Steel brick buildings

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Steel Brick Buildings

Structures en acier et maçonnerie

Bauten aus Stahl und Mauerwerk

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GENERALITIES

Any transformation in the process of production which leads to a reduction in overall costs compared to quality, may be defined as the industrialization of building. This industrialization, which, in time, permits a decrease in costs, does not dismiss the validity of existing building schemes or their construction processes, although upon a rational, objective examination these could well prove to be theoretically unacceptable. Should the opposite occur, however, the application of industrialization would be limited to a possible razionalization of the existing building process (Industrialization within Building), avoiding its complete transformation (Industrialization of Building). In the first instance, even despite the rational use of existing production plants for existing schemes, it might well prove impossible to invert the present rising curve in the cost of building in time.

Moreover, it is obviously irrational to attempt the industrialization of one single aspect of the building process, for this, in time, will bring about a lack of equilibrium within the organization of the process itself. The most advanced part of the process will refuse those modifications which might result in the total transformation of its plants, while the less advanced part will be unable to organize itself autonomously. For a basic examination of the validity of any industrial process, therefore, it is necessary to formulate objective, general criteria, independent of existing schemes, referred and referrable to the process of production as a whole, and to each of its individual parts, for only by respecting both of these it will be able to guarantee an inversion of the curve of overall expenditure in the future.

THE CRITERIA OF INDUSTRIALIZATION

Because of the need for integrality and generality, these criteria must be formulated independent of the individual process of building, the only presupposition being the verification that the qualities of the building conform to the needs of its users. Moreover, if we take the final, unique aim of the process to be that of meeting man's requirements, and the aim of the criteria that of valuation in the reduction of the cost of the building, we shall see that the criteria themselves must be connected in such a way as to form a "system".

Since, however, the individual application of some of those criteria used in order to evaluate the transformation of the building process as a whole, may well give a negative result, whereas the result they give may well be positive when the complete "system" of criteria is used, even if the system is only being used in the evaluation of the transformation of a certain part of the process; it is consequently easy to see how the order in which these criteria are presented is completely irrelevant. In fact, in the list which follows, the placing of the criteria is arbitrary.

a) The speed of production. The most noted and commonly accepted criterion is that of growth in the speed of production, usually dependent upon progress in the field of technology. The growth of automisation, the introduction of processes of moulding, injecting, die-casting and mass-production, reduces production time.

b) Degree of integrality. This criterion may be expressed via the percentage of sub-processes which the transformation affects, or the relationship between the reduction of the cost of the transformed parts of the process and the cost of the building.

c) The amount of pre-planning. A reduction in the amount of pre-planning necessary in the elementary components of building, brings about a reduction in the range of the family of components in a measure corresponding to the reduction of the parameters (which are variable), with the result that the complete elimination of any kind of pre-planning would lead us to an elementary component with no specific function whatsoever. This criterion favours those processes which require the production of functionally simple elementary components capable of becoming functionally more complex during the succeeding phases of assembly, and frowns on those processes which require the production of complex elementary components such as "beams", "pillars", and "flooring".

d) Modular coordination. Every simplification in the assembly process of the various components of a building reduces cost. The space modular coordination of the components themselves is therefore particularly important, as it sub-divides the total volume of a building in cubes with modulated corners. It should, however, be congenial with the geometry of the construction process.

e) Standardization. As far as the volume of a building is modulated it is advisable to reduce the number of different types of component.

f) Reduction in weight. A reduction in weight (gross and net) leads to a reduction in costs, at the input and output level of the sub-process, with both direct and indirect results. Although sometimes weight has several points in its favour, e.g. thermic inertia, sound insulation, its reduction has been revealed as a positive factor in the evolution of all sectors of production (aeronautic, automobilistic, etc.), and even in the building sector as demonstrated by the gradual reduction of the weight of buildings through the centuries.
g) Duration of efficiency ("Functional space"). An increase in the duration of the efficiency of a building, or rather of the period in which it satisfies man's needs, by supplying a valid environment in which he may work (industrial building) or live (domestic building), is equal to a reduction in its cost. To this end, it is essential to be able to arrive with ease at any given point of the building, via a "functional space", so that new plants may be installed or obsolete ones changed.
h) Social compatibility. The effect a process of transformation has upon society may well condition its adoption. When, for example, it results in overall benefits, yet damages some operator or other in the process, it may provoke the operator to curb it on a social, economic or political level.

