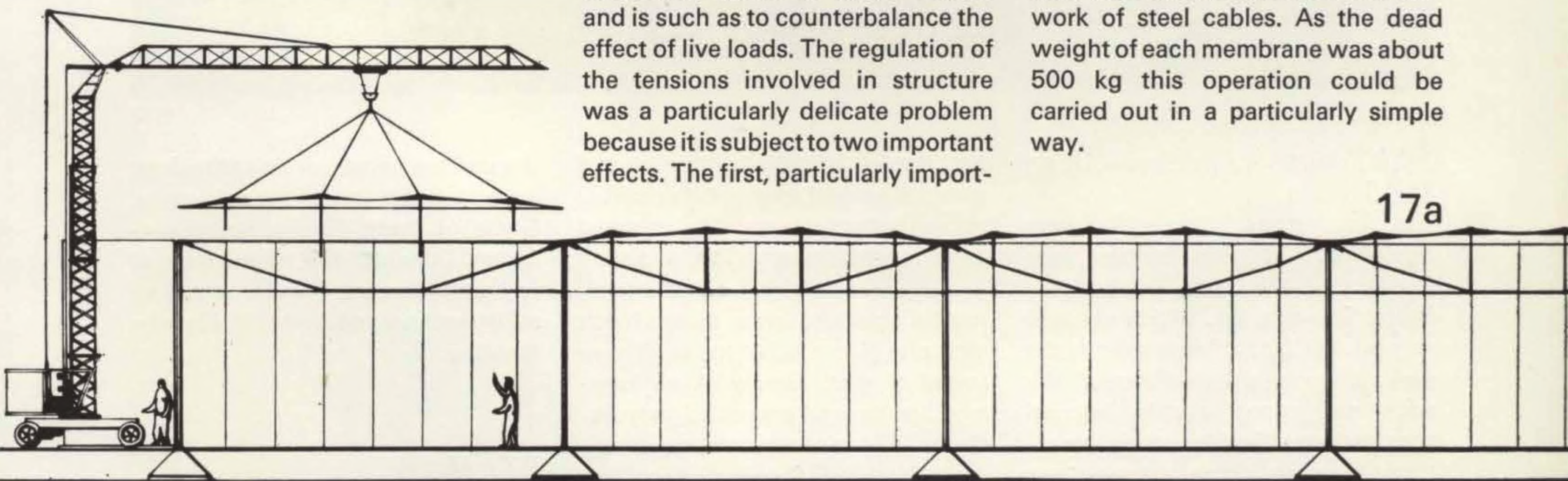
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structure and those of the wind coincide.

The prestressing applied to the structure is such as to hold the oscillations of the membranes and their characteristic period to a low value. Prestressing of the entire organism is produced by means of large counterweights in concrete connected to the network of steel cables along the perimeter. The weight of the concrete counterweights (approx. 5 metric tons) corresponds exactly to the prestressing load, while the weight of the plinth tied to them and subject to traction is about 10 metric tonnes and is such as to counterbalance the effect of live loads. The regulation of the tensions involved in structure was a particularly delicate problem because it is subject to two important effects. The first, particularly import-

ant in a plastic material, is plastic deformation; the second is thermal expansion. Both these effects were controlled by a highly articulated system of maintaining the tensions. In fact the general level of tension of the entire membrane is obtained by means of an adjustable screw placed at the head of each pylon.

The system of mounting presents another interesting problem. The 10×10 m modular membrane connecting the 16 standard panels was welded on the ground and raised up by means of 16 steel cables joined to the head of each panel and was then placed in position on the network of steel cables. As the dead weight of each membrane was about 500 kg this operation could be carried out in a particularly simple way.



