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# PREFABRICATED ELEMENTS FOR INDUSTRIAL BUILDINGS CONCEPTION, FABRICATION AND MOUNTING 1/

by

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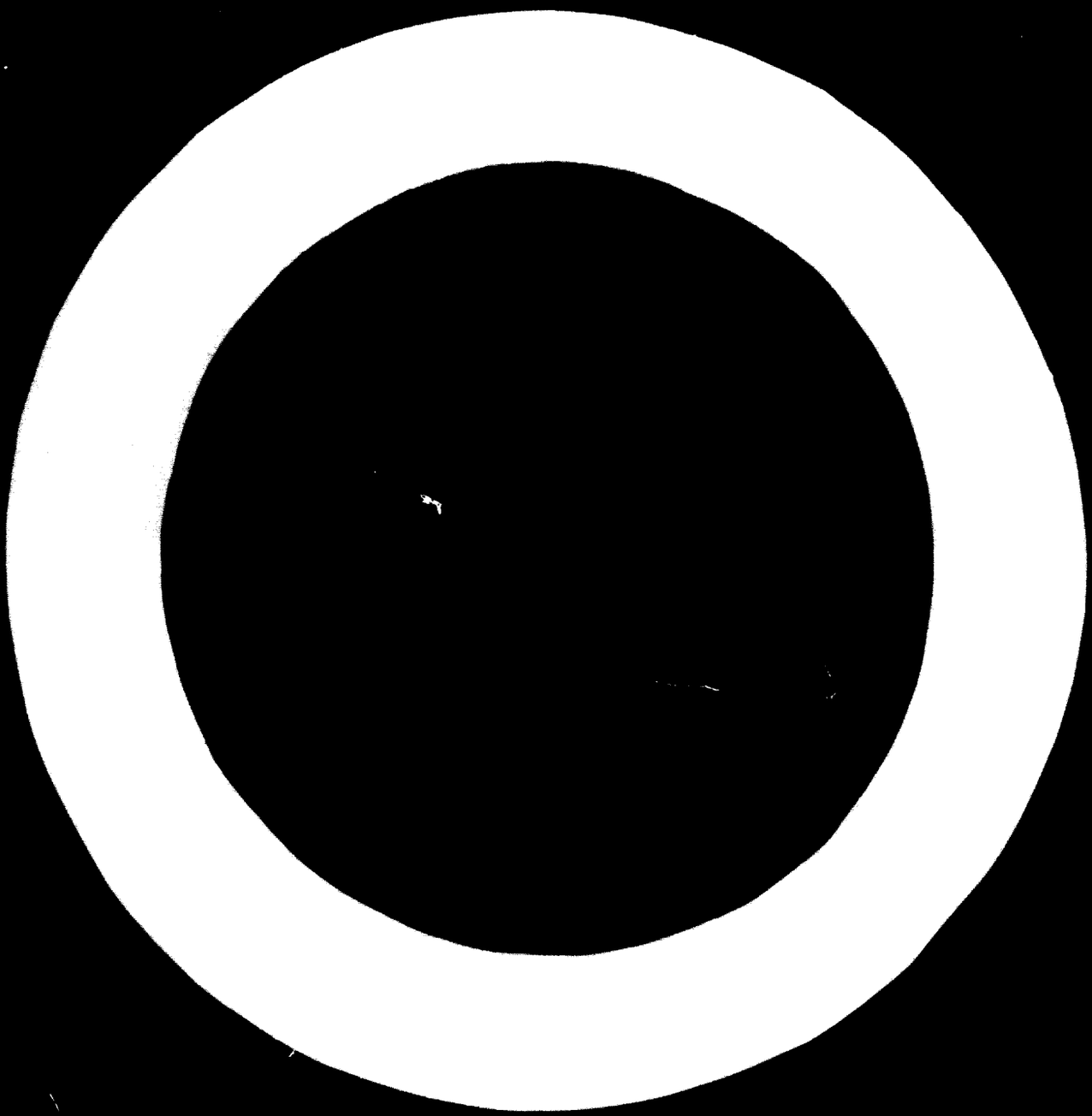

The technical-scientific revolution characteristical of our time demands a large volume of constructions among which industrial houses have a considerable importance.