It has already been seen that if a technologically industrialized sector is percentually predominant, it may prevent the beneficial transformation of the entire process, should this transformation lead to its own elimination.

EXISTING BUILDING SCHEMES

The afore-mentioned criteria of industrialization can be translated into numerical indexes and thus also form a "system".

Research into, and the definition of this system, are undoubtedly conceptually and operationally important to the objective analysis of the evolution of existing production processes, both from the point of view of total transformation (new process) or of partial transformation (rationalization).

When it comes to total transformation, completely freed from tradition, the Building Industry finds itself at a distinct disadvantage compared to the new industries (aeronautical, automobilistic), for throughout the ages it has been an expression of man's desire for a form of habitation, and has consequently been structuralized by the traditions which have been passed down from craftsman to craftsman.

But even if, for the moment, it could seem simply a utopistic solution to be verified only in the distant future, some kind of hypothesis is nevertheless important as an indication of the direction which the transformation of present day processes should take from an economic point of view. By this we mean that critical analysis can and must tell us beforehand if existing processes of construction are theoretically susceptible to industrialization or not, or whether, in time, they will have to be either partly or wholly abandoned. With regard to those schemes which, theoretically, seem beyond industrialization, the fact that they may well have reached a high level of efficiency in the production of some intermediary component is of no importance whatsoever. Thus if, for example a reduction of costs in time in the typological scheme for "steel buildings", should require the elimination of the sub-process production of beams, the existence of sizeable factories, producing beams should not form an obstacle to that reduction. The same argument holds good for the "reinforced concrete building" scheme, and factories should be prevented from mass-producing pre-cast "columns", "beams" and "flooring" should it be known that these products prevent the building industry from placing itself upon a curve of decreasing costs in time.

RESEARCH PROGRAMMES AND CONCEPTUAL EXPERIMENTS

While waiting for the above-mentioned numerical index system to become available, incorporated in a general theory of industrialization, it has seemed opportune to assume that existing building schemes are doomed to remain on a growing curve of costs in time.

In the face of this limited hypothesis, one wonders if there cannot exist new construction schemes, which, largely satisfying these criteria, could succeed in placing themselves on a decreasing curve of costs in time. Should such schemes exist, they would help to guide actual building research programmes towards solutions possibly completely different from those already in existence.

As an exclusively theoretical treatment of the problems which have come to light would be far too abstract, the National Council for Research has decided, in its "Programme for the Industrialization of Building", to give concrete form to the answer to these problems via the construction of a model whose only aim is to affirm the existence and theoretical validity of that answer, by demonstrating the position of its prototype on a curve of decreasing costs in time, and not its position in the field of existing economic competitivity.

CRITICAL DESCRIPTION OF THE EXPERIMENTAL MODEL

The experimental model, described with the criteria listed in par.2 in mind, is a building which has been realized using the elementary component illustrated in the following figures, and which has significantly been called a "steel brick". Its space-modular dimensions are 2M x 2M x M when M=30 cm, and it is made of sheet metal. The possibility of mass-production by cold-forming enables a single press to produce almost a building a day. As the bricks may be used, joined together, both for the horizontal roofing and for the vertical walls, the installation of a mass-production plant even for a small number of buildings is justifiable. The space modulation is strictly congenial both to the parallelepiped geometry and to pressing, and involves the modulation of useful surfaces, which may be covered by four types of pannelling (perimeter walling, both external and internal; flooring and roofing) with modular characteristics of unification and mass-production similar to those of the brick, and extended throughout the entire building. It is obvious that the dividing-walls, the doors and the windows all follow the same modulation.

The brick does not have a specific, autonomous function; that is to say it is not a "beam" or a "pillar"; and in fact the term "brick" itself indicates the absence of any kind of pre-planning. The lightness of the building represents notable progress in weight reduction. The remarkable rigidity of the reticular structure is evident from the views of the experimental building.