17a



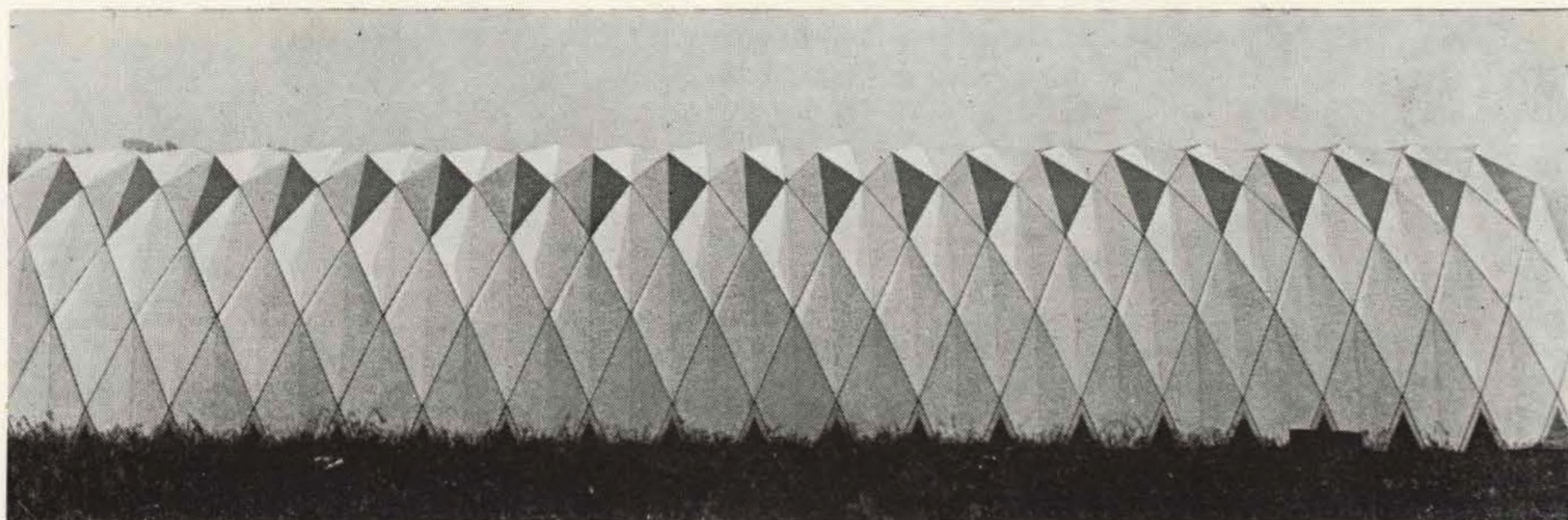
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14th Triennale Pavilion – Milan 1968

The final plans (illus. 18) were carried out in 1968 for the Park Pavilion of the 14th Triennale in Milan. The pavilion, which covered an area of 2,500 m² was sited in the park. It was supported around the edge and along certain internal corrugations. Besides their structural function these corrugations

had the job of defining the internal services as well as a certain number of exhibition spaces. The material used for the construction, and tried out in a series of full-sized experimental models, was a sandwich structure 7 cm thick made of two layers of glass fibre with an intermediate layer of expanded polyurethane. The entire membrane was assembled by chemically welding

the various panels, which was done automatically in a special press. Some of these panels, using perforated polyurethane, were intended to be translucent in order to assure sufficient natural light inside the building.