Till recently industrial houses were dimensioned for a determined technological sequence of operations or for a determined functional scheme which were not essentially modified during the period at the term of which the respective building became unserviceable due to its normal wear. The activity developed in such a building was consequently in good agreement with its constructive characteristics.

Today, however, when the rhythm of the technical development has become so vertiginous and when the moral wear imposes frequent and fast changes of profile and of technologies, the constructive solutions for industrial houses must not only constitute no hindrance for their eventual modernization but must even facilitate it to some extent, by the chosen overall dimensions and by the opportunities to sustain different networks, ventilation and lighting fittings or even some technological transport plants and equipment, such as conveyors, jib arms of derricks etc.

All these requirements have led to the abandonment of the traditional construction methods and to the recourse to industrialized solutions, among which the prefabrication is the principal one.

The precast concrete elements are now largely utilised due to some important advantages, and especially to the shortening of the execution time and to their greater economic efficiency.

To be as competitive as possible and to be preferred to other constructive solutions, the precast concrete elements must be uni-

form qualitatively and with regard to productivity at least as well as the metal constructions.

The necessity of typifying the constructions and their elements must be understood in the light of the above mentioned considerations; this activity, on which the industrialization hangs and which aims principally to a higher efficiency by the manufacturing of large series alters some of the habitual principles of the construction design, bringing it nearer to the conception prevailing in the machine building industry.

In the special field of the industrial houses the typified solutions respond to many requirements connected with the technical possibilities of fabrication, with transportation and mounting.

A first category of such solutions are those utilising the fragmentation of the structures in a small number of prefabricated elements of maximum 5 tons weight each.-

The structure system consists of truss girders and precast panels, assembled at the building yard by prestressing, with spans between 12 and 24 m and bays of 3 m; the roof can consist of reinforced concrete caissons, on cell concrete plates with 6 m span, of reinforced concrete templets with 6 m span and reinforced concrete plates, or of autoclaved cell concrete with 3 m span.

Where 12 m bays are needed trimmer trusses consisting of panels assembled through prestressing are utilized.

With such structures industrial houses with various bays and spans can be realized, which permit also the suspending in the height of the roof of conduits and other technological outfits, of various types of strands or of suspended conveying means, such as jib arms of 3-5 t lifting capacities, monorails, conveyors etc.

The advantages of these structures result from the relative lightness of their precast components, with all the ensuing repercussions on the transport and handling; the functional characteristics of this type of structure cover large and various fields of application.

One of their disadvantages is however the assembling operation which must be carried out by prestressing the trusses, and for which specialized man-power as well as outfits to prestress the cables and to inject the protection mortar are needed.

The manufacturing of the typical prefabricated elements of these structures (truss elements, templets, caissons) is carried out by means of complex forming equipments of the shell type, without mobile encasing elements.

In view of this, the precast elements have been adapted to the requirements of the new technology by providing minimal slopes at the vertical planes in the casting position and by replacing the intersections of the encased planes under boundary angularities with intersections bounded with the aid of small roves, depending on the thickness of the metal sheets used to plate the moulds.

With an insignificant supplementary expenditure of metal it was possible to obtain double wall shells through which a thermal agent (steam or hot water) can circulate, so that by applying this thermal treatment the hardening of the concrete can be accelerated.

For the compaction of the concrete the forming equipments are provided with elastic supports: the vibration is carried out by concrete form vibrators placed at determined points resulting from calculations and verified by testing.

After the concrete has hardened the precast elements are striked by expulsion with the aid of pushers placed at adequately chosen points and actuated by mechanical or hydraulic power engines.

In the case of parts of small overall sizes, the expulsion of the prefabricated elements can be carried out also by means of a striking platform which actuates simultaneously all the expulsion pushers of the mould.

By the utilization of this type of moulds remarkable results have been achieved, especially in the manufacturing of truss elements, which is very difficult due partly to the large overall size of these parts (9 x 3 m) but mainly due to the large number of rods and of their connections included in such elements.