The functional space within the walls and flooring offers a simple solution to the problem of the housing of a variety of installations, and guarantees their continual modernization. The remaining space, together with the internal and external wall coverings, constitutes a valid instrument of thermic and acoustic insulation, in tune with the modern conception of a building as a comfortable container of installations.

The fact that it is unnecessary to define the particular material which will be used to realize the various parts of the building - without excluding any sector of present industrial activity - is an indication of social compatibility of such a typology ("Open Industrialization through Components"). The architectural flexibility of the system does not create tensions within the planning sector, and may be varied to meet the demands of the user. The experimental building has also been tested in order to verify its degree of safety. The following figures illustrate the experimental study.

SUMMARY

Building is the only industrial sector which presents growing costs in time.

The theoretical criteria of Industrialization (standardization, repetition, lightness, mass-production, coordination), although theoretically quoted and affirmed, are not, in fact, respected by present building schemes. In order to obtain a decreasing curve of costs in time new systems must be devised, and new processes of construction evolved which really respect the theoretical criteria. It is the aim of the model realized in steel "bricks" at the CESUN in Naples to theoretically demonstrate this fact.

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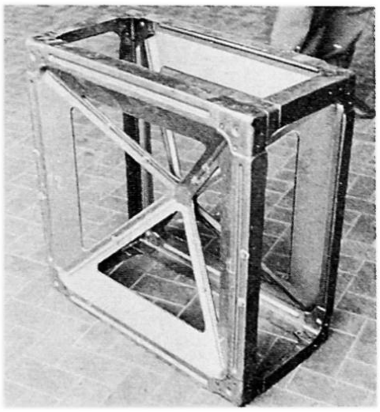
(1) The first studies in "steel brick building" were carried out in 1966 by the author of this article, prof.Pagano, with the collaboration of Carlo Funel and Alfredo Sbriziolo. A.Giliberti, F.M.Mazzolani, L.Morrica, N.Palumbo and S.Terracciano also collaborated.

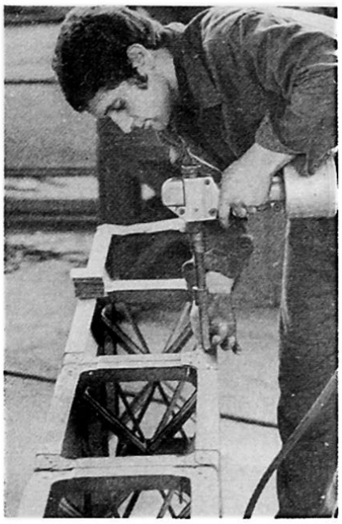
Research into "steel brick building" is actually being continued by prof.Pagano with the financial aid of the C.N.R. - Programma per l'Industrializzazione dell'Edilizia, at the CESUN (Centro Studi per l'Edilizia).

CONSTRUCTION TECHNOLOGY IN
STEEL BRICK BUILDING



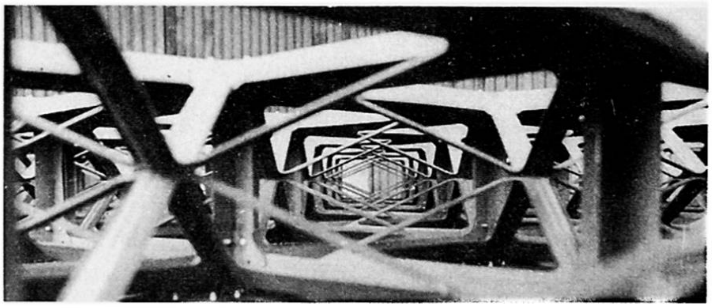
The steel brick:
2Mx2MxM M=30 cm

1



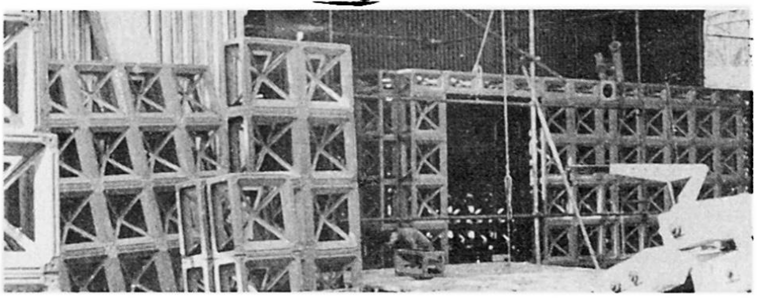
2

Assembly procedure using fastening rivets.