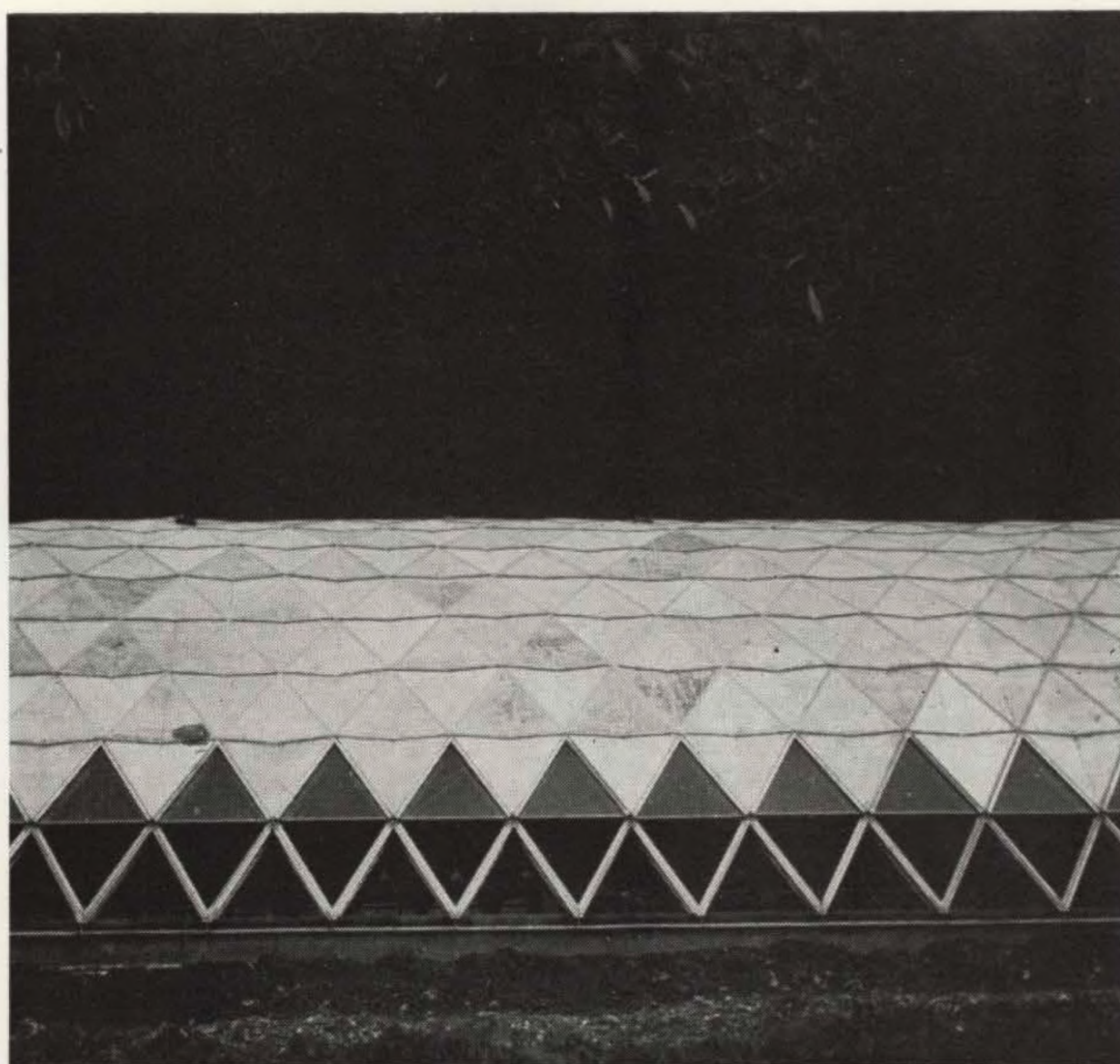
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Sulphur factory – Rome 1966

A factory for the extraction of mineral sulphur was erected near Rome in 1966. It is based on the idea of placing the factory itself along the excavation trench in order to reduce the time taken in moving the material. For this reason the factory was designed as a light structure in reinforced polyester which is unaffected by sulphur

vapour. It was supported on a continuous strip of foundations on which the standard elements were placed (weight 14 kg, 1.20 × 2.70 m), being demounted on one side and re-erected on the other side of the construction. The factory is illuminated through the structural elements themselves, some of which are made of transparent polyester. Watertightness was obtained by employing a continuous elastic joint

around the edges of each structural element. The elements were joined together by means of stainless steel nails. The roof was stiffened by a series of three crossed arches, two formed by the junctions among the panels and one by the longitudinal fold in each element. The junction of the polyester structure is very elastic and the rigid foundation is formed by a continuous hinged profile in steel plates (19, 19a).



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Wood factory – Genoa 1965

An important example of the optimization of productive processes is represented by a factory for handling timber erected at Genoa in 1965. The productive principle consisted in defining a basic structural element which would also be a basic spatial one and which should be available with the least possible fabrication. The basic element was a cut and folded steel plate measuring 1.20 × 2.10 m and weighing 25 kg. The fabrication of the piece consists exclusively in cutting the plate and folding it along five fundamental lines. The entire construction, which is made of continuous dimpled vault, has an internal clearance of 18 m; it is nevertheless possible to obtain any average or large clearance by varying the angle of the central longitudinal fold of the basic structural element.