The templets can be manufactured in shell moulds of the battery type, where several parts are simultaneously encased.

I would like to [illegible] high quality and on the insignificant tolerances which can be obtained by utilising the shell moulds for [illegible] elements.

The industrial [illegible] structures consisting of precast trusses have been [illegible] in our country between 1962 and 1964, in the [illegible] machine building and the consumer goods industry.

As a consequence of the development of the material base for the production of precast elements and of the amelioration of the prestressing technologies, and concomitently with the better endowment of the production units with high capacity, transport and mounting equipments, the conception referring to the structures for industrial houses has correspondingly changed.

The attention was focused on eliminating the prestressing operation on the building site, which was difficult and needed a large amount of manual labour and at the same time to limitate as much as possible the operations executed there only to mounting operations.

Structures for industrial houses consisting of prestressed concrete plain girders with [illegible] and with roofs consisting of caissons and reinforced concrete plates or of autoclaved cell concrete plates were designed and typified. Functionally these structures responded to many technological requirements so that they have utilized in almost all [illegible]

The components of these structures are:

- transversal beams of 12, 18 and 18 m span, for 3-6 m bays
- longitudinal beams of 6 and 12 m span.
- roof caissons of 1, 5 x 6,00 m and 3,00 x 6,00 m.
- roof plates from autoclaved cell concrete of 3.00 and 6.00 m span.

The T-beams are manufactured with the aid of forming equipment of the shell type, provided with heating, with own vibrating outfits and with hydraulic expulsion devices. Their dimensions are so chosen as to take-up the prestressing force of the reinforcement.

The I-beams are manufactured with the aid of forming equipment with translatory moving lateral sides. They can be utilized either

on stand lines provided with abutments to take-up the prestressing force of the reinforcement (in which case the equipment is so designed as to obtain the form of the processed element, to perform the compaction of the concrete by vibration and to accelerate its hardening by a thermal treatment), or on stand lines without abutments (in which case the forming equipment performs a sustaining function, being adequate to take-up also the prestressing force).

The adoption of these new structures led to a considerable increase of the labour productivity as well in the prefabrication works as on the building sites. A noticeable qualitative amelioration and better indices for the consumption of materials were also registered.

However, this type of structures need special handling and transport equipments. For the transport of the beams railway waggons or trailers equipped with metal racks, are necessary in order to ensure the integrity of the transported elements and the security during the transport. Lifting metal devices and equipment with a capacity of 12-15 t are also needed.

Although marking an important stage in the technique of industrial buildings, this phase couldn't satisfy the needs of an extensive program of economic development; this explains why new preoccupations directed towards a further amelioration of the technical-economical indices, towards a raising of the labour productivity, as well as fabrication as as at mounting, and towards a betterment of the functional characteristic of the industrial buildings have appeared.

All these desiderata were meet by the following measures:

- the manufacturing of precast parts of large dimensions
- the manufacturing also of the secondary roof elements from prestressed concrete
- the reduction of the number of parts and joinings and the lessening of the amount of concrete cast on the building site for the construction of structures for industrial houses.

This solution is compatible with more versions of structures for industrial houses, for which following elements can be used:

- longitudinal beams with 12m span
- roof elements of a large area of the "T"- and T-type, with plane or curved back, of 12, 15, 18 and 24m span and of 1.5 or 3m width.
- cairoons with curved back, of 12, 15 and 18m and of 1.5m with.

By means of the above described system various types of industrial houses with 12 x 12, 12 x 15, 12 x 18, 12 x 24, 15 x 15 and 18 x 18 spacings can be constructed.

From the functional point of view the large span roof elements for the industrial houses are much more flexible with regard to the functional requirements because:

- the even distribution of a natural lighting system on the roofs is possible;
- hollow spaces for laying of fans or of flues to evacuate gases or smoke can be designed;
- technological hollow spaces are possible practically in every necessary position;
- the possibility is given of suspending inner transport.
- means on every lay-out accordingly to the technological requirements.

The new types of large dimensions precast elements manufactured from prestressed concrete led to a further amelioration of the forming equipments, which are now complex plants of a high technical degree.