3

Functional space for installations inside roofing and walls.



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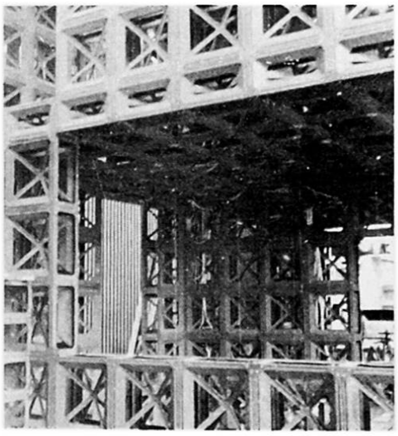
Walls and roofing ready for assembly.

Some detailed views of the building.

5



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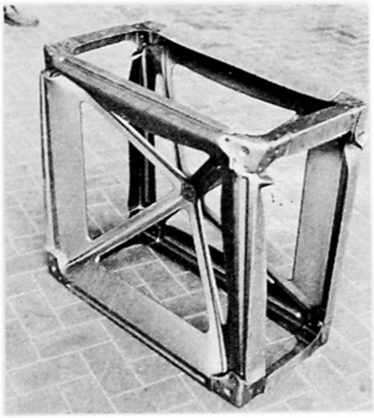

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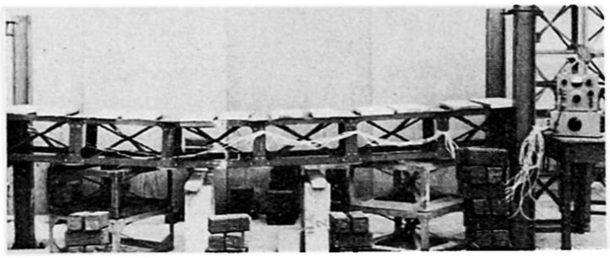
TEST RESULTS

Beam flexional test.



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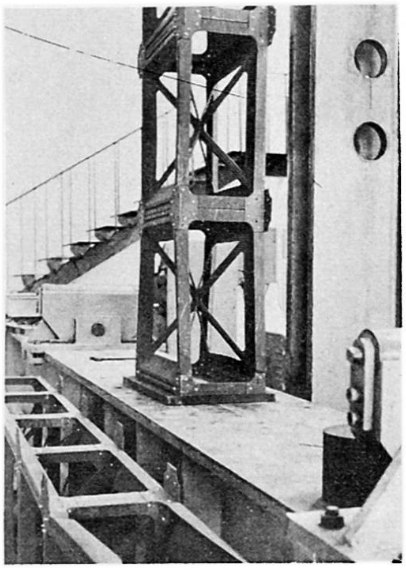
The collapse of the corners of a prototype of the brick as a result of a compression test.

Column test

9

Detail of previous view



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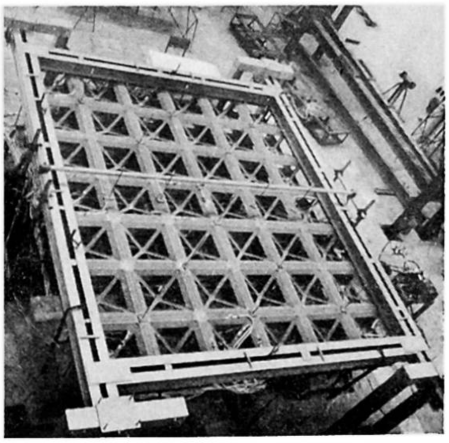
Roofing test



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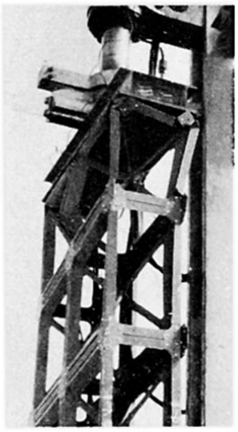
Double column test



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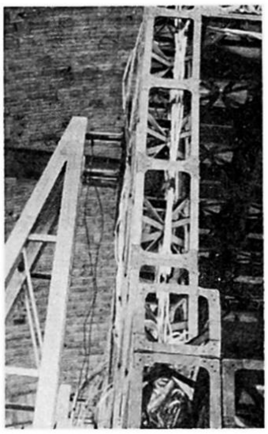
The whole construction subjected to horizontal forces



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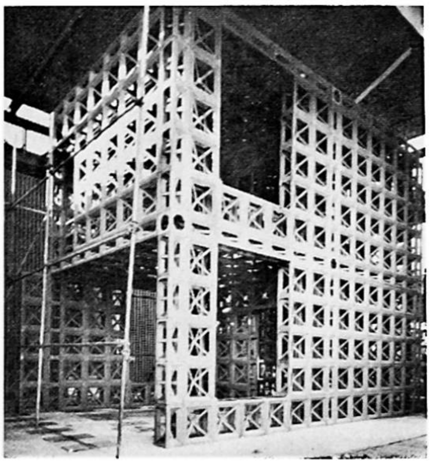
ARCHITECTURAL COMPOSITIONS



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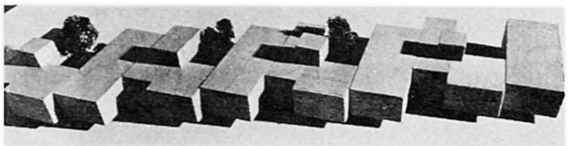
View of the steel brick building prototype.



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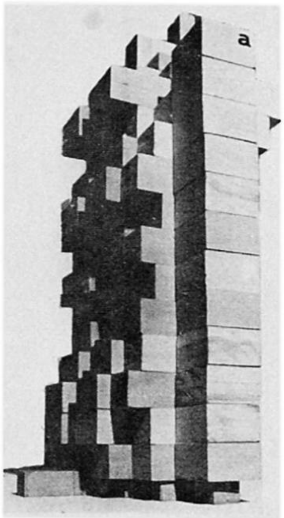
View showing the flexibility of the construction system.

The system permits construction both one-floor and multi-floor buildings.
The system does not limit architectural and volumetric construction in any way whatsoever.



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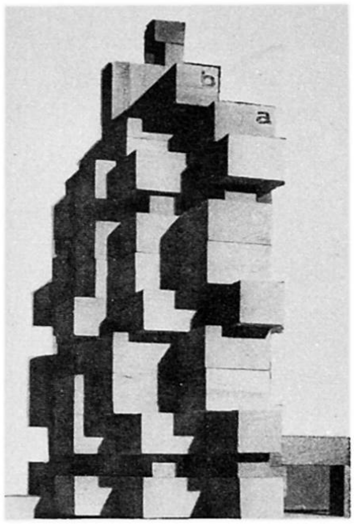

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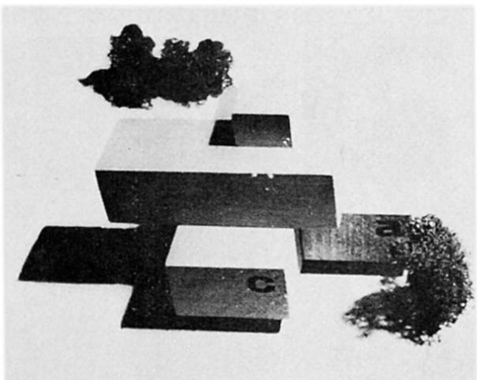

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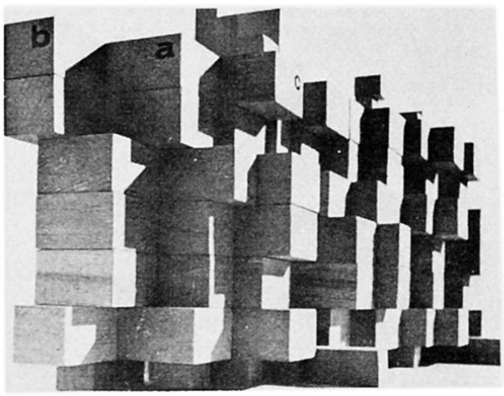

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