NON-TECTONIC SYSTEMS

AN ILLUSTRATED REPORT OF THE OPEN LIGHTWEIGHT SILICATE-BASED BUILDING SYSTEMS*

M. PÁRKÁNYI

Institute of Building Constructions and Equipments, Technical University, H-1521 Budapest

Received April 15, 1985
Presented by Prof. Dr. O. László

Prefatory Theses

According to a document of the Economic and Social Council of the United Nations published in 1963 it is estimated that 24 million housing units have to be built annually in order to overcome the present shortage in the developing countries and to meet their future demands.

In the same period the capacity of a bigger European housing factory was around 5000 dwelling units per annum.

In our days the building industry — upon which (according to another UN document) not less depends than the survival of a really humane society, has become the narrowest bottleneck of the world's industries.

*

In our research work — of which this illustrated report can only give a very compact account — mass-housing in the developing countries was given a fundamental role from the very beginning. Ever since the sixties, this problem has never been taken off from the agenda of different international congresses and symposia: Studies bearing on this theme have meanwhile amounted to libraries, the real breakthrough, however, concerning the merits of mass construction in developing countries has not yet been achieved.

*

* This report was compiled by the Institute of Building Constructions Faculty of Architecture, Technical University Budapest.

The theme was elaborated by *M. Párkányi* D. Sci. and his co-workers *Dr. L. Hajdú* architect, *J. Barcza* mechanical engineer, Ms *R. Kövesdi* architect and *Z. Szirmai* architect.

Consultants were *Prof. L. Gábor* architect academician (†1981), *L. Garai* C. Sci. Struatural engineer, *A. Zöld* D. Sci. mechanical engineer.

On the basis of the results achieved over two decades of research and experimentation we came to the conclusion, that the type and extent of building necessary in the developing areas create a unique technological problem, a problem really unprecedented in the history of mankind, the solution of which simply cannot be directly derived from the experience of developed nations, and that the creation of a new quality of harmony between needs and capacities in the mass-construction of developing countries can only be expected from an axiomatic technological change.

* * *

By the beginning of the eighties — mainly under the pressure of twin forces of architecture and town-planning — the methods of building industrialization have been queried in the developed countries as well, since the results — exactly in the field of mass-housing — turned out to be unsatisfactory both on an international and a national level;

— internationally and quantitively, since the industrial capacity measured on a global scale hopelessly lagged behind the worldwide needs as mentioned before and since modern building technology was simply unable to cope with the challenge — that is the spontaneous urbanization coupled with demographic explosion — hitherto unprecedented in world history;

— nationally and qualitatively, since it did not come up to the architectural expectations, since the modern technologies based on the use of structural systems as regards their architectural-urbanistic achievements, in general, fell behind the traditional technologies.

*

Amidst the permanently changing social-technical-economic conditions the industry actually could not adjust itself adequately to the characteristics of architecture up to now. Under the pressure of solving the excessively great building tasks, the goal, that is satisfying demands of housing was subordinated to the means, that is to the industrialization of building, more accurately: to a given method of industrialization and thereby mass-production was created on the building level, since it was the building that became the characteristic object of repetition. Building industry — in contrast to the nature of building — was founded on the analogy of the mechanical industries.

— As opposed to the mechanization-based manufacturing technologies in which the process of production is always finished in the factory, consequently, the elementary constituent parts can be specially made, since it is the final product which is standardized: typewriters, tractors, automobiles etc. rolling down from the assembly line, namely, always remained the same,

— in the building technologies exactly the opposite is necessary. The process of production, namely, is not completed in the factory but on the building site, consequently, in the manufacture of the elementary parts it is most expedient to aim at a universality, for the purpose is to avoid the standardization of the final product, since in this case the final product is expected to be of high-grade variability. Thus, building is not a mechanization-principled technology and so it can not be established purely on the analogy of the mechanization-based industries.

*

In mass-construction — the life and soul of which is repetition, without which industrialized building can not exist, and which is the foreseeable task of even the most distant future — up to this time there evolved no conception about what the object of repetition most suited to the characteristics of building should be, and what its method. Our study elaborating the theoretical outline of an axiomatic technological change and the methodology of its technical realization basically answers this question — in its totality.

As it is known, both traditional and industrialized building as a process is based on the axiom of tectonics, that is on the simple principle of putting loadbearing structural elements (bricks, pieces of stone, blocks, panels etc.) on one another, according to a certain order. This is a thought-provoking fact, since it means no less, that in the field of building the qualitative change — so characteristic in the development of other industries — did not take place.

*

Our researches and experimentations have led us to the fundamental recognition that tectonics is not the only possible axiom of industrialized building and our study basically proves that such an axiomatic change is realizable in the field of building as well, also that we may open new, hitherto unknown ways of industrialization of building, if we break with the axiom of tectonics.

*

As opposed to the tectonic building requiring immediate stability and carrying capacity not only from the final product — that is the building — but from every single phase of the building process, in the non-tectonic building it is only the stability and carrying capacity of the final product that is regarded as unconditional, whereas it is not required in every single building phase continuously, but in cycles only.

*

In order to be able to follow the permanently changing requirements of planning and producing, the non-tectonic building chooses a fundamentally new "brick" as an elementary constituent part for buildings, a brick which cannot have either carrying capacity or immediate stability — since it has to break exactly with tectonics — but, as opposed to this, it does have to have the most important and from an architectural point of view directly vital quality of the classical brick, that is aesthetic neutrality and structural universality. This new elementary constituent part — the non-tectonic surface element — is a lost casing of the actual building structures and as such it shapes on the one hand the very structure, on the other hand it creates its final, visible, plane surface.

*

The new brick is semantically meaningless from an architectural point of view, since it is not bound to any particular location in any particular building. This, however, altogether means that the non-tectonic building actually organizes the industrialization of building on a new basis, on the basis of the well-known Gutenberg — principle.

Similarly to the letters of the phonetic alphabet, or more accurately: similarly to the types of the printed alphabet, which in themselves have no meaning, yet they allow any kind of texts to be printed;

the surface elements of the non-tectonic system — the so-called "non-tectonic bricks" — are not structures themselves, yet they permit to assemble any kind of building. The non-tectonic bricks are actually nothing else but letters of a structural system.

* * *

In the course of the last decades, building — this characteristically and exclusively local operation for thousands of years — has stepped out from its national frames and — as building *industry* — extended its activity to the field of export, as well. As a result, the methods of industrialization already queried in the developed countries now turned out to be inadequate in the developing countries, too. Response to the challenge failed to come about: the new production culture and structure of industry so much waited for in mass-construction did not come into being. It could not come to existance anyway, since the "turn-key" method yielding the biggest profit from a business point of view is unfitted for this purpose from the very outset, whereas the building technologies realized through the so-called "transfer of technology" remained inorganic and as a foreign body could not become "appropriate". This lesson was also confirmed by a symposium organized by the UNIDO on the theme "Construction in Developing Countries" held in Havana, in December, 1984.

*

The system of requirements of industrialized building stepping out from the national frames is extremely composite and complex not only because quite a series of technological, economic and social constituents have to be taken into consideration but first of all because this system of requirements keeps permanently changing in space and in time. A technology satisfying a system of determined requirements as favourably as possible in a given space and in a given time may lose its validity — its relevance — if applied at another time or in another place.

From this it clearly follows that when evaluating the adaptability of a manufactured structural system to some particular case varying in space and in time, we can only scale its efficacy from a technological point of view by the possibilities offered by the system to create various adaptations, in other words: by its capacity for self-adaptation, by the combinatorial qualities of the structural system, in short: by the degree of its technological relevance.

Our study basically proves that the degree of technological relevance in the industrialized building reaches its maximum in the non-tectonic systems and it is exactly this feature which renders it possible for the system to create an assortment of products ranging from individually manufactured individual products through individual products produced by mass-production methods up to mass-products produced by mass-production methods.

*

The fact that in the developing countries the system of requirements of mass-construction shows an extreme diversity, in other words, the social-sociological, technical-economic, zonal-geographic, constructional-architectural requirements etc. vary on a rather wide range, brings to the fore the adaptation of building systems of high degree of technological relevance. This explains why the non-tectonic systems may claim an outstanding role in the mass-construction of developing countries. Beyond this it is also not difficult to comprehend that within mass-construction the real domain of adaptation of these systems is the low-cost mass-housing particularly in hot-arid tropical or subtropical areas: whilst in the developed countries the specific cost of the primary loadbearing structures — that is to say: the specific part of the building cost where the silicate-based lightweight, open non-tectonic systems may save a particularly considerable sum of money — does not amount to more than approximately 10—20% of the total building cost, in the developing countries exactly the opposite is relevant: in the low-cost mass-housing of the developing countries, namely, the building cost of the primary structures may reach even 80—90% of the total building cost.

* * *

It cannot be stressed too often that mass-construction in the developing countries is one of the global problems of our age. Non-tectonic building basically offers a technological response to this challenge, so in this sense, it is of a political importance, as well.

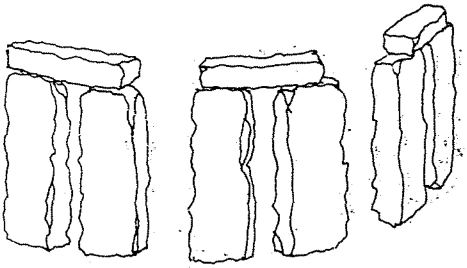
*

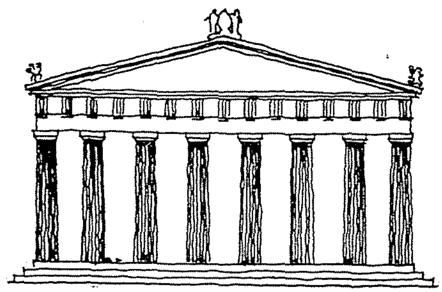
In our study and on the basis of this train of thought flashing two decades' theoretical, research, experimental and construction work, we finally came to the conclusion that according to our present knowledge there exists no such developed building technology which could be competitive with the non-tectonic systems in hot-arid tropical or subtropical areas.

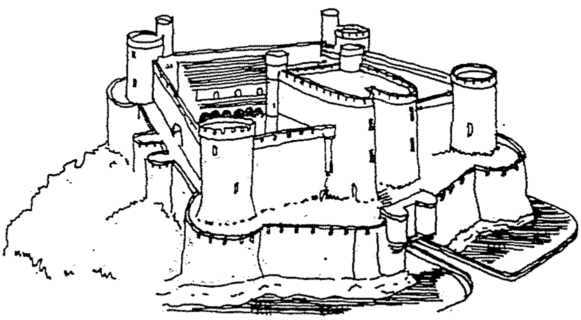
* * *

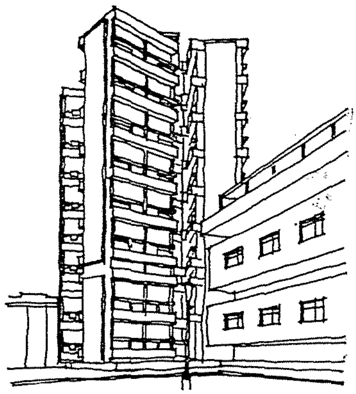
NON-TECTONIC SYSTEMS

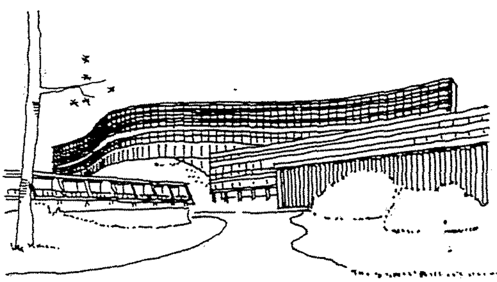
Tectonic structures

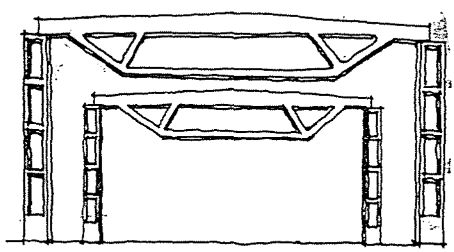








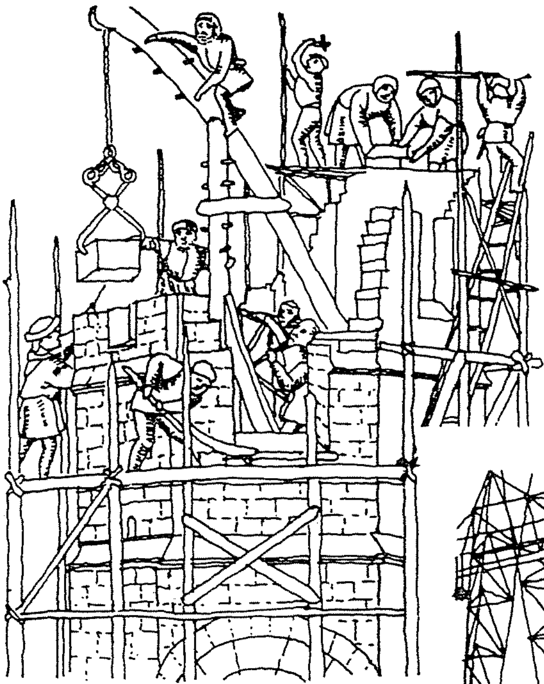




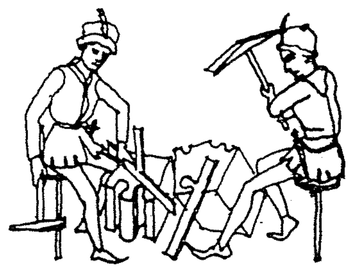
Breaking with Tectonics and switching over to Non-tectonic systems

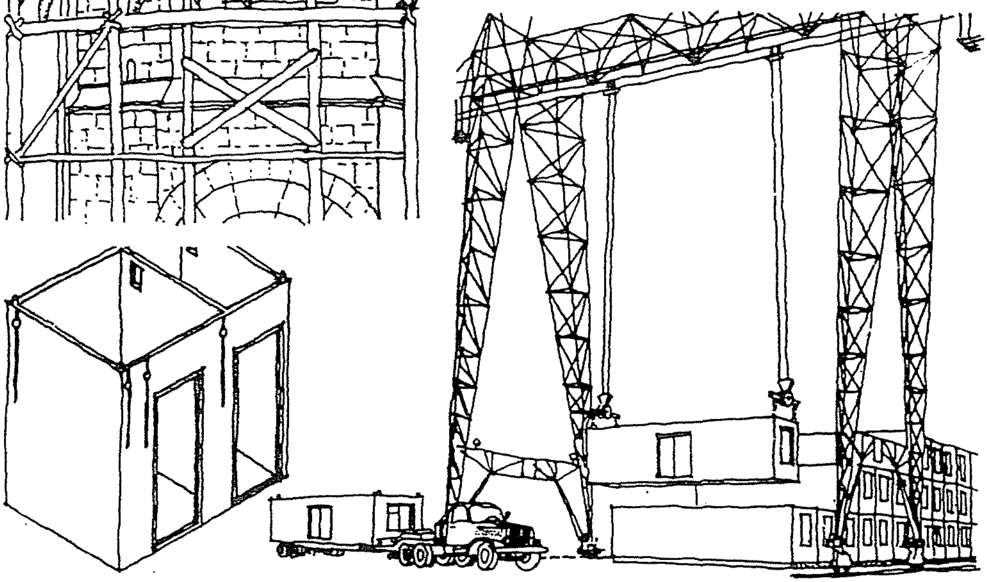
As we all know, both traditional and industrialized building as a process is based on the *axiom of tectonics*. This simply means that you first put down an element (i.e. a piece of stone, a manufactured large panel) strong enough to support a load and then you place on it another element (a beam, a manufactured floor slab, etc.) to be supported.

The principle of building with loadbearing structural elements, in other words: the simple principle of putting loadbearing — i.e. *tectonic* — *structural elements* on one another (according to a certain order, of course), this is the essence of every *tectonic* structure, be it traditional or industrialized.