New handling devices for the handling and the transport by railway or by road, adapted to the increased dimensions and weights of the new precast elements have also been designed, in the condition of the parts cutting.

The organized transport of roof elements of 36 $m^2$ area or of beams with 18 or 24 m span, weighing between 15 and 20 t, has become now a current activity.

It is however understood that the building sites must also be endowed with high efficiency equipment to carry out the handling and mounting operations of such large elements.

The outstanding results obtained with reference to the consumption indices, the duration of execution, the technological flexibility and the cost price have led to a large scale utilisation of these structures, even in such fields where till recently metal constructions were exclusively used, namely in the construction of industrial houses for metallurgical or engine building works.

In 1972 more than 1.5 million $m^2$ industrial houses have been manufactured and mounted by utilizing this type of structures.

The flexible character of the inner space of these industrial houses, marked especially by the supple roof elements is an aspect that cannot be ignored.

It must also be retained that, at equal free overall sizes, the structures employing curved roof elements give the possibility of erecting industrial houses with lower heights than other types of structures, what constitutues an important advantage of such houses during the working time, especially if they are ventilated.

It was inevitable that while the designing conception of precast elements was evolving, the necessity to widen the utilisation opportunities of the buildings in the frame of the technological unit they house did not appear.

Consequently the buildings acquired also some technological functions as the vehiculation and the distribution of the conditioned air, the uniformization of the inner artificial lighting etc.

In order to fulfill these tasks industrial houses with box-section girders to sustain the roof and to transport and distribute the conditioned air were designed and erected for several spinning and weaving mills.

The box-section girder is spatial element of 18 m span for 12 m bays, the hollow section of which is so dimensioned as to make possible the transport of the air quantity needed for the respective building; the distribution of the air in the inner of the building is made by providing slopes on the vertical faces of the beams.

The first realized type of box section girders, weighing 36 t, consisted of six elements assembled by prestressing at the building site. The roof was initially constructed of transversal beams and reinforced concrete plates later it consisted of curved elements of prestressed concrete.

Presently the execution of a box-section girder from two prestressed concrete elements, with strands, is in preparation; the prestressing operation will be executed in the works and no important reductions of the needed manual labour will be obtained.

Another version of armoured industrial building used in technologies which request air-conditioning is the industrial building with technical bridge constructed of prestressed concrete elements in the plant or in the site-polygon.

The resistance structure of 12 x 18 m consists of precast poles, uses a I-girder of 18 m long on which there are put in its upper side curved prestressed concrete elements of 12 m forming the roof; at the upper sole, the same elements are laid at intervals of 50 cm, forming the ceiling.

In the distance made in that way between the roof and the ceiling, which is easy to (reach) and to circulate in, most of the equipments are (erected) as follows;

b) The air-conditioning channels made of heat-insulating panels, as for instance, the "AZBOPAN" by closing of maximum two sides of a rectangular section (area) out of which the other two sides are the structure elements (caissons, girder).

The distribution of the air in the hall is made through the space between two ceiling caissons by help of a membrane laid on the lower side of the girders and along them.

c) The rain fire prinklers instalations, and so on.

This version, using exclusively standardised elements of prestressed concrete has the following advantages;

- high productivity lighting
- high quality of maintained by the possibility to pass on the technical bridge to the lighting equipment;
- increased air-conditioning channel sections, allowing of the eliminating of the intermediate distribution channels (the air can be blown on a distance of 72 m) and the economical designing of the conditioning plants.
- in the noisy halls, the hanging of phonoisolations, whenever required, on the same elements on which the lighting installations are supported.

It is to be mentioned the elasticity of the solution for funetional parametres (temperature, humidity, lighting) from the begining as well as during its exploitation and a high degree of convenience wich ensures a high labourn productivity.

The elasticity also refers to the possibility that this type of industrial building should be (built all over the world, due to the thermal buffer of the tehnical bridge which makes the construction independent of the external climat conditions.

This elasticity also refers to the possibility of obtaining unconditioned halls with the same span, by eliminating the ceiling (workshops, stores, fabrics finishing departments) but which can be brought in at any time by developing, by maintaining the ceiling elements.

Presently the manufacturing of type Π precast concrete elements is under preparation; by the adjoining mounting of such tubes, flues and gullets are alternately obtained, the first for the circulation of the conditioned air and the letter for the mounting of lighting fittings. This solution is utilized as well for ground-floor as for multiple-stage industrial houses.

Concomitently with ground-floor industrial houses which represent the preponderent part of such buildings and which are conceived for horizontal organized operation sequences, multiple stage industrial houses are also constructed for cases in which the operation sequence is predominantly vertical.

This way the problem of the utilization of the building ground finds also an adequate solution.

This type industrial houses have a combined structure, consisting of monolith pillars and of a precast ceilling.

The Π-type ceiling elements with constant section of 1,50 x 6,00 are manufactured in two versions, namely from reinforced or prestressed concrete. They are supported by precast transversal beams, either in their height or above them. The main function of the longitudinal beams is to rigidize the construction along the T-section.

To obtain an horizontal membrane above the Π ceiling elements, an upper layer of reinforced concrete is applied, which is cast simoultaneously with the monolith casting of the truss joints.

Presently some other versions for mult-stage industrial houses are under preparation aiming at adequate solutions to enlarge the bay - 9 x 6 m - and to obtain a wholly prefabricated structure.

Another field in which the prefabrication could bring about important technical-economical advanteges is the manufacturing of precast elements for the closings of the industrial houses. In connection with this problem, the harmonization of the architectural and functional requirements with those dictated by the industrialization of the fabrication and by the mounting operations was permanently considered; the

aim is to obtain closings which be as adequate as possible with the present utilization of spaces and areas of the industrial houses and at the same time to allow for their eventual extension and modernization.

One of the most important functions the wall elements are called to perform -namely the heat isulating and the avoiding of condensed water - has been adequately solved by the utilization of light materials (polystyrene, silanee etc) and of autoclaved concrete.

The constructive solutions envisaged are the following:

- light panels consisting of "sandwich"-type elements with asbestos-cement plane plates on the outer side and with a heat insulating layer of polystyrene;
- panels consisting of two layers of heavy concrete on the outer sides, with a heat insulating core consisting of light materials or of autoclaved cell concrete;
- panels wholly executed from autoclaved cell concrete;
- TT-section concrete panels of reinforced or prestressed concrete mounted normally in the vertical position.

The choosing between the above mentioned solutions will hang on considerations dictated by the heat insulation requirements, by the moisture content, by the functionality and of course by the architectural plastics.

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Finally I would like to mention that the forwing equipments for the manufacturing of reinforced or prestressed concrete elements, which are to-day complex and autonomous outfits, offer also another important advantage, namely the possibility of being utilised as well in the prefabrication works as directly at the building site.

If utilized at the building site, besides the necessary lifting, handling and transport equipment, connections at a power network and at a steam or hot water source are also needed.

The transport and mounting of such moulds are now normal operations, even for the smaller building sites.

The manufacturing of prestressed concrete at the building site can be organized in one of following alternatives:

- either on a portion of the building site, which must be placed as conveniently as possible in relation to the buildings;

- either directly on the building emplacement, if the building platform offers this possibility.

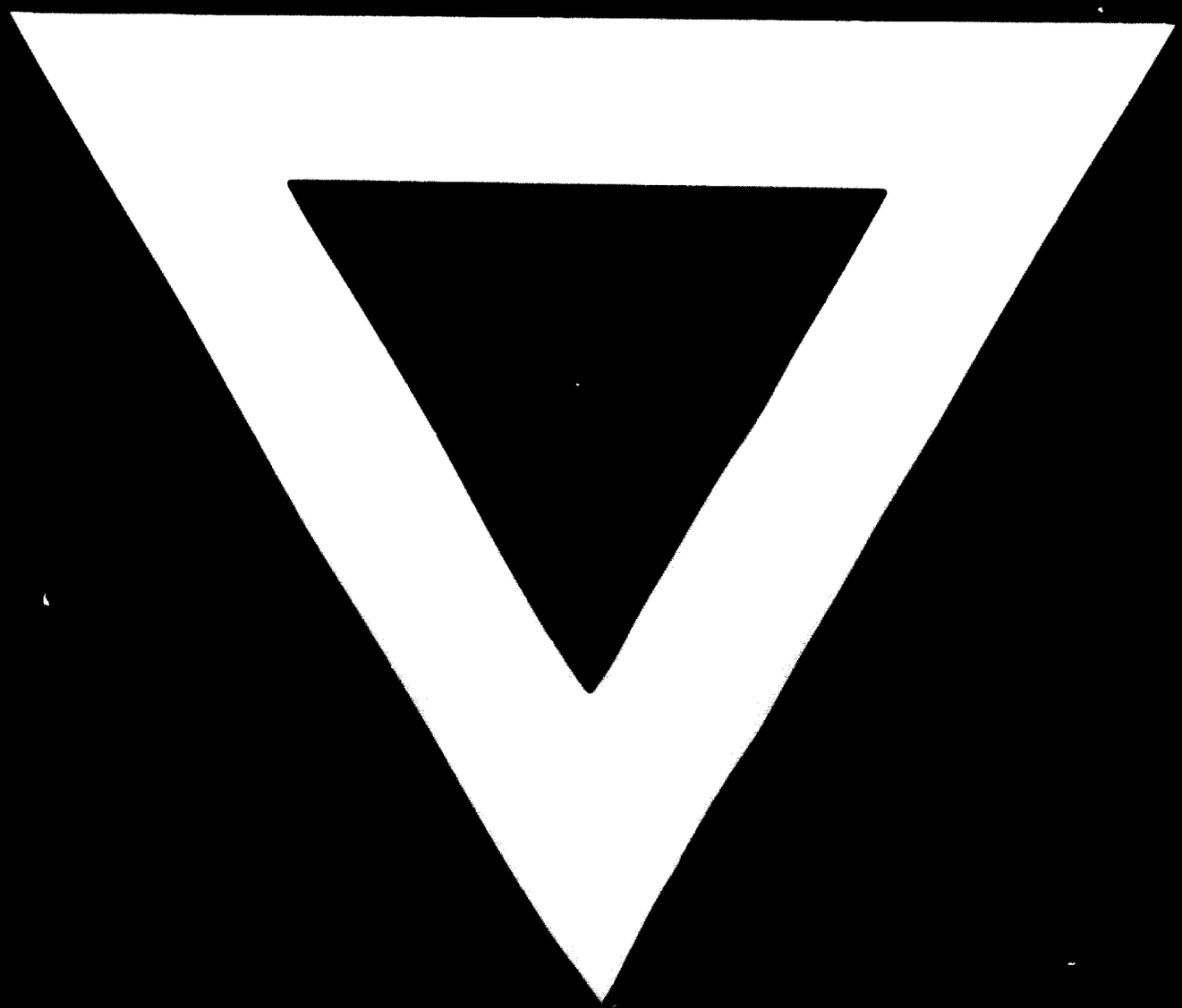
The advantage of the first version is to make possible the manufacturing of the precast elements without interferring in any way with the execution of the underground operations or with other operations related to the buildings. Its disadvantage consists in the fact that some supplementary lifting and transport equipments are needed and that an adequate area of land must be available.

The advantages of the second version consist in the fact that the mounting and the execution of the precast elements can be carried out with the same lifting equipment, the transport of the elements inside the building site is eliminated and no supplementary area of land is needed. It requires however that the building platform can be utilized to manufacture the precast elements.

In the last version is choosen, the moulds must be so adapted that they can be transferred to the building emplacement in the same rhythm in which the mounting is executed, so that this operation be directly carried out and the transport of the precast elements be eliminated.

The manufacturing of reinforced and of prestressed concrete elements at the building site, with autonomous mobile equipments could be a tempting solution: the only required condition is the availability of adequately trained personnel and the possibility to carry out the necessary control tests.

If this requirements are meet the economical results achieved are outstanding.



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