The axiom of tectonics: building with loadbearing structural elements

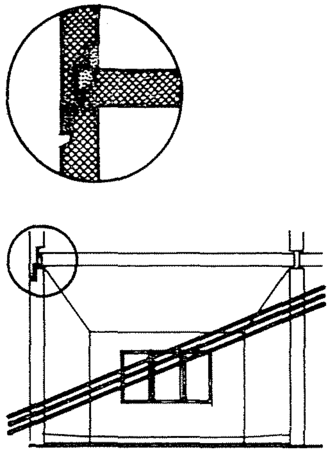


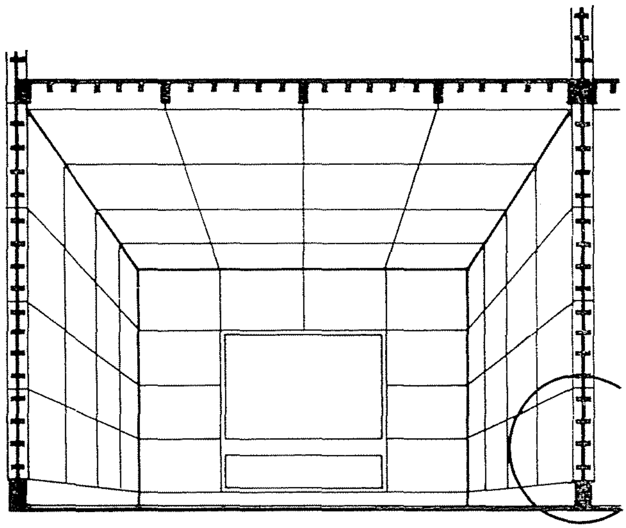


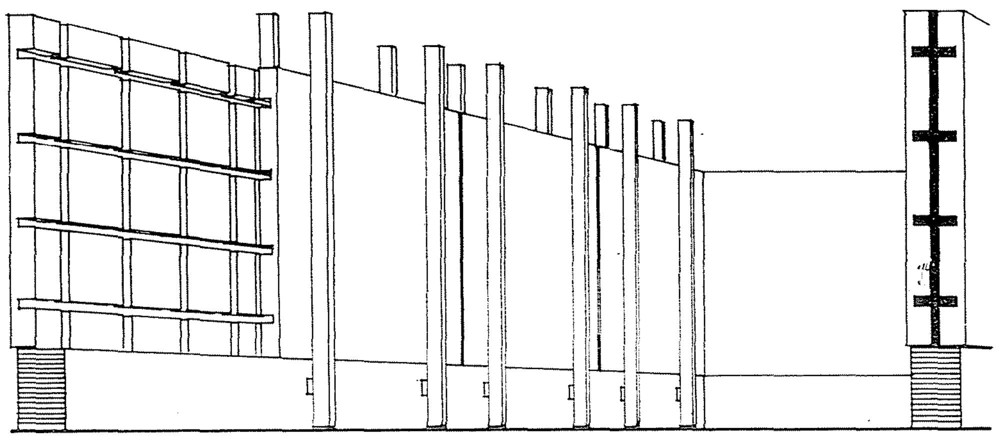
In *traditional tectonic* structures emphasis is on the load-bearing elements and irrespective whether they are finally shaped in form and size (i.e. bricks) or not finally shaped (i.e. pieces of stone) they are always individually workable and have an immediate *loadbearing* capacity, therefore, architectural variability is just boundless (as proven by the history of traditional building) because it is created through additivity of individually *workable* tectonic elements.

Manufactured tectonic systems put the emphasis on the usual manufacture of the components of the *loadbearing* structure (such as beams, panels, box-units, etc.) and since all these elements are finally shaped in form and size, therefore architectural variability is very limited (as proven by practice) because it can only be based on the additivity of individually *unworkable* tectonic building components.

Non-tectonic structures



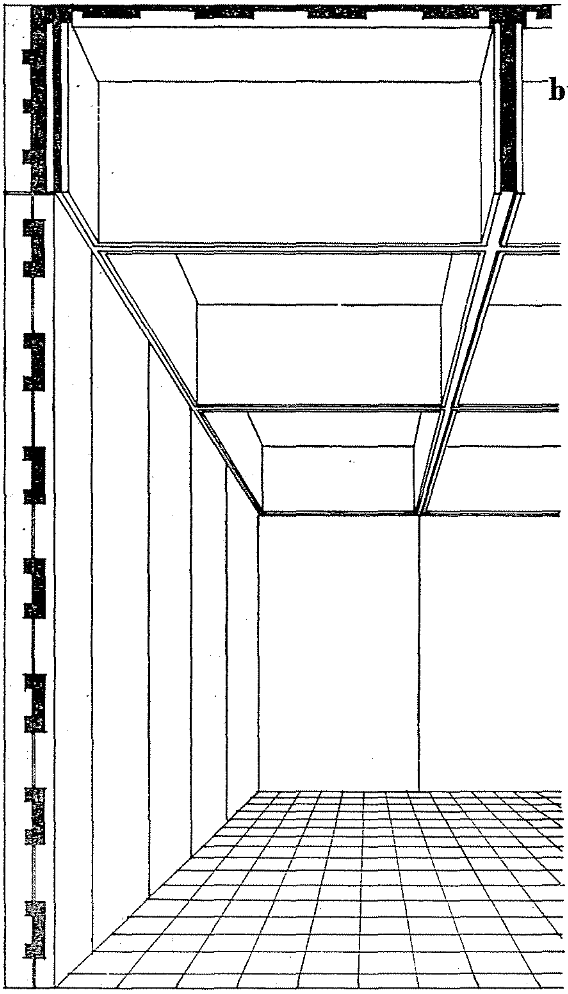




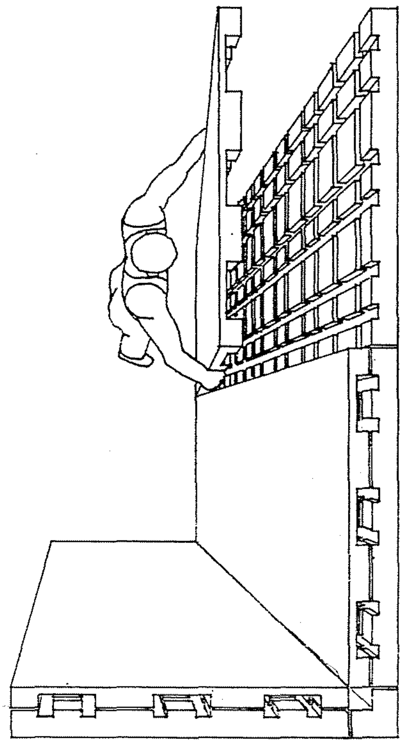
The *non-tectonic* systems break with the axiom of tectonics and substitute it for the *principle of surface.* This simply means that in these systems the immediate object of manufacture is not the loadbearing structure but its surface.

The surface elements of the loadbearing structure are of low specific gravity (they are mostly made of gypsum), consequently they have *no carrying capacity;* they are very thin, after all they are a skin construction and thus they have *no immediate stability* either. In brief: they are non-loadbearing, *non-tectonic* elements to be kept in position by simple regainable *auxiliary* structures during concreting.

As a consequence of the moisture absorbing capacity of gypsum, the concrete — poured into the very thin cavities and channels arising between the



The principle of non-tectonic building: building with non-loadbearing surface elements

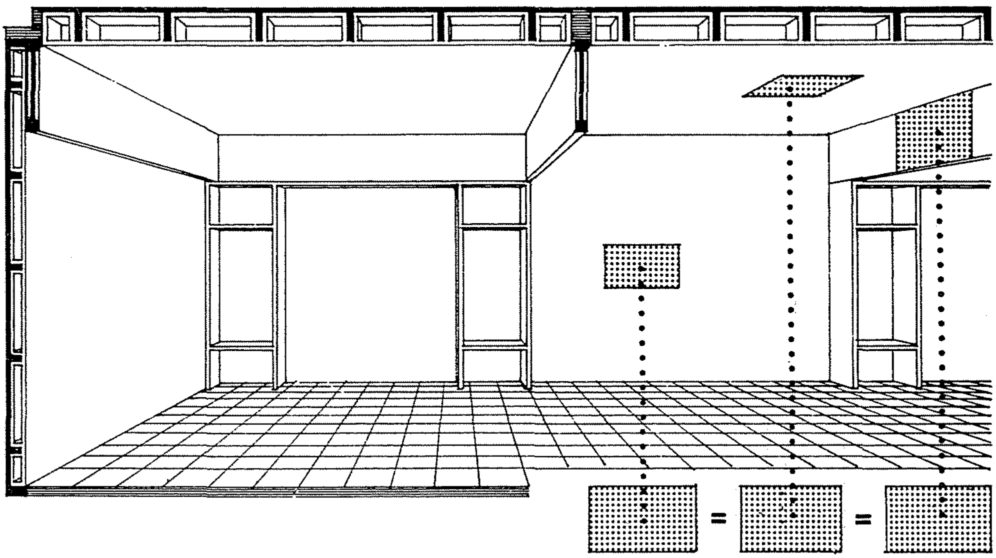


surface elements — becomes stabilized almost immediately: it *freezes* on the gypsum.

The new — *non-tectonic* — construction arising as a result of this process is a *light-weight*, *silicate-based*, *rigid*, *monolithic r.c. structure* and as such it is really unique in the industrialized building.

The principle of building with non-loadbearing surface elements, in other words: the simple principle of vertical and horizontal alignment of non-load-bearing — i.e. *non-tectonic* — *surface* elements next to one another, either in the factory or on the building site (according to a certain order, of course) and uniting them into a monolithic structure (through pouring concrete into the cavities and channels arising between, within or on top of these surface elements) — this is the essence of every *non-tectonic* structure, be it done by handicraft forms of production or by any higher level of industrialization.

The aesthetic neutrality: the neutrality of the surface



Changing the principles of design, manufacture and construction

The change-over from the present tectonic structures to non-tectonic systems is a real axiomatic change, which completely transforms each individual principle of design, manufacture and construction, and thereby — as we shall see — it transforms at the same time the very structure of the building industry as well.

Principles of Design

The aesthetic neutrality

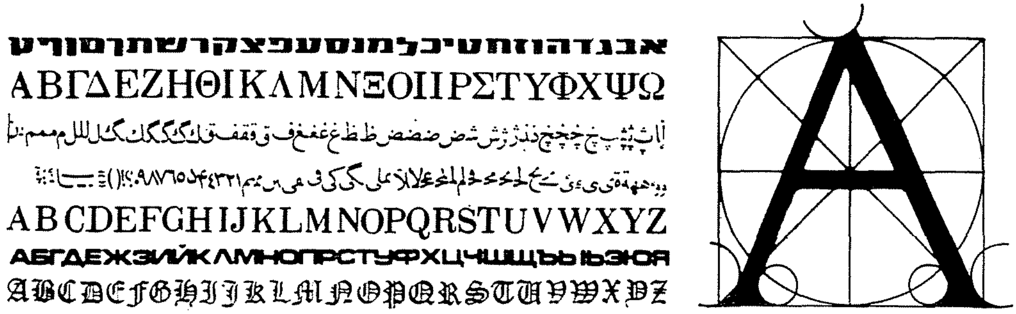
The principle of building with non-loadbearing surface elements changes first of all the *architectural* aspect of the industrialization of building. The elements of the finished surface, are, namely, absolutely *neutral* from an aesthetic, architectural point of view.

The non-tectonic elements with their glass-smooth surface on their final visible side never "betray" what they are the surface of. You never can tell from this surface, whether it will become a surface of a dwelling, or that of an industrial hall, whether it will become a surface of a wall, or that of a floor; the *surface being the same* in all these cases.

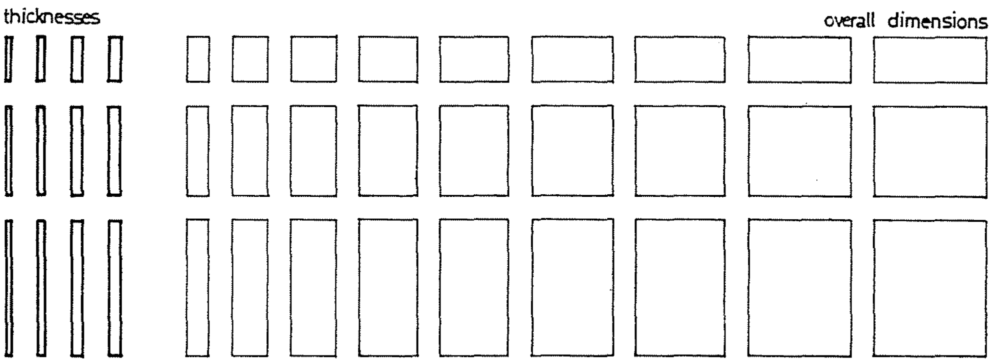
This fact is very important because this kind of *aesthetic* neutrality is extremely favourable from the point of view of architectural *design.* The neutrality of the elements, namely, almost "invokes" to call into being real *open sytems of construction* and this in turn, is a fundamental *architectural* precondition of *planning for change.*

We have thus seen that in the non-tectonic systems the surface elements are *semantically meaningless* since they are not bound to any particular location in any particular building. This however means that the non-tectonic building method actually transplants the well known *Gutenberg-principle* to the industrialized building.

The "types": **the letters of the alphabet**



The non-tectonic bricks: **the letters of a structural system**



The Gutenberg-principle

Similarly to the *letters* of the phonetic alphabet, or more accurately: similarly to the types of the printed alphabet, which in themselves have no meaning yet allow any kind of texts to be printed;

the surface elements of the non-tectonic systems — the so-called "non-tectonic bricks" — are no structures themselves yet they permit to assemble any kind of buildings.

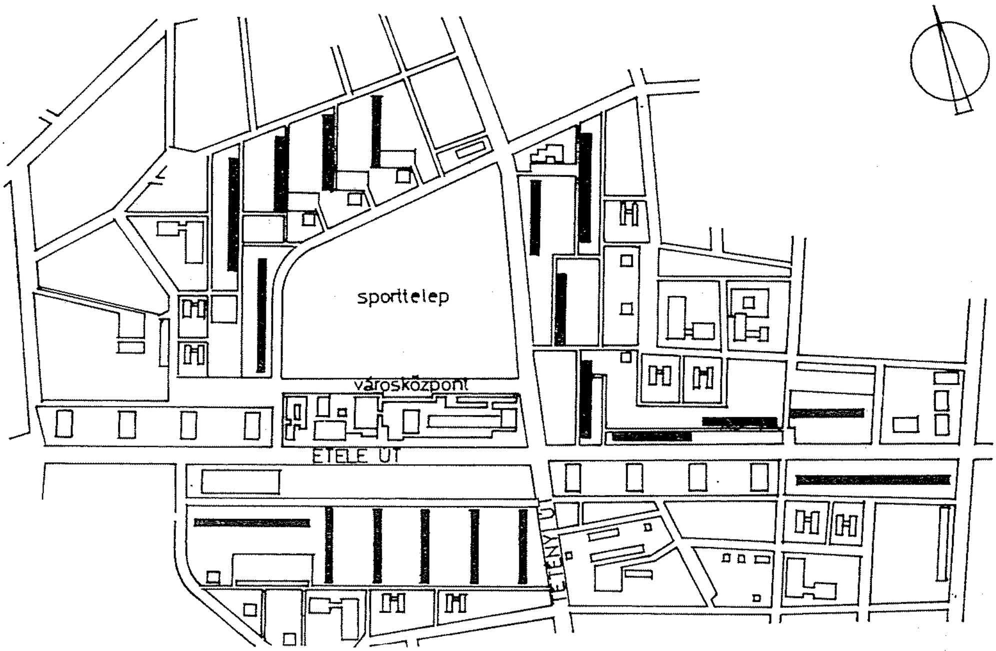
The *non-tectonic bricks* are actually nothing else but letters of a structural system and, as such, they can equally be used for housing, schools, communal buildings, industrial halls, etc.

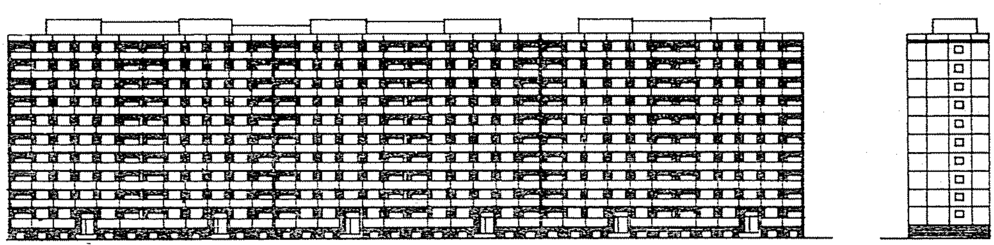
Variability: planning for change

This explains why in the *Gutenberg*-principled building there is finally no reason for typification of any kind since instead of aiming at the repetition of *typified* buildings, the non-tectonic systems aim at establishing a real *variability* of the final product.

The non-tectonic surface elements with their most variable overall dimensions, forms, thicknesses, etc., which can be used for the most variable kinds of buildings, actually create every architectural precondition of *planning for change*.

Mechanization based building: repetition of buildings





Open, light-weight systems versus closed, heavy-weight systems

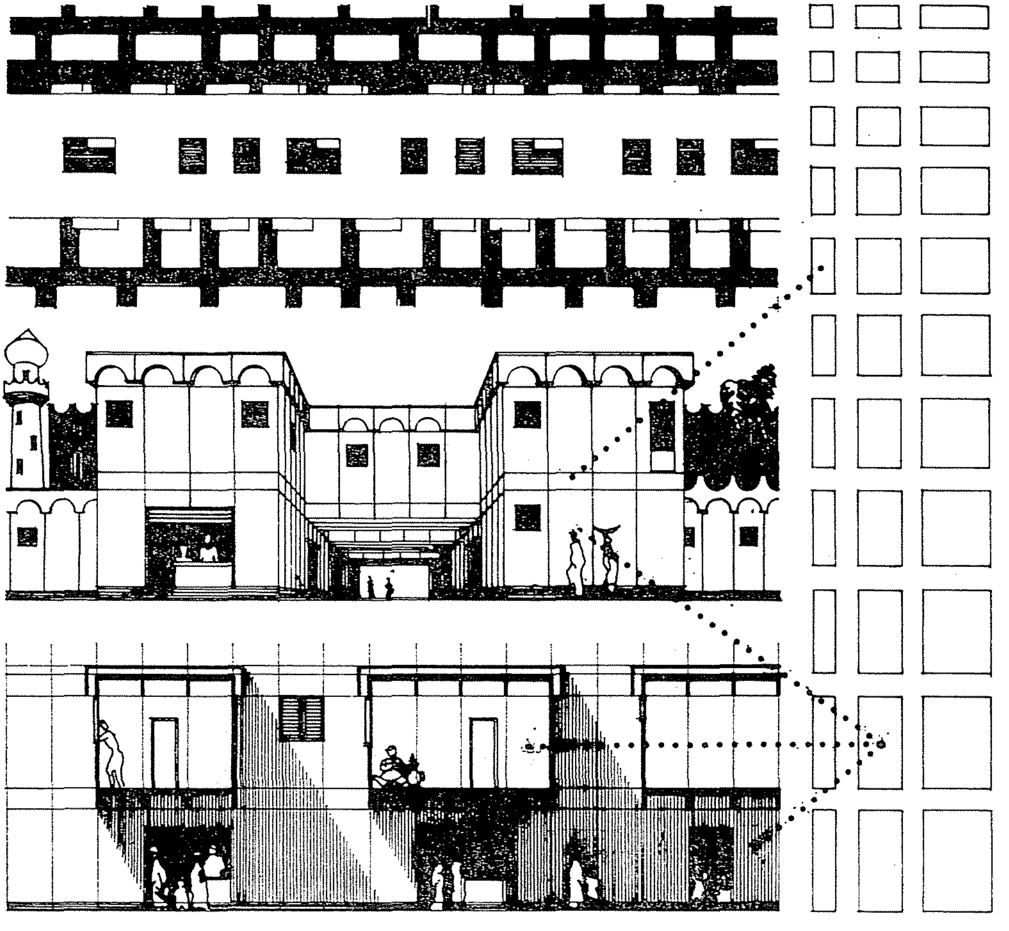
Mechanization based building — as it is known — starts out immediately from a definite final product, the building, and breaks it up into large sized, heavy-weight, loadbearing — i.e. *tectonic* — structural elements: the large panels.

The elementary part — *the large panel* — is actually nothing else but a large sized *manufactured tectonic brick* but as such, it is *not neutral* from an architectural point of view. On the contrary, it is *semantically meaningful* since — as opposed to the traditional brick — it is not only a part of a building, but a *determined part of a determined building*, consequently it definitely influences the final shape of the building.

Systems of tectonic bricks inevitably create *closed, heavy-weight,* silicate-based systems, since the large size *structural* elements they work with, are definitely bound to determined locations in determined buildings.

This, however, does not apply to the *Gutenberg*-principled building.

Gutenberg-principled building: planning for change



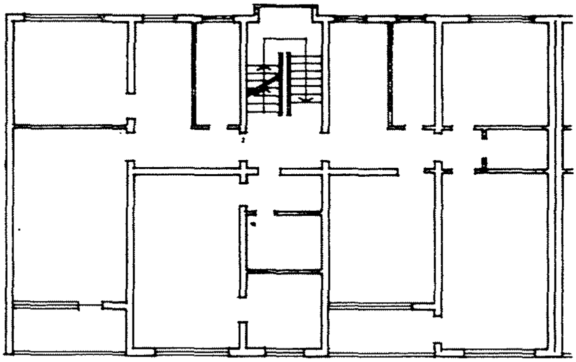
Gutenberg-principled building starts out from an undetermined final product, more accurately: it starts out from the surface of undetermined buildings and breaks up this surface into medium size, light-weight, non-loadvearing — i.e. *non-tectonic* — elements. The Gutenberg-principled building conceives the surface as a mould, that is the negative of the final load-bearing structure.

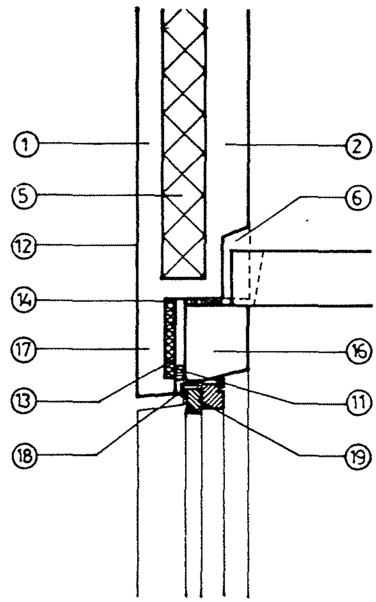
The elementary part — *the surface element* — is a simple skin construction, a lost casing element in gypsum. It is actually nothing else but a *manufactured non-tectonic brick* and as such it is really *neutral* from an architectural point of view, since — similarly to the traditional brick — it is *semantically meaningless.* It is really only a part of a building, more accurately: it is only an *undetermined part of an undetermined building,* consequently it does not influence the final shape of the building.

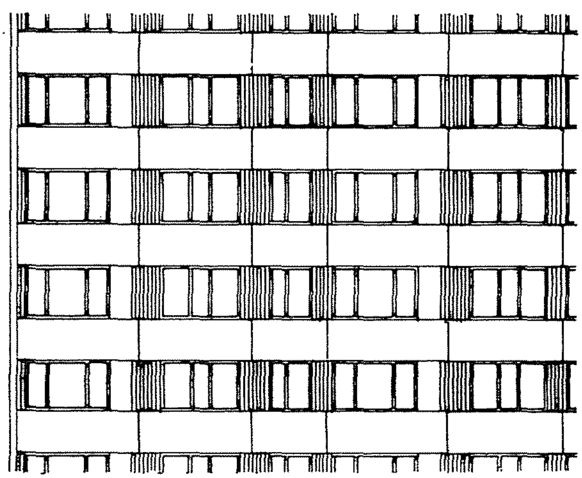
Systems of non-tectonic bricks inevitably call into being *open, light-weight* silicate-based systems since the medium size *surface* elements they work with, are definitely not bound to any determined location in any determined building.

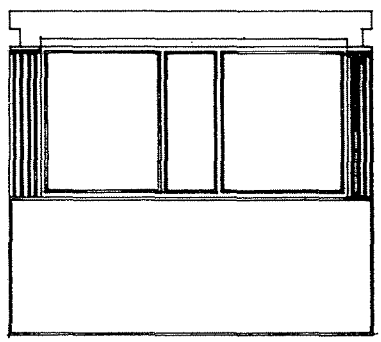
Gutenberg-principled building aims at *planning for change.*

Mechanization-based building: the housing factories ”see” the final product







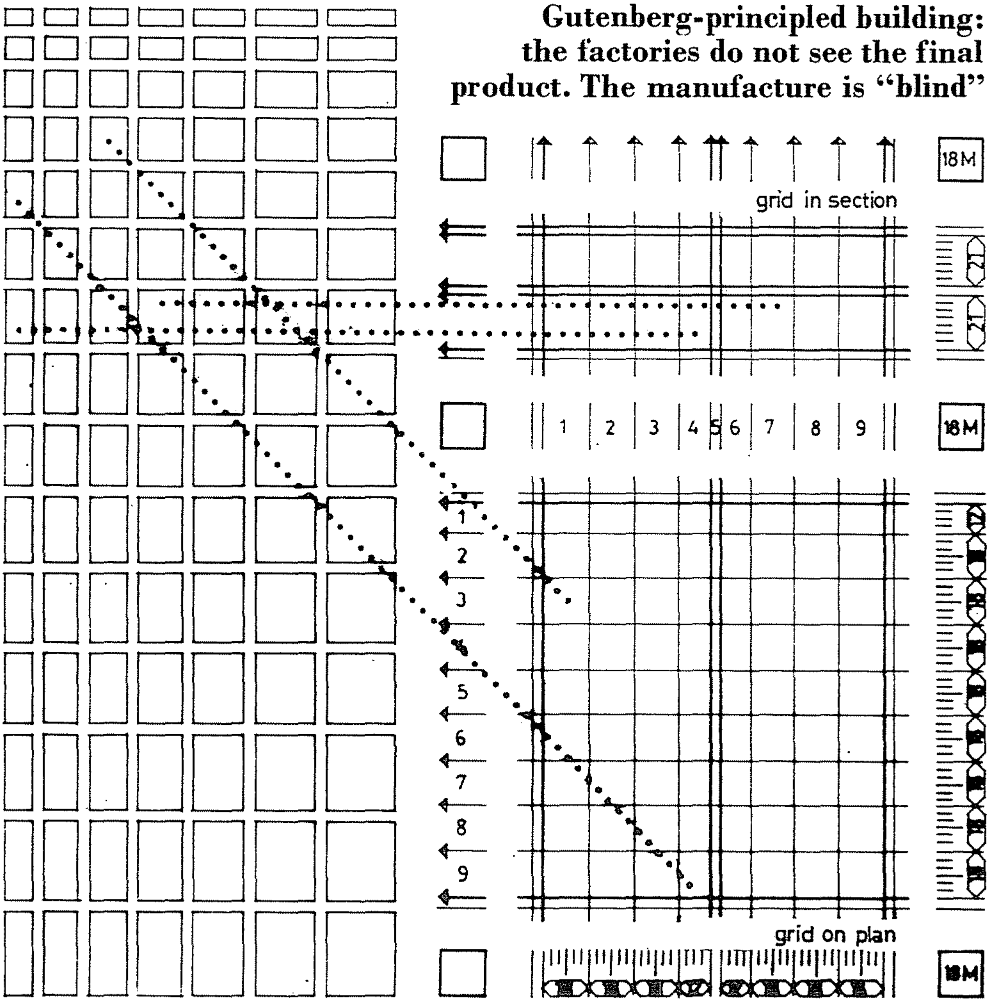


Principles of Manufacture

"Blind manufacture": an approach to producing light-weight, silicate-based open systems

Breaking with the axiom of tectonics and substituting it for the principle of surface, completely changes the principle of manufacture as well.

Mechanization based building — as we have seen — operates with closed systems of heavy *tectonic* bricks. You cannot start, however, the *manufacture* of these large elements unless you see the completed whole, that is the building to be erected, know the ground plans, sections with all their least details. The housing factories have to see the final product, since otherwise the large size tectonic elements (these determined *structural* elements to determined locations in determined buildings) wouldn't match and so they could not fit into the buildings.

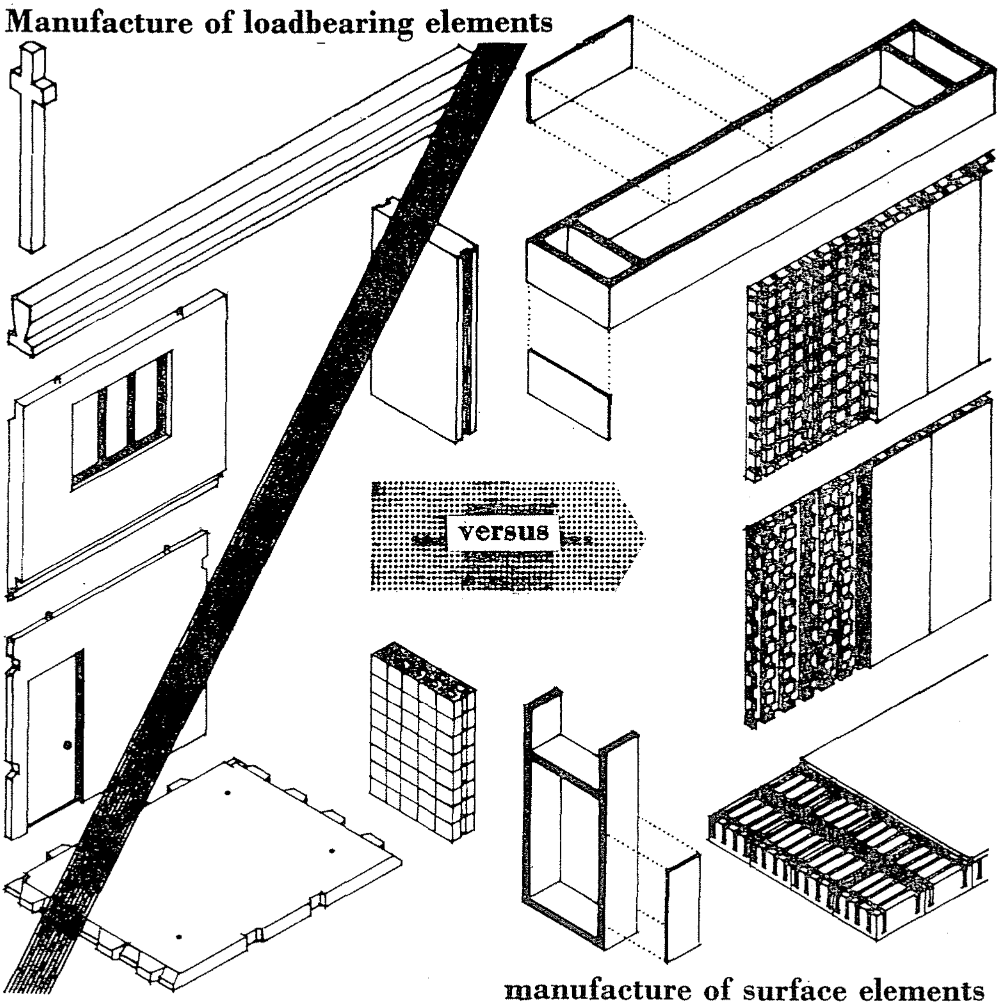


Gutenberg-principled building: the factories do not see the final product. The manufacture is "blind"

As opposed to this:

The Gutenberg-principled building operates with open systems of lightweight *non-tectonic* bricks. Here the building is undetermined and so the knowledge of the final product is not a precondition of *manufacture*. All you have to know is the system of grids on plan and in section, since the non-tectonic elements (these undetermined *surface* elements to undetermined locations in undetermined buildings) will fit into that grid system anyway. The factories do not have to see the final product.

This type of manufacture, however, is of a completely different character. It is *blind manufacture*.



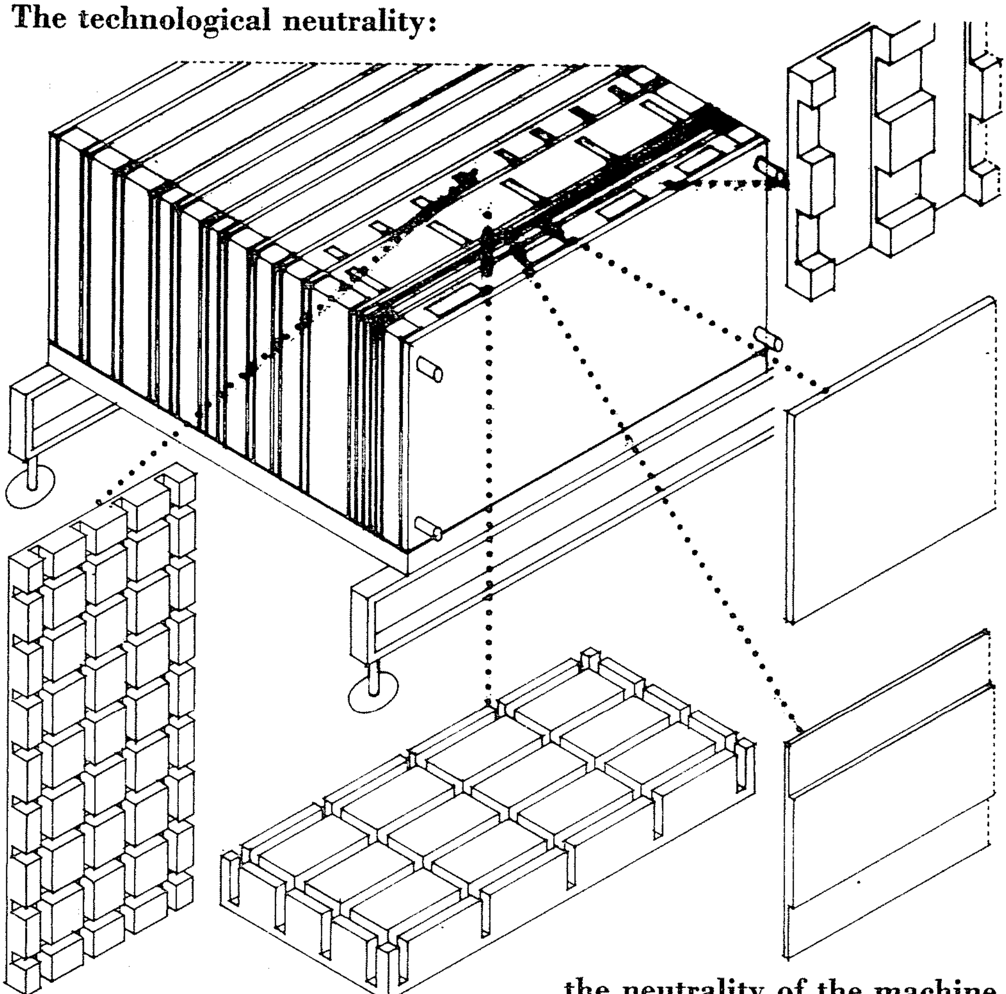
The nature of blind manufacture

Blind manufacture is a fundamentally new approach to mass-producing light-weight, silicate-based, open systems of construction.

As opposed to any other manufactured *tectonic* system, in which the emphasis is always put on the manufacture of the components of the *load-bearing structure;*

the *non-tectonic* system puts the emphasis of manufacture on the surface, that is on the manufacture of the non-loadbearing surface elements and instead of manufacturing heavy, loadbearing, tectonic beams, wall or floor elements, etc. light, *non-loadbearing* non-tectonic *surfaces* of beams, walls, floors etc. are mass-produced.

The technological neutrality:



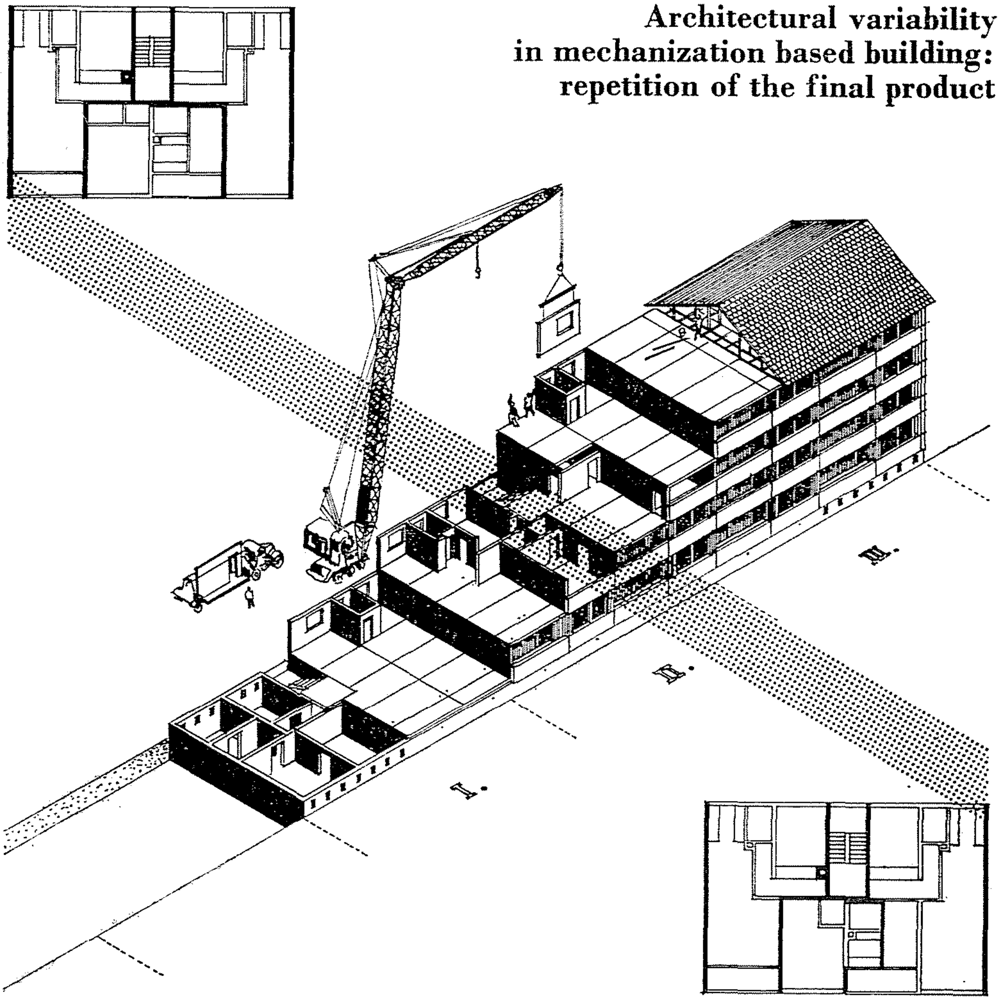
the neutrality of the machine

A technological aspect: the neutrality of the machine

The principle of building with non-loadbearing surface of beam, wall or floor elements completely changes the *technological* aspect of industrialization as well. These elements, namely, are absolutely *neutral* from a technological point of view: they do not require specific apparatuses for beams, walls, floors, they can be produced by the same convertible machine, the final visible *surface being the same* in all cases.

This fact is very important because this kind of *technological* neutrality, the neutrality of the machine, is very favourable from the point of view ot *mass-production* of surface elements, it almost "calls" for *open system industrialization* which in turn, is the technological precondition of *producing for change.*

Architectural variability in mechanization based building: repetition of the final product

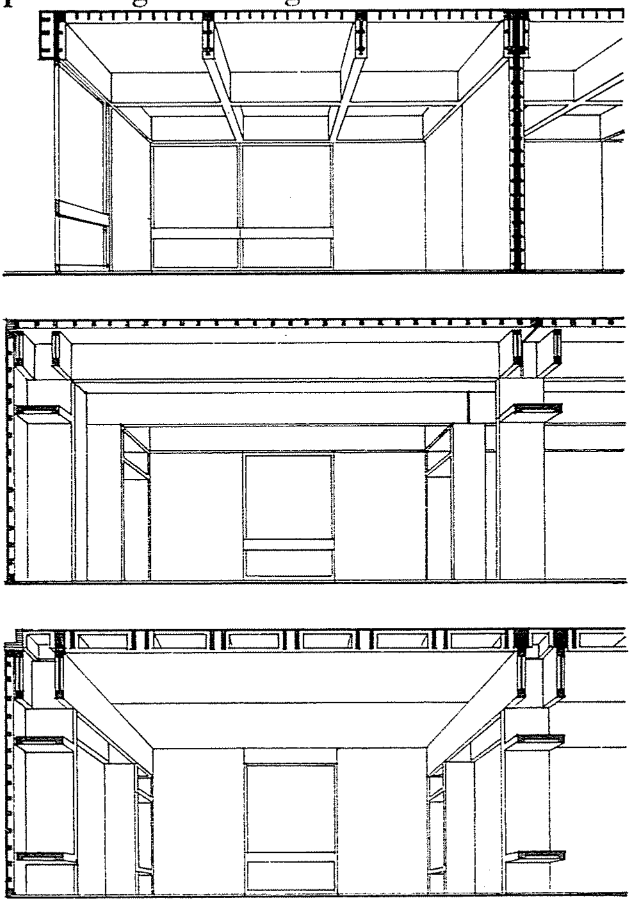


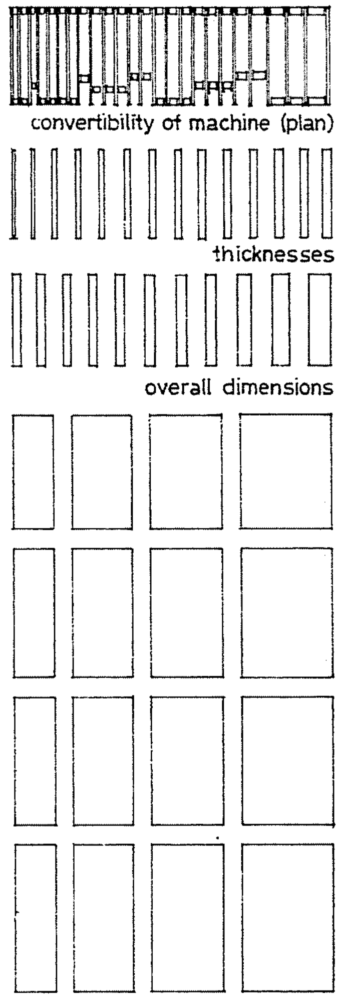
Producing for Change: workability of the structure and convertibility of the machine

Now, in order to be able to make the non-tectonic surface elements fit into the modular grid system of any undetermined building at all events, blind manufacture combines the shaping of the building, or rather, the workability of the structure (which is a precondition of planning for change) with the convertibility of the machine (which, in turn, is a precondition of producing for change).

Whereas in any *mechanization based* tectonic system, the shaping of the building, that is the architectural variability is necessarily limited since it can only be based on the additivity of heavy, tectonic structural elements finally shaped in form and size, as shown by the figure above;

Architectural variability in Gutenberg-principled building: producing for change

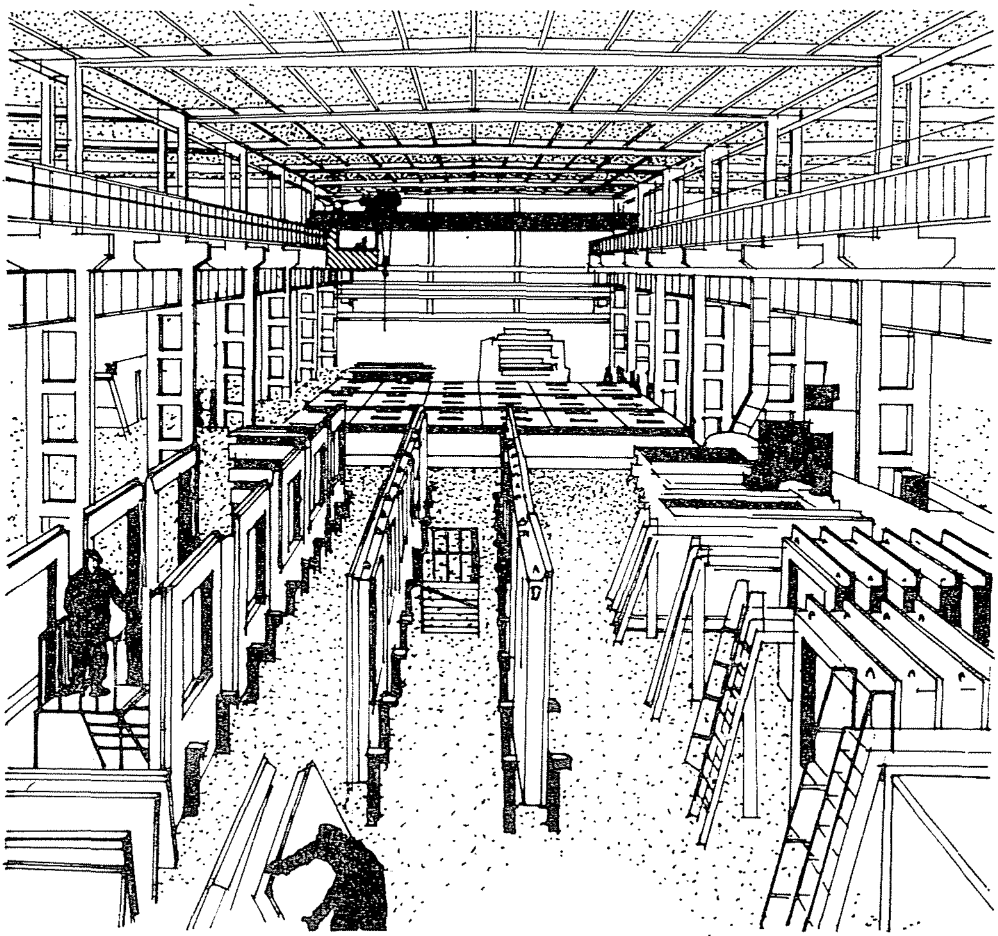




The *Gutenberg*-principled building offers practically unrivalled possibilities to increase architectural variability. In the non-tectonic systems the shaping of the building, that is, architectural variability is practically unlimited, first: because it is based on the additivity of light-weight non-tectonic surface elements, second: because in the non-tectonic systems the surface elements themselves become variable: in blind manufacture the variability of the elements is based on the convertibility of the machines, and thereby the sizes and forms selectable for the elements may reach a maximum.

Architectural variability in the non-tectonic systems is based on a simultaneous workability of the structure and convertibility of the machine.

The mechanization based building manufactures in planted factories and tends towards concentration of industry

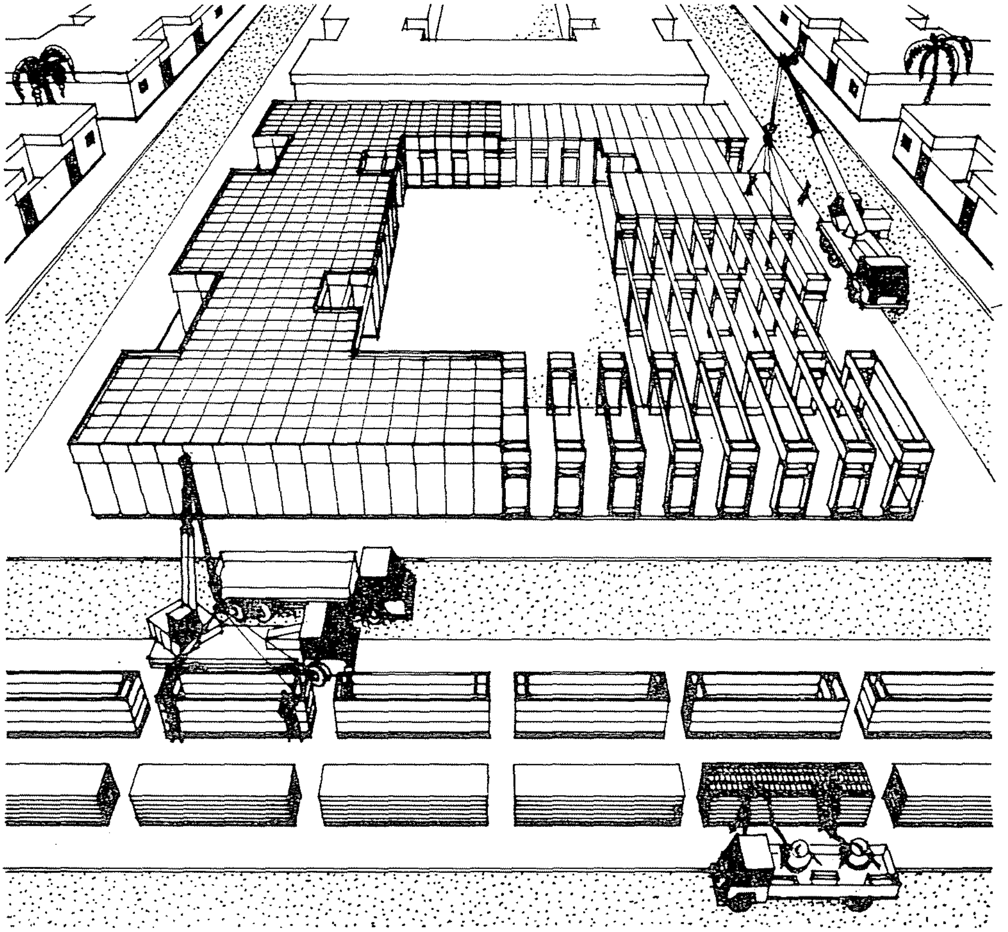


Transplantable workshops versus planted factories; decentralization versus concentration of the building industry

Blind manufacture, this new approach to open system industrialization, finally, completely transforms the very structure of the building industry both from technological and from socio-economic points of view.

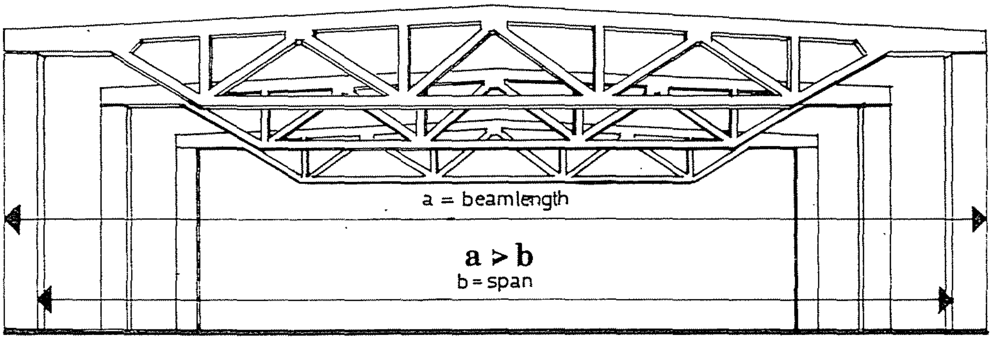
As opposed to *mechanization based building* in which the mechanized production of heavy structural elements requires huge *planted factories* established at enormous costs and which therefore, aims at the *concentration* of the building industry mainly around urban areas;

The Gutenberg-principled building manufactures in transplantable workshops and tends towards decentralization of industry

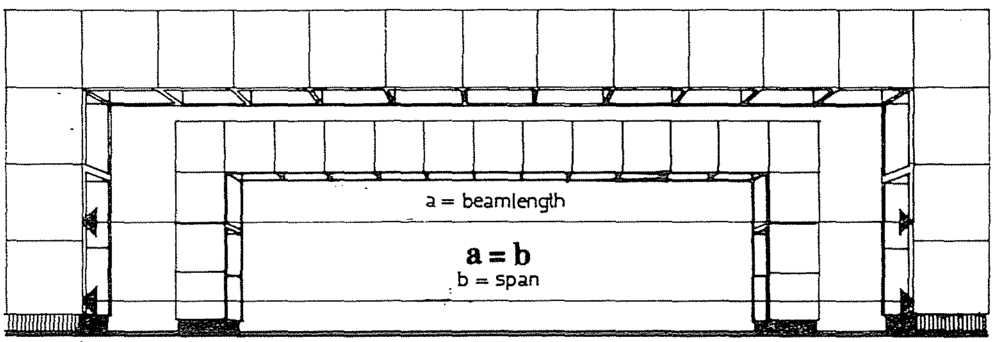


The *Gutenberg-principled building* aims at *decentralization.* The blind manufacture of the light-weight surface elements, is namely, founded on a system of *transplantable workshops.* These elementary factories can be scattered throughout the country, require low investment costs, work with cheap, small, convertible, transportable and transplantable manufacturing apparatuses which can be operated even by unskilled workers.

Tectonic structures: beam longer than span



Non-tectonic structures: span equals beamlength



Principles of Construction

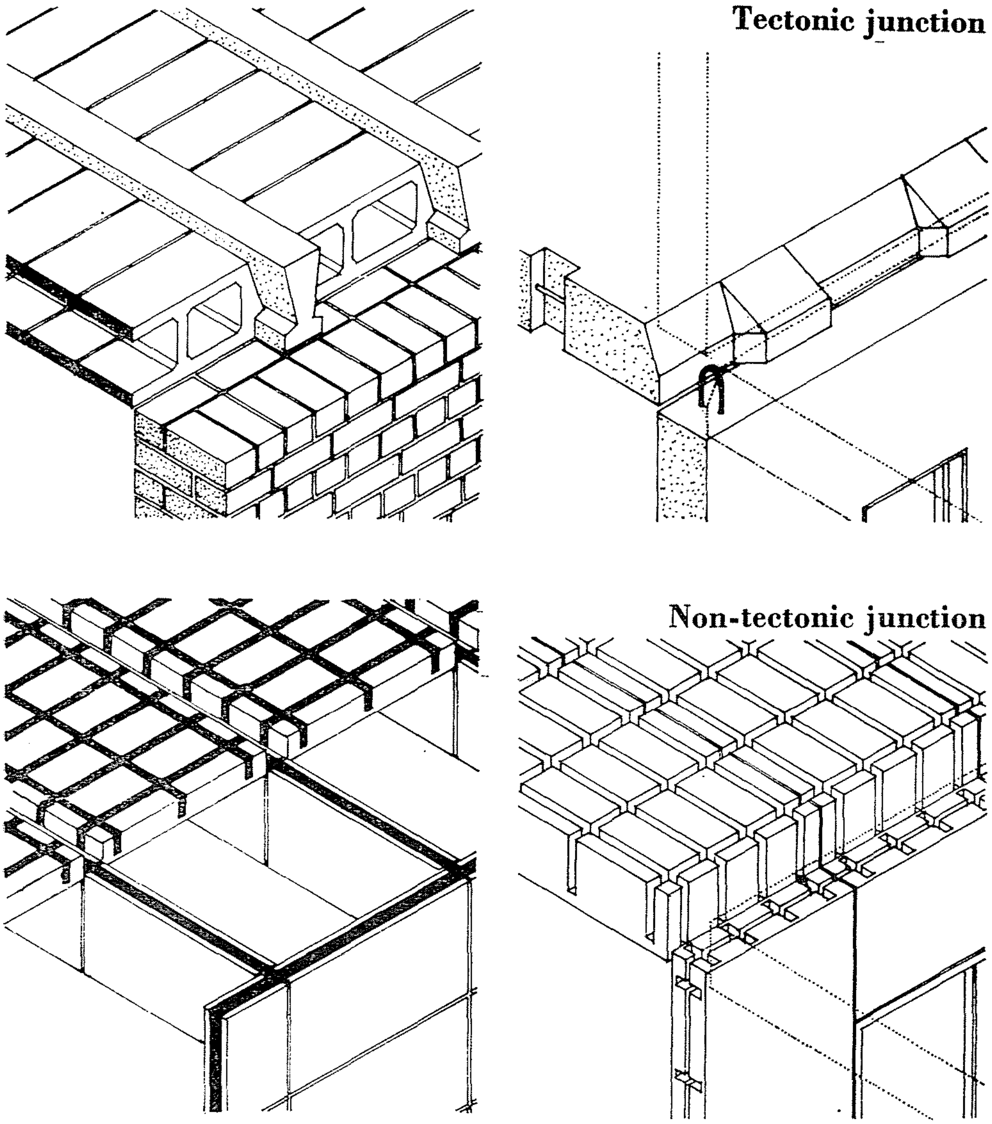
a) Unique features of non-tectonic structures

The simple fact that in the non-tectonic systems the *vertically and horizontally aligned surface elements* (which have no carrying capacity and no immediate stability) *are always put next to one another* (and not on top of each other) renders the non-tectonic structures quite a series of unique features. Here are some:

"Span-indifference"

As opposed to tectonic structures, where the length of the horizontal structural elements — i.e. the length of a beam — is always longer than the span (otherwise it could not be supported), which means that these elements — from point of view of manufacture — are "*span-sensitive*";

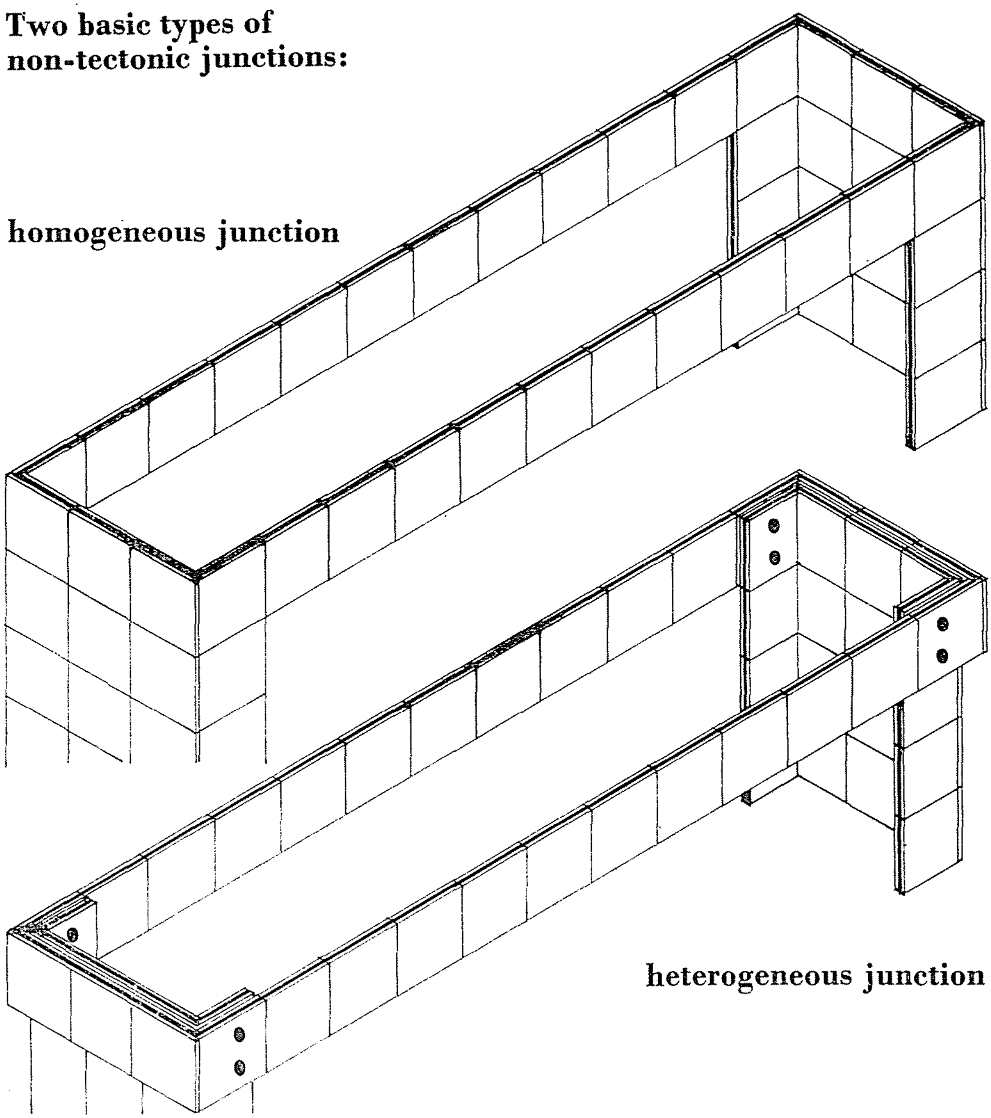
In the non-tectonic structures the span — i.e. the distance between the walls — always equals the beam length, since here the span arises as a result of the additivity of the surface elements of the loadbearing structure, which, in turn, means that these elements — from the point of view of manufacture — are "*span-indifferent*".



The method of jointing

Tectonic junctions always spell a vertical ("on top of") connection between superimposed loadbearing structural elements. This kind of "load-supporting—load-trasferring" junction can not arise in the non-tectonic systems, since here we work with the surface of the structure. As opposed to this:

non-tectonic junctions always spell a horizontal ("next to") connection between the vertically and horizontally aligned surface elements, as schematically shown by figure.

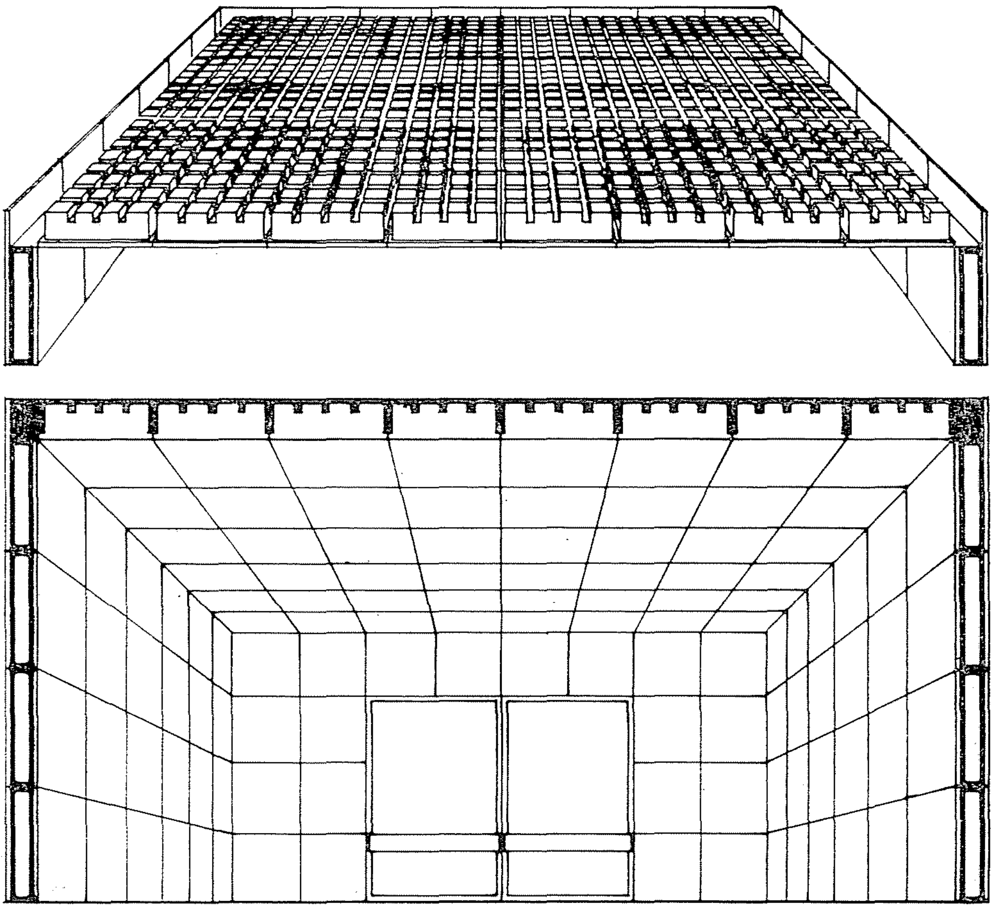


The two basic types of non-tectonic junction are the homogeneous and the heterogeneous junctions.

Homogeneous junction: that is a monolithic reinforced concrete junction created by pouring concrete into the cavities or channels arising between, or within the aligned surface elements.

Heterogeneous junction realized by steel jointing points used for creating structural connection between the adjacent vertical and horizontal monolithic reinforced concrete structures, as schematically shown by figure.

Creating monolithic structure through the additivity of surface elements



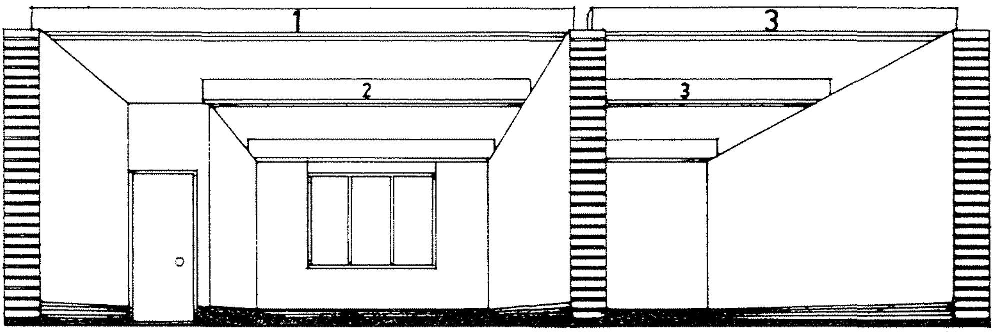
The method of creating monolithic structure

The fact that in the non-tectonic systems the architectural variability in based on the additive quality of surface elements is an important factor from the construction point of view, because it makes something possible that we could never totally realize in manufactured reinforced concrete structures, namely, to combine *monolithic* structure with the *additive* principle of construction, and thereby

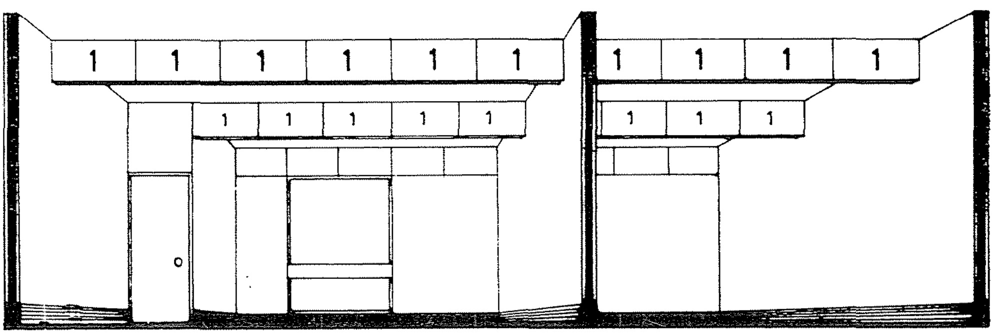
— on the one hand to produce buildings that are structurally monolithic, rigid and *earthquake resistant;* and

— on the other hand to produce structures that are ***not bound to definite*** *spans.*

Manufactured tectonic structures are bound to definite spans



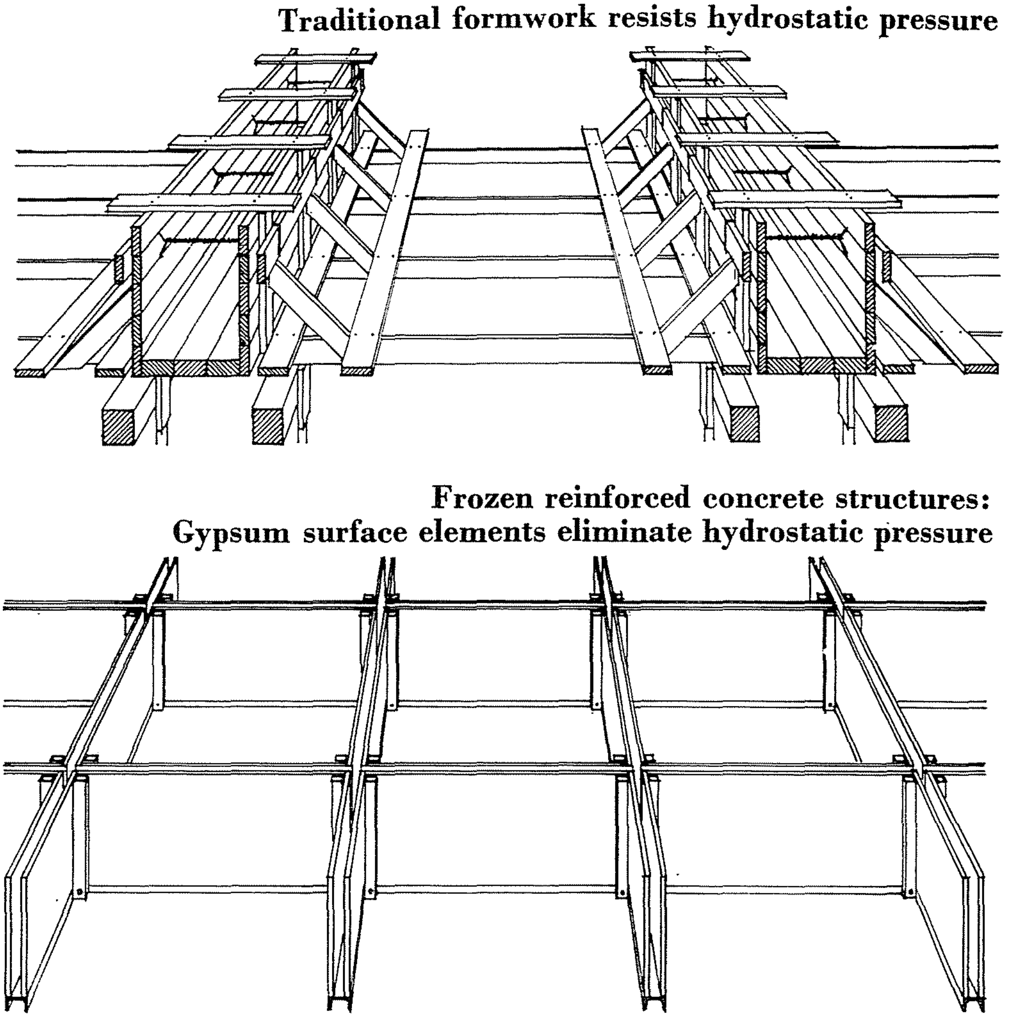
Non-tectonic structures are not bound to definite spans



Interpretation of the openness of the system

Whereas in the tectonic systems the manufactured horizontal, loadbearing reinforced concrete structural elements are unambiguously bound to determined spans; and so, the possibilities for designing different kinds of structures are restrained and restricted by the limitations in increments, stresses etc., consequently they tend to make the system more closed;

In the non-tectonic systems — as we have seen — the span is not a question of manufacture, but of the additivity of surface elements, and so the possibilities of design are not restrained and restricted, design becomes open; beams, structural heights, dimensions of cross sections can be freely disposed of.

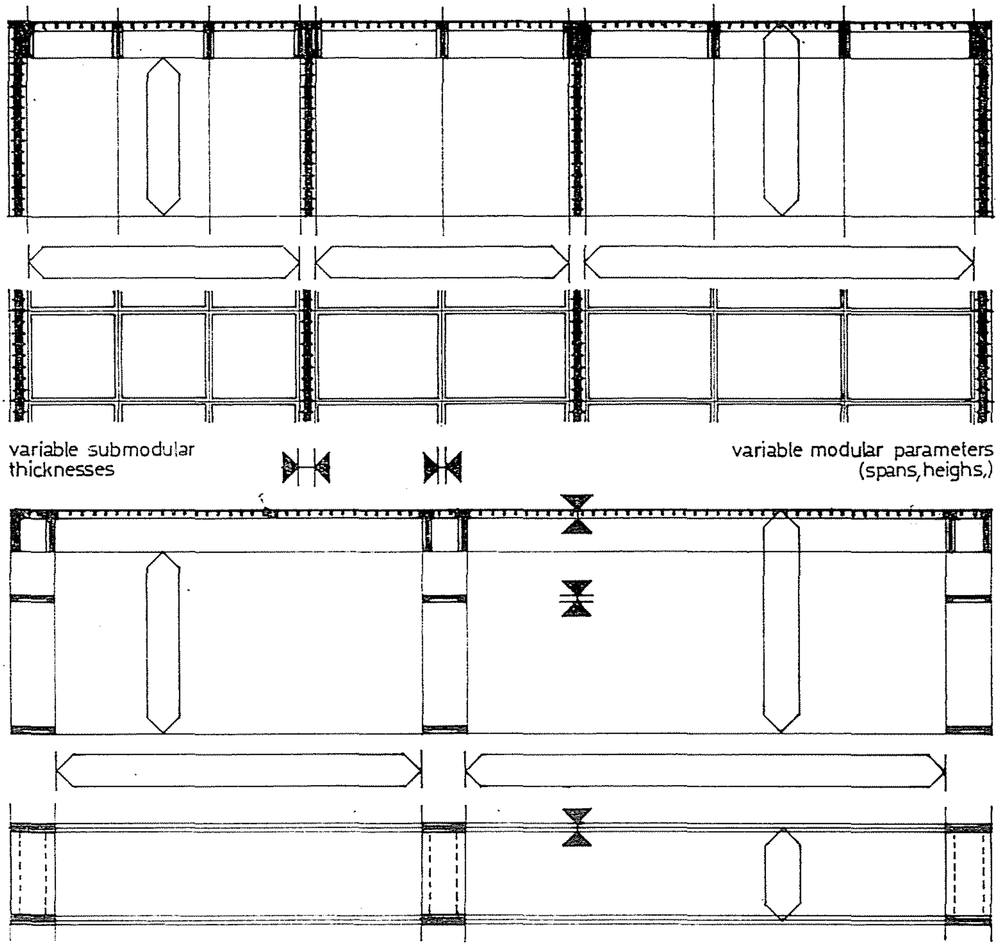


The use of "freezing" in reinforced concrete technology

As opposed to traditional r.c. structures where the formwork has to resist enormous side pressure, in the non-tectonic system the hydrostatic pressure of the concrete can be totally eliminated if properly chosen concrete is poured in between properly formed gypsum layers, suitable for freezing of the concrete.

The arising new constructions, the *frozen r.c. structures* are very thin membranes, they combine the highest structural qualities with an utmost reduction of weight of structure through reduction in the material. Their application for mass-housing — particularly in developing countries — is seemingly very promising.

Creating reference between modular structural parameters and submodular structural thicknesses



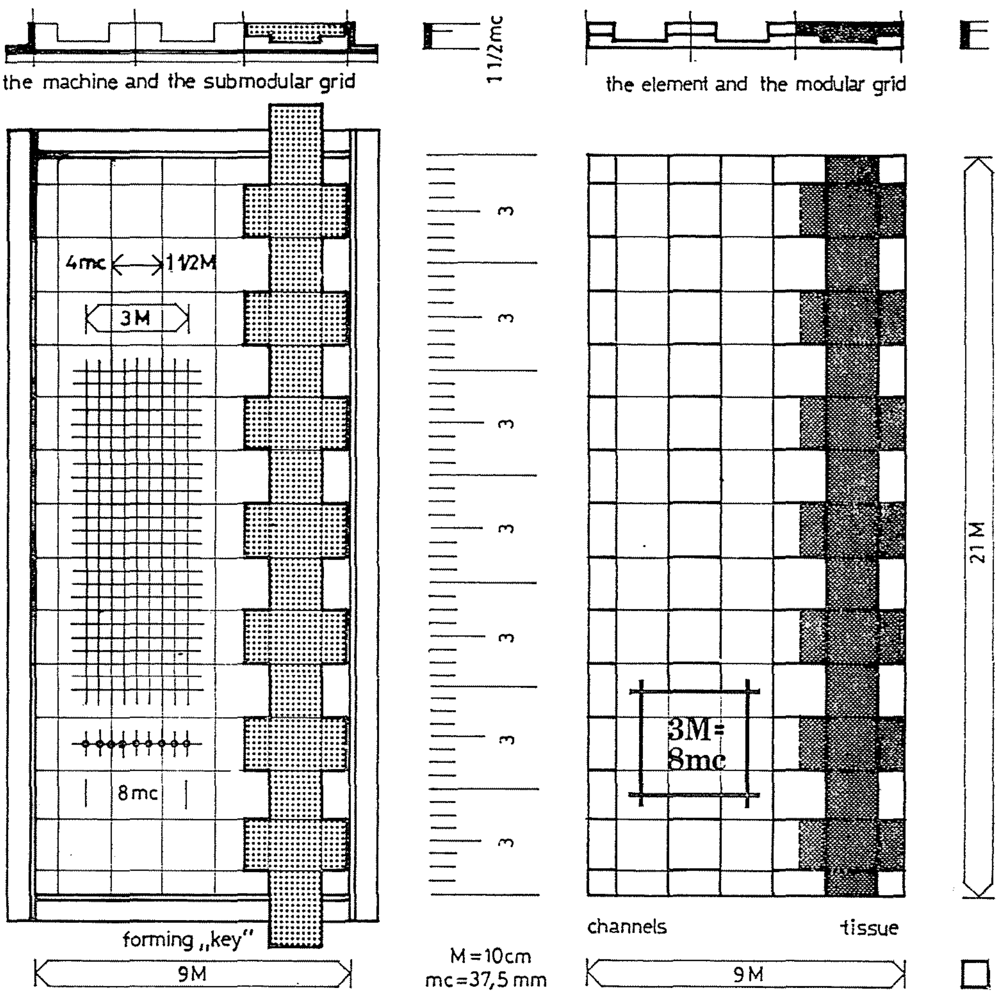
Creating reference between modular structural parameters and submodular structural thicknesses

Now, in order to be able to combine the workability of the structure (a precondition of planning for change) with the convertibility of the machine (in turn, a precondition of producing for change) the non-tectonic systems relate the variable *modular parameters* (spans, heights etc.) to the variable *submodular thicknesses* (stuctural thicknesses of elements, etc.) and thereby the nontectonic systems establish a double-reference:

— on the one hand a *modular* reference between the *elements* and the *modular (parameter) grids* on the building site, and

— on the other hand a *submodular* reference between the *thicknesses* and the *submodular (micro) grid* built into the manufacturing apparatus.

Double co-ordinated structures



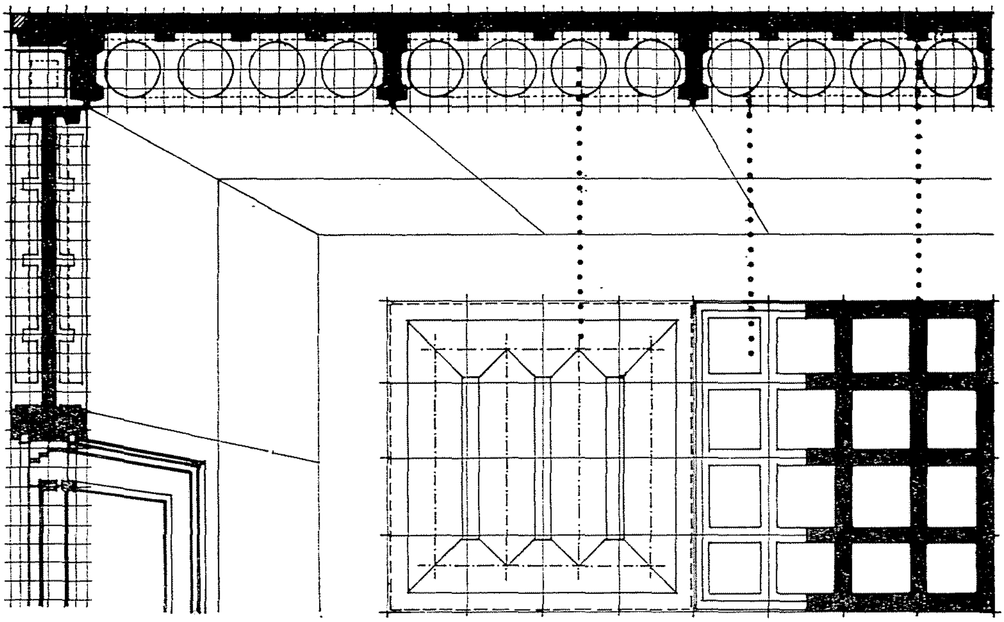
The ratio of modular to submodular grids can be expressed in a simple mathematical form. This *formula of double-coordination* in our case is

$$3\ \mathrm{M} = 8\ \mathrm{mc}$$

as symbolically illustrated by the figure. This formula means that 3 basic module grid units (M = module = 10 cm) within the structural system correspond to 8 micro grid units (mc = microcell = 37.5 mm) within the manufacturing apparatus.

Through this unique double-reference system (which cannot be realized in silicate-based manufactured, closed, tectonic systems), we realize an *optimum structural engineering performance* in which the variable loads and all the variable modular and submodular dimensions of the loadbearing, frozen reinforced concrete structure are strictly related to one another.

Thermal stabilization and heat control of buildings: light-weight, silicate-based heat-storing structures



The possibility of incorporating heat-storing systems

Last but not least: if the buildings require thermal stabilization, then the non-tectonic systems may incorporate proper equipments, that is: sealed registers containing a phase change material (PCM) into the surface elements themselves and thereby they call into being heat-storing prefabrication systems without giving up any principle of design, manufacture and construction.

By increasing the heat-storing capacity of the light-weight construction without practically increasing its weight it becomes possible to decrease the heating and/or cooling load and thereby to reduce prime energy and running costs.

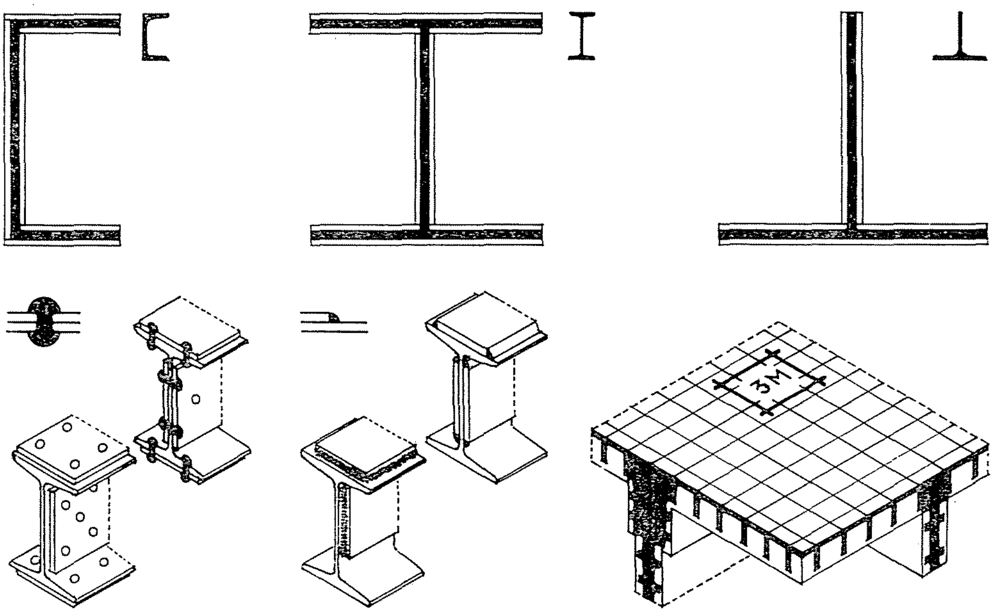
The media for heat-storage are phase-change materials (PCMs). The temperature level at which heat can and has to be stored can be chosen according to actual climatic conditions.

The PCMs have a high specific heat capacity and low vapour pressure. They are non-corrosive, non-toxic, inflammable, chemically inert and stable, there is no danger of fracturing their container.

The built-in, sealed registers are plastic tubes or specific reservoirs made by polimerization.

By the use of the heat-stabilizing equipment built into the structure and operated on a physico-chemical method, the light-weight, silicate-based constructions can be rendered almost equivalent to heavy-weight constructions from the point of view of building physics by storing solar heat-gain in the phase change material.

Translation of the language of steel structures to that of reinforced concrete structures



Translating the language of steel structures to that of reinforced concrete structures

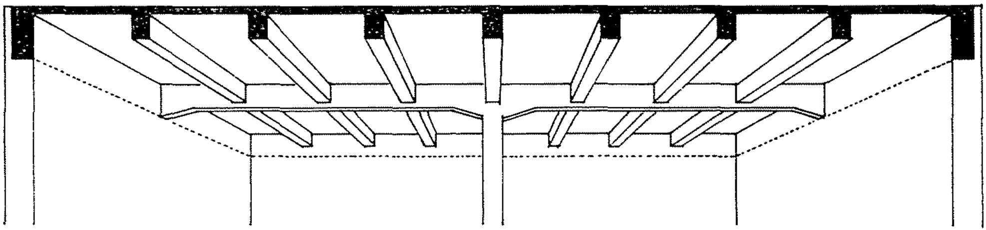
According to the general theory of technology, each technology can be conceived as a particular *language* which can be translated to the language of other technologies. The non-tectonic building method was conceived as a translation of the language of steel structures to the language of reinforced concrete structures. Starting from this consideration the non-tectonic systems transform the traditional reinforced concrete structures in a way, that

firstly: they translate the well-known *forms* (profiles, sections etc.) so well proved in steel structures into the language of reinforced concrete structures by switching over from the traditional r.c. structures to the r.c. *folded shell* constructions (as schematically shown by figures) and further expounded on the next page;

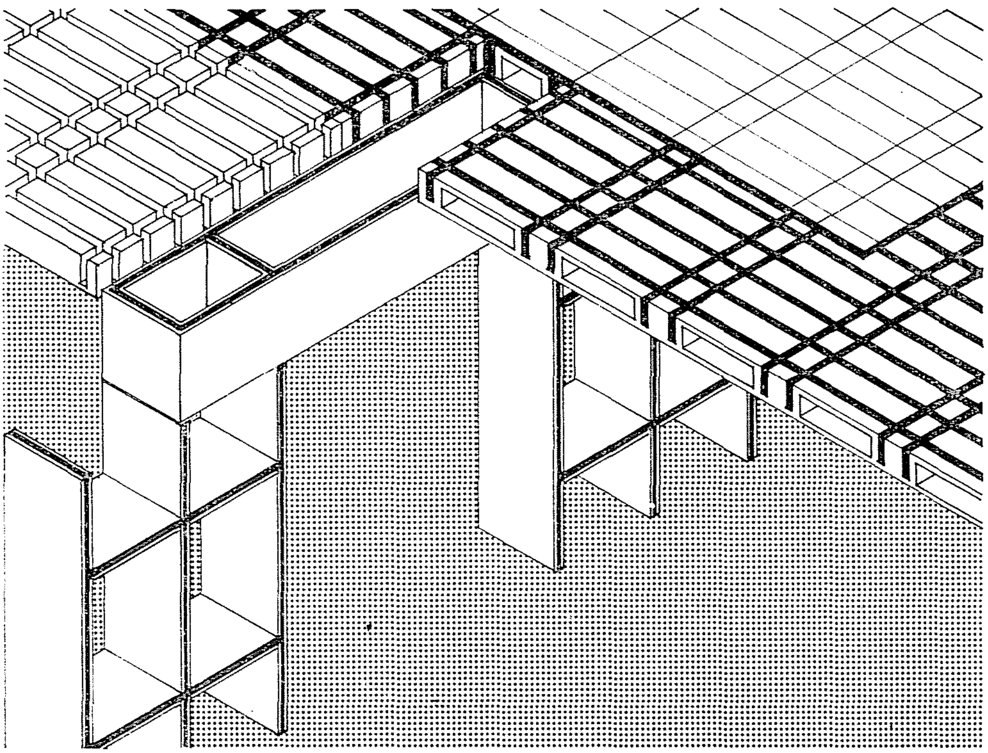
secondly: they translate the well-known methods of *jointing* so well proved in steel structures (riveting; welding) into the language of the reinforced concrete *tissue.*

This translation, this transformation of the traditional reinforced concrete technology — this is finally the characteristic feature of the frozen reinforced concrete constructions.

Traditional reinforced concrete structures



Frozen reinforced concrete structures



b) Two basic types of frozen reinforced concrete structures: the folded shell and tissue

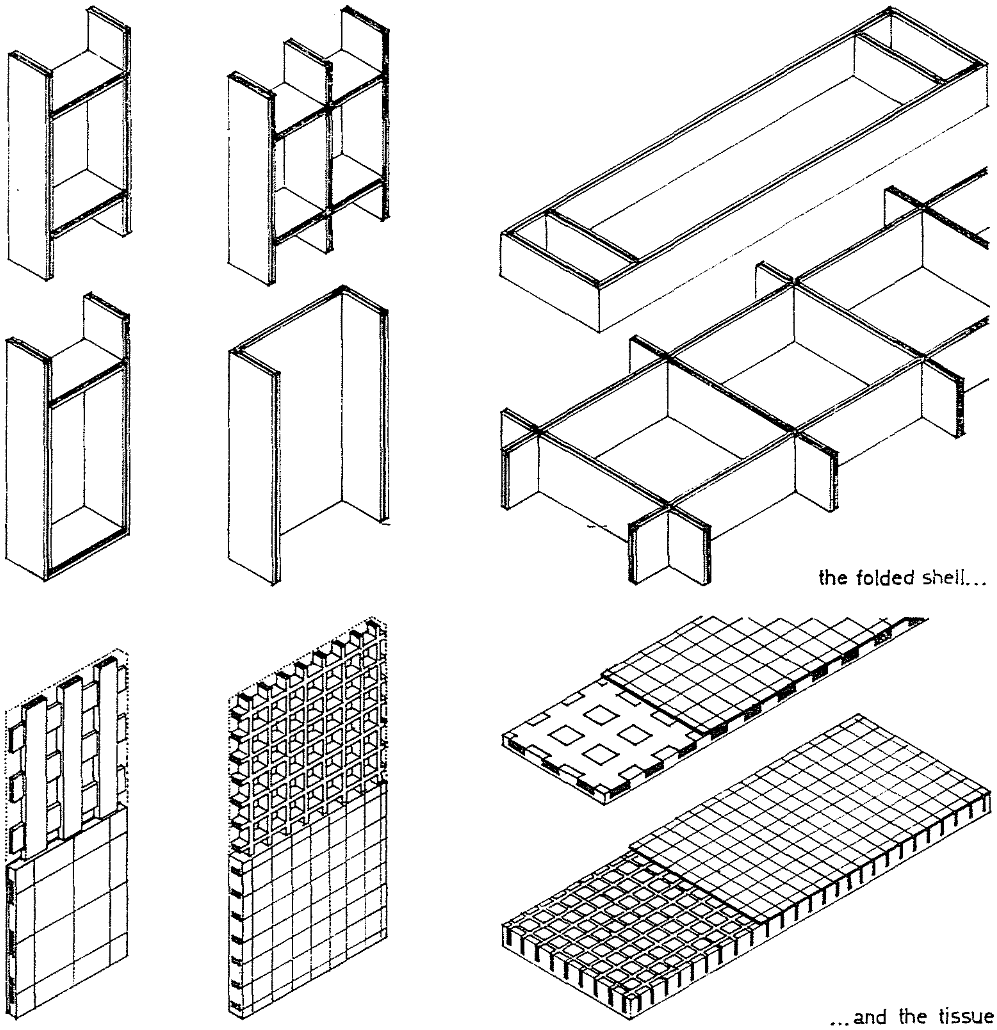
As opposed to the *traditioxal* r.c. structures representing homogeneous, isotropic, monolithic constructions, the *frozen* r.c. constructions created by the non-tectonic systems are inhomogeneous, anisotropic, monolithic constructions. They are

— *inhomogeneous*, in so far as the final structure is composed mostly of two materials (reinforced concrete stabilized between, within or on top of surface elements of low specific gravity);

— *anisotropic*, since the physical property of the final r.c. structure varies with the direction in the body;

— *monolithic*, because the additivity of surface elements leads to creating continuous structures.

Basic types of frozen reinforced concrete structures

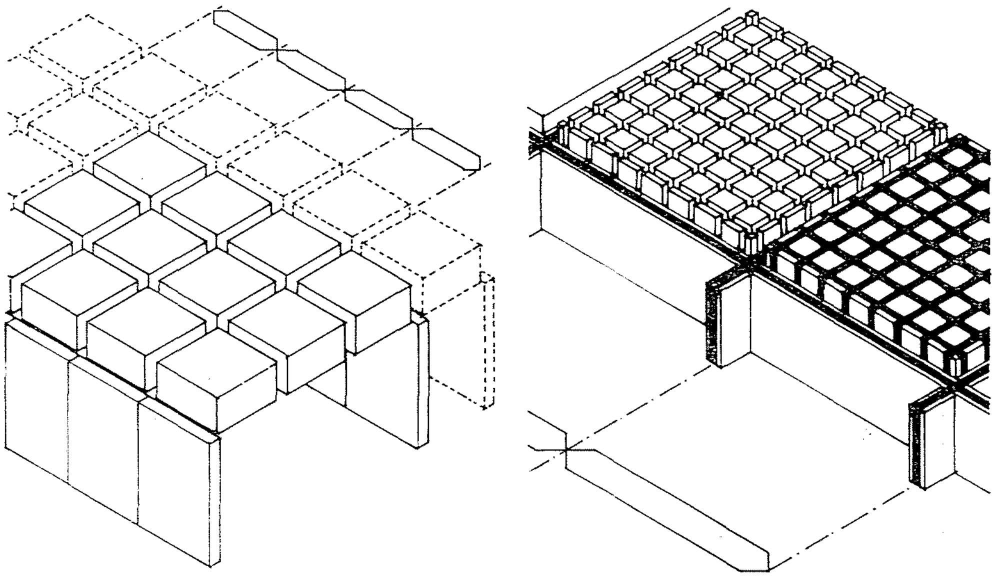


Frozen reinforced concrete stuctures have two basic types:

The *folded shell:* the reinforced concrete visible *primary structure* — or, rather, cellular structure — stabilized between the surface elements. Its form is that of a closed or open steel section (I; T; U-profiles) or, rather, of a cardboard box with reinforcement led around the corners. The frozen shell is, namely, a thin folded r.c. membrane.

The *tissue:* the hidden reinforced concrete *microstructure* — or, rather, microcellular structure — stabilized within the two-way channel system of the surface elements always appearing in the form of a r.c. grid reminding of the form of a woven cloth tissue. Hence its name.

Two basic principles of construction of frozen r. c. structures: the cell and the microcell as principles of construction



c) Basic principles of construction of frozen reinforced concrete structures: the cell and the microcell as principles of construction

In order to be able to satisfy all possible (architectural, functional, technological, socio-economic etc.) demands the non-tectonic systems definitely aim at enormously increasing the number of variations not only on plan and in section but in the very form of construction as well.

Since the analysis of the large panel systems clearly shows, that the inevitable tendency towards increasing the span is incompatible with maintaining the *slab* as principle of construction; and

since the analysis of heavy, space-unit building method clearly shows, that the tendency towards increasing the sizes of the parameters runs counter the *box* as principle of construction;

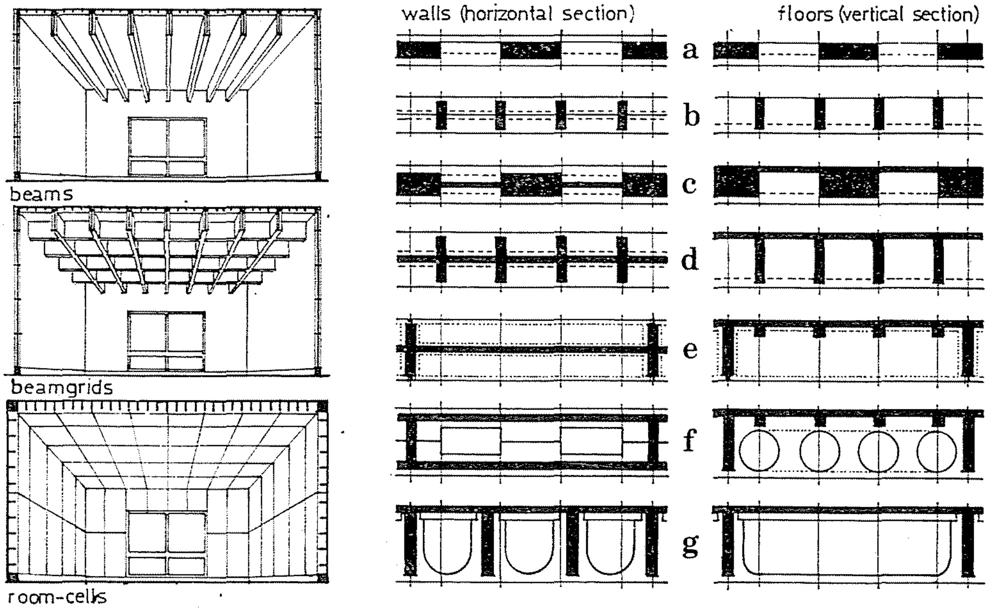
therefore: the non-tectonic systems give up the idea of working either with the slab, or with the box as principles of construction and as opposed to these characteristic principles of contemporary, manufactured, silicate-based, heavy, closed systems, they introduce

first: working with the *cell* as principle of construction for the frozen, reinforced concrete *primary structure* (which means the use of many different forms of the *folded shells)*;

then: working with the *microcell* as principle of construction for the frozen reinforced concrete *microstructure* (which, in turn, means the use of many different forms of *tissue-structures)*.

Two basic forms of frozen r. c. structures:

cellular structures **microcellular stuctures**



d) Two basic forms of frozen reinforced concrete structures: the cell and the microcell as structural forms

The two basic forms of frozen reinforced concrete structures — the cellular and microcellular structures — which mostly arise as a combination of some form of r.c. folded shell and r.c. tissue, offer a very wide range for satisfying different requirements by rendering it possible to select quite a series of different structural solutions for the same plans, functional arrangements, etc.

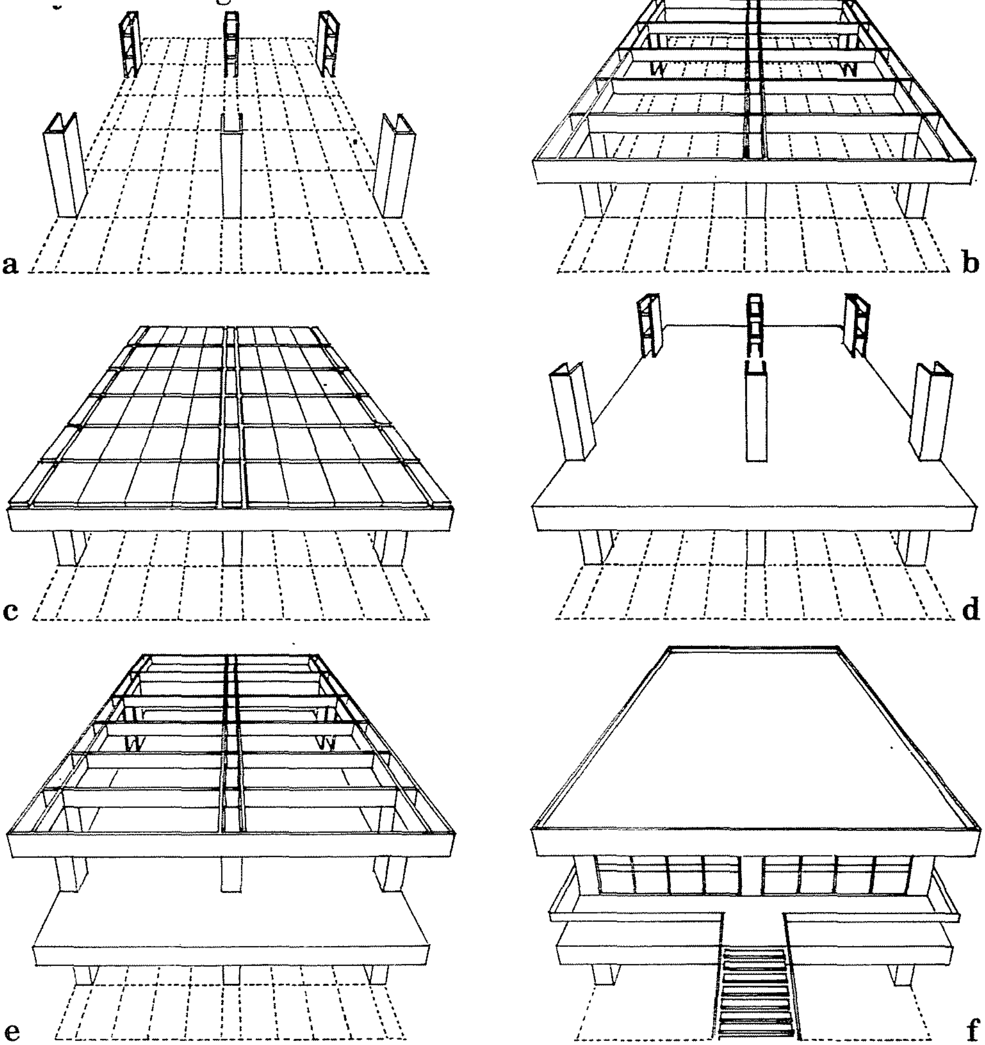
The *cellular* systems may operate with beams, beamgrids, or with the room units (room-cells) themselves. These forms represent the *visible* forms of non-tectonic structures.

The thin and delicate *microcellular* structures — irrespective whether they are used for walls or floors, or whether they are made of r.c. tissue, or of a combination of r.c. tissue and r.c. shell — always remain *hidden* behind the surface.

In case of *walls* e.g. we may use tissue exclusively, the tissue can be "loose" or "dense" (a, b), or combinations of tissue and shell (c, d) combinations of ribs, hidden beams or beamgrids with shell (e), or combinations of ribs and double shell, (f) finally closed cellular anisotropic slabs (g).

In case of *floors* e.g. if the cellular system works with beams or beam-grids we may again use r.c. tissue (a, b), combinations of tissue and shell (c, d), if room-cells are applied then we may again use e.g. combinations of ribs, tissue and shell (e, f), the heat-stabilizing containers in this case may be hidden within the surface elements (f), finally we may also apply closed cellular anisotropic slabs (g).

In-situ building methods

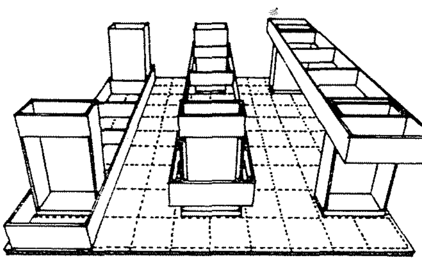


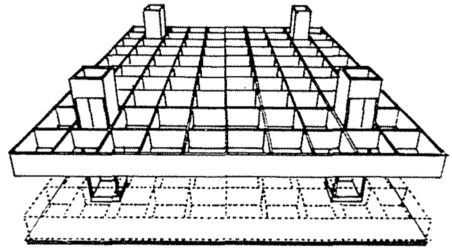
e) Basic methods of non-tectonic building: the in-situ, the lifting, the box-unit the box-frame-unit and the closed cellular building methods

Until now five basic types of non-tectonic building methods have been elaborated.

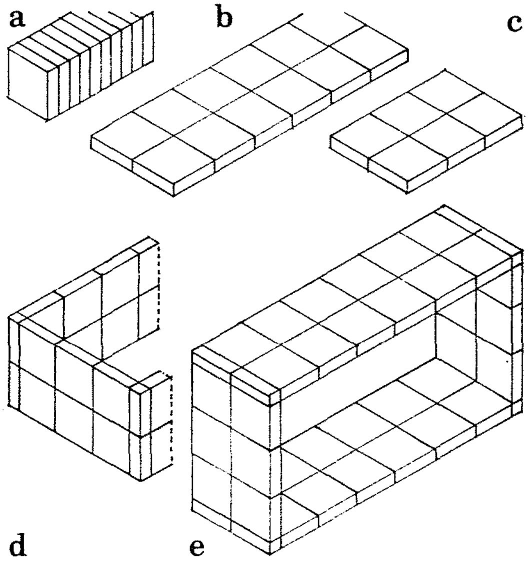
In case of the *in-situ building method* the chronological and logical order of the building process itself corresponds to that of the mechanization based tectonic building, in so far as the building is erected "from below upwards", each structure is built in its final position, beams, beam-grid or floors following the erection of walls, or folded shell pillars (a, b, c) and the process is repetitive (d, e, f).

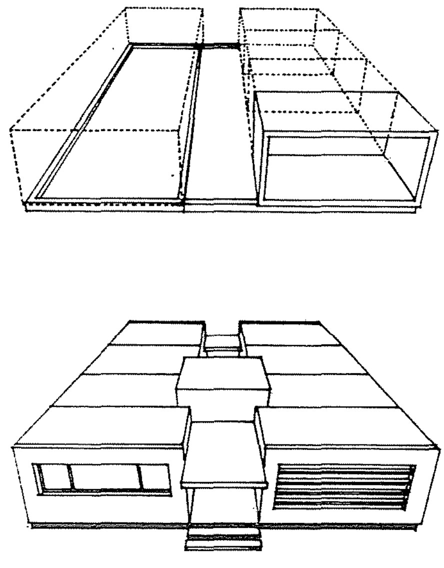
Lifting building methods





Box unit building methods





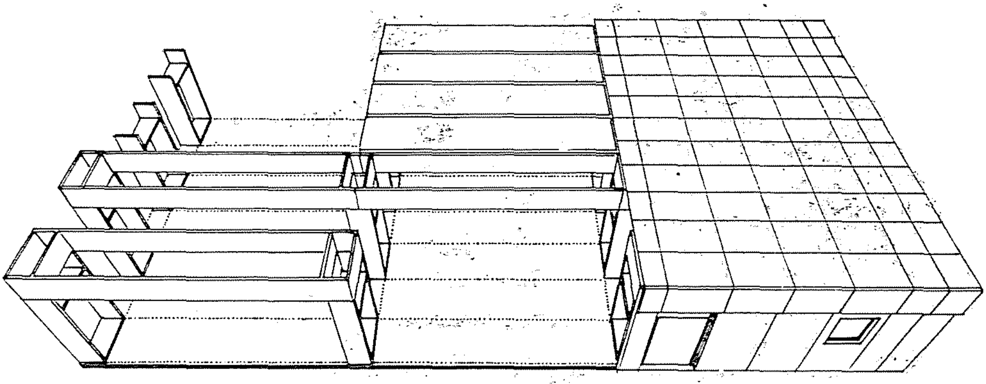
In case of the *lifting building method* the horizontal load-bearing structure — e.g. the beam-grid — is built exactly underneath the final "in-situ" position and it can be lifted into final position even by hand, through mechanical transmission.

The lifting apparatuses can also be integrated with the vertical load-bearing structure. In this case they are always mounted on top of the folded shell pillars or walls.

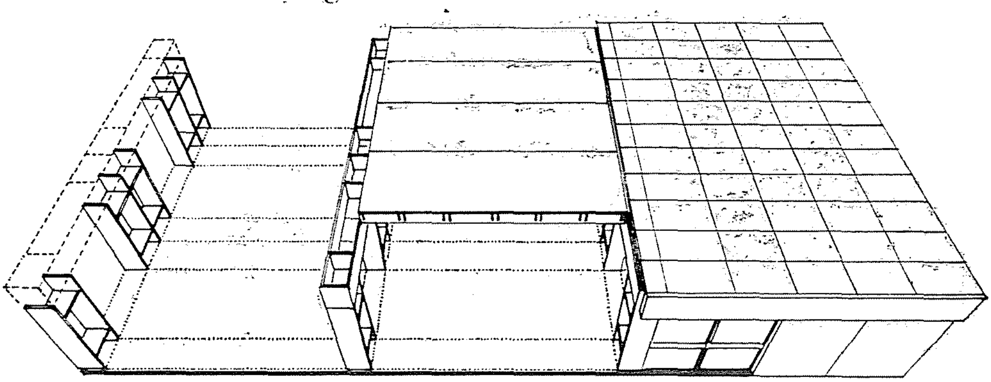
If the horizontal load-bearing structure is built and lifted in "linear" parts, the method is called "*lift-grid*", if however, the horizontal load-bearing structure is built and lifted in "field-units", the method is called "*lift-field*".

In case of the *box-unit building method* the box units constituting the building are produced in a factory in such a way that first we manufacture the non-loadbearing surface elements (a) then the load-bearing plane (wall- and floor) structural elements (b, c) and finally we assemble them into rigid, loadbearing box-units (d, e). On the site the building process is confined to the assembly of box-units.

Box-frame unit building methods



Closed cellular building methods



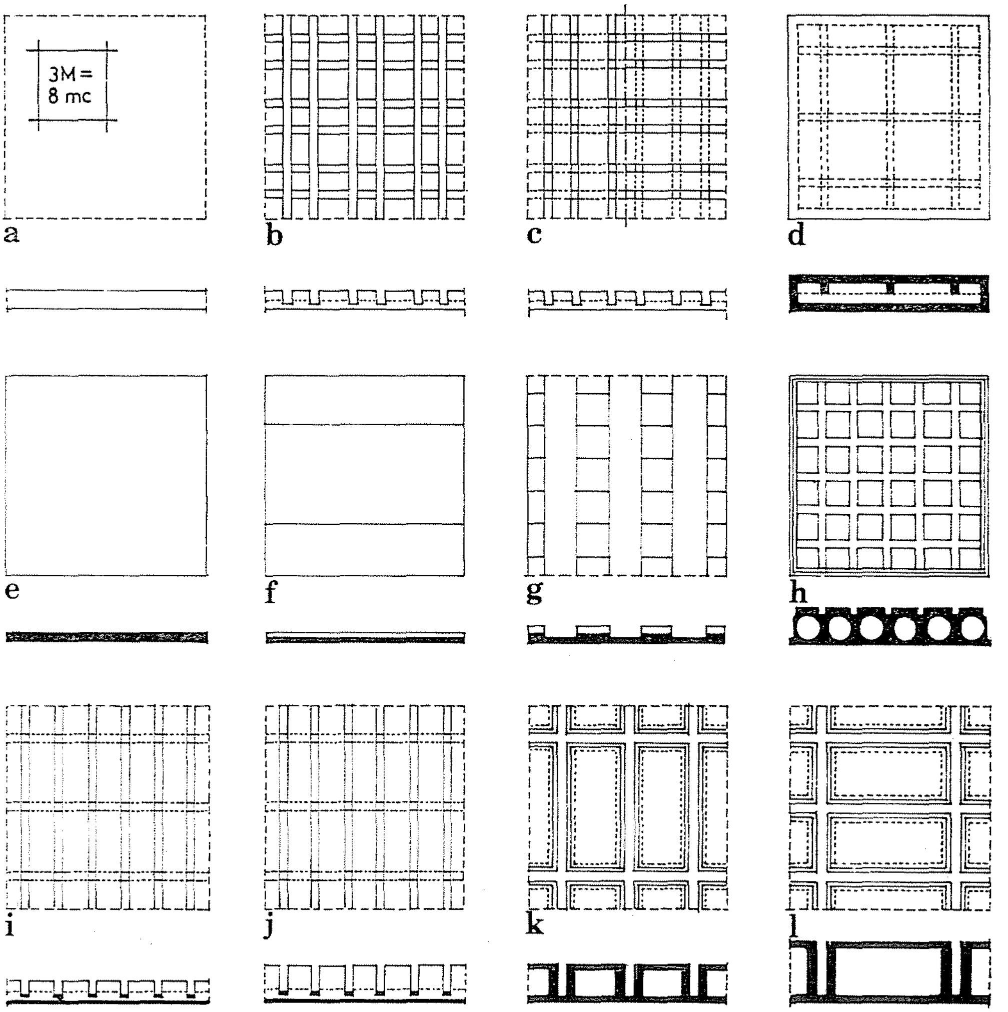
In case of the *box-frame unit building method* the small box-units (the "ring"-units, the empty box-frame units) constituting the building are produced in a factory in such a way, that first we manufacture the non-tectonic surface elements (plane, gypsum elements) and then we assemble from them loadbearing small box-units (more accurately: pillar box-frames or beam box-frames).

On the site we first assemble the pillar box-frame units by fixing them in their final position, then — on top of these — we place the beam box-frame units, the structure is finally completed by the location and homogeneous junction of the tissue structural slabs (the floor elements and exterior wall elements) rendered already tectonic in the factory.

In case of the *closed-cellular building method* the constituents of the building: the box-units, the plane elements (that is: the empty box-frames and the anisotropic slabs of a parameter size in at least one direction) are produced in a factory in such a way that the largesized tectonic pillar box-frame units and beam box-frame units are assembled from plane non-tectonic gypsum surface elements, whereas the large-sized tectonic anisotropic slabs are called into being from periodic largesized gypsum surface elements supplied by a twoway channel system and a periodic system of closed internal cells, through pouring concrete into the channels and on top of the closed cells.

On the site the cycles of assembly, in case of the example shown in the figure, are essentially identical with those of the box-frame unit building method.

The Gutenberg-principled non-tectonic surface elements

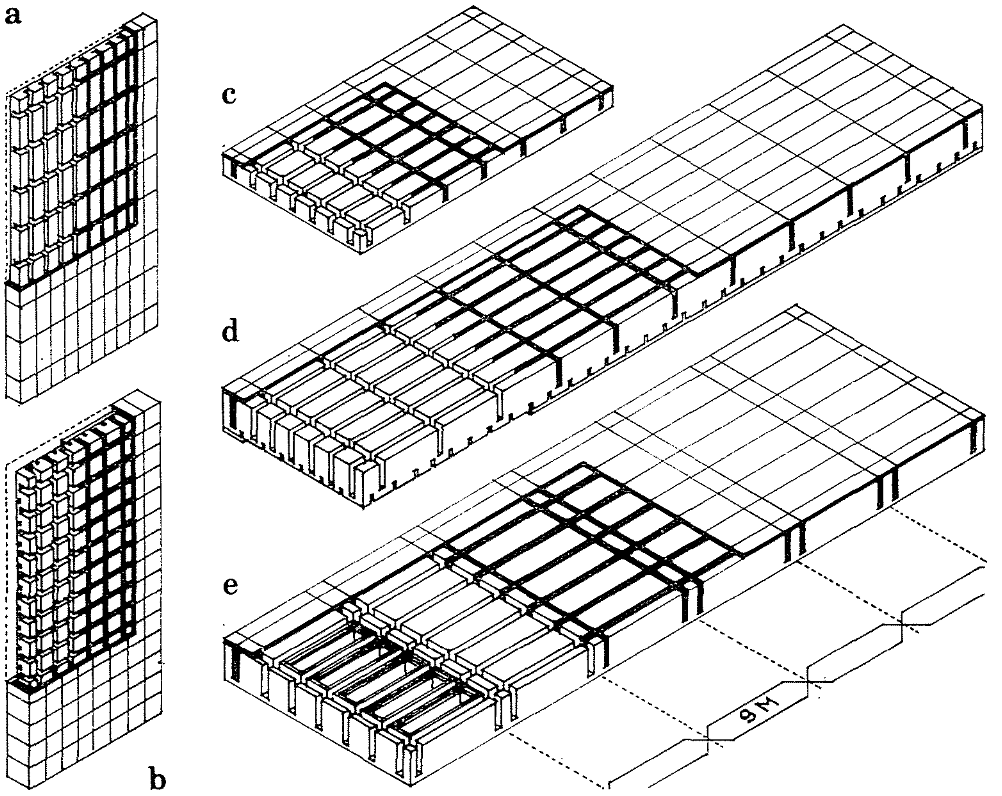


f) Basic elements of the non-tectonic systems

Basic principles of the classification of elements

In the non-tectonic building the basic elements applied have to be classified on the one hand according to the principle of disintegration (decomposition), on the other hand according to the composition of materials, method of forming, geometrical shape and functional designation. According to the *principle of disintegration* two main groups of the elements may be distinguished, that is: the group of the *Gutenberg-principled* non-tectonic surface elements, and the group of the *mechanization-principled* tectonic structural elements. According to the *composition of materials* the manufactured elements can be realized with one single material (polystyrene or gypsum), with a combination of two materials (polystyrene + gypsum; gypsum + reinforced concrete), or with a combination of three materials (polystyrene +

The mechanization-principled tectonic structural elements



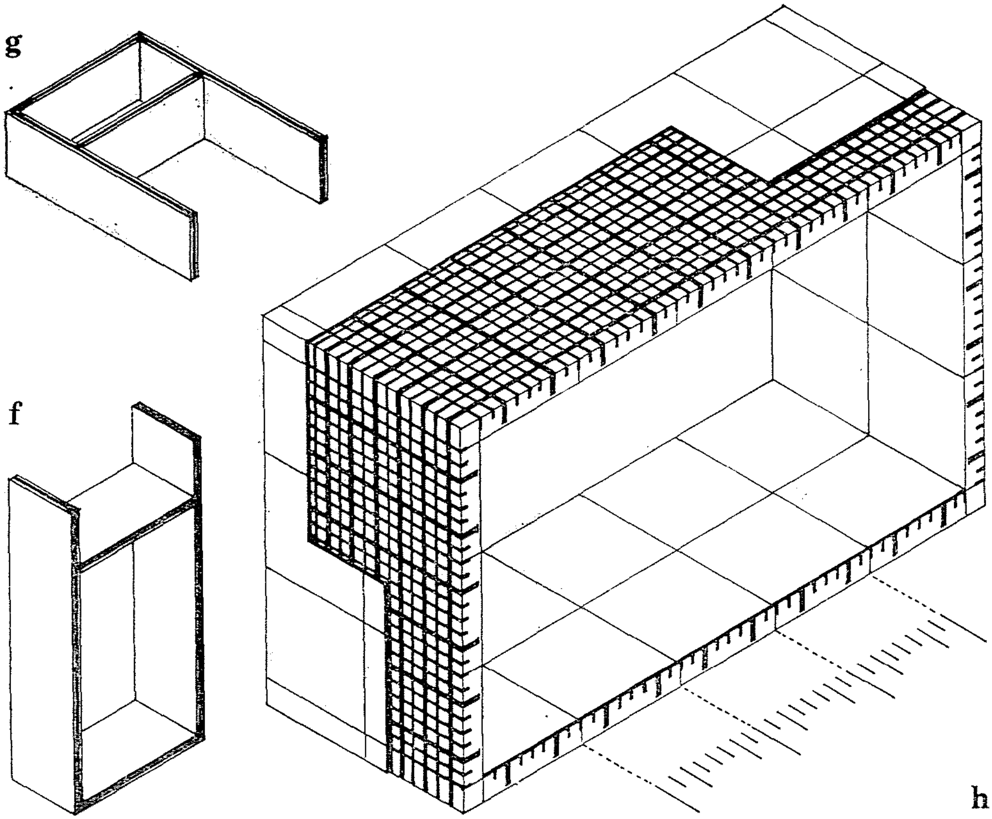
gypsum + reinforced concrete); according to the *method of forming* the element can be plane, profiled, periodic, perforated, etc.; according to the *geometrical shape* it can be a plane element or a space element, finally, according to the *functional designation* it can be a wall-, pillar-, beam-, floor-, or cell element. (Let us mention finally, that in the non-tectonic building the elements applied — according to their *overall dimensions* — can be small size or large-size. In case of plane elements an element is called *small-sized* if both its widths and length stay below the parameter size, whereas *large-size* elements are of parameter size at least in one direction. In case of space elements an element is called *small space element* if it is of parameter size at least in one direction, whereas a *large space element* is of parameter size in two directions.)

According to this the basic elements of non-tectonic systems are as follows:

The Gutenberg-principled non-tectonic surface elements

a) Plane polystyrene basic element; b) polystyrene basic element periodic on the one side; c) polystyrene basic element periodic on both sides; d) plane basic element composed of two materials (polystyrene + gypsum) for freezing concrete from inside; e) plane gypsum surface element for walls, pillars and beams; f) profiled gypsum surface element for walls, pillars, beams; g) periodic gypsum surface element for walls and floors; h) periodic gypsum surface element for floors with heat storing register; i, j) periodic surface element composed of two materials (polystyrene + gypsum) for walls and floors; k, l) periodic closed cellular gypsum surface element for walls and floors, etc.

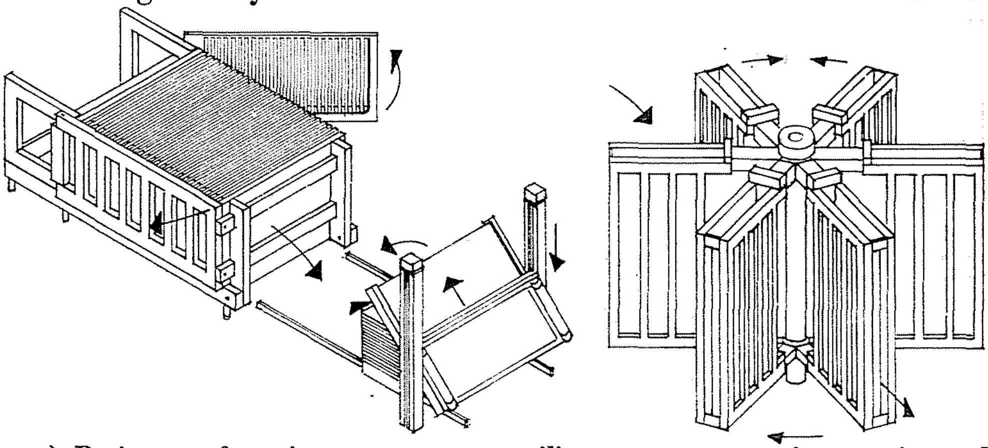
The mechanization-principled tectonic structural elements



The mechanization-principled tectonic structural elements

a) Tissue-structural exterior wall element (plane element) composed of two materials (gypsum + reinforced concrete); b) tissue-structural exterior-wall element (plane element) composed of three materials (polystyrene + gypsum + reinforced concrete); c) tissue-structural floor element (plane element) composed of two materials (gypsum + reinforced concrete); d) tissue-structural floor element (plane element) composed of three materials (polystyrene + gypsum + reinforced concrete); e) closed cellular anisotropic floor slab (plane element) with ribs in two directions rigidified with a membrane, composed of two materials (gypsum + reinforced concrete); f) pillar box frame unit (small space element) composed of two materials (gypsum + reinforced concrete); g) beam box-frame unit (small space element) composed of two materials (gypsum + reinforced concrete); h) cell unit (large space element) composed of three materials (polystyrene + gypsum + reinforced concrete), etc.

Manufacturing apparatuses for producing surface elements
a. casting battery **b. carrousel**



g) Basic manufacturing apparatuses, auxiliary structures, storing, moving and lifting equipments of the non-tectonic systems

Basic manufacturing apparatuses of the non-tectonic systems and their classification

It is quite obvious that in the non-tectonic building the basic manufacturing apparatuses applied depend first of all on the type of the ilements to be produced, consequently, they have to be classified on the one hand according to the principle of disintegration, on the other hand according to the method of manufacture.

According to the *principle of disintegration* we may distinguish two main groups of manufacturing apparatuses, that is: *apparatuses for manufacturing Gutenberg-principled non-tectonic surface elements* and *apparatuses for manufacturing mechanization-principled tectonic structural elements.* As far as the *method of manufacture* is concerned within these two main groups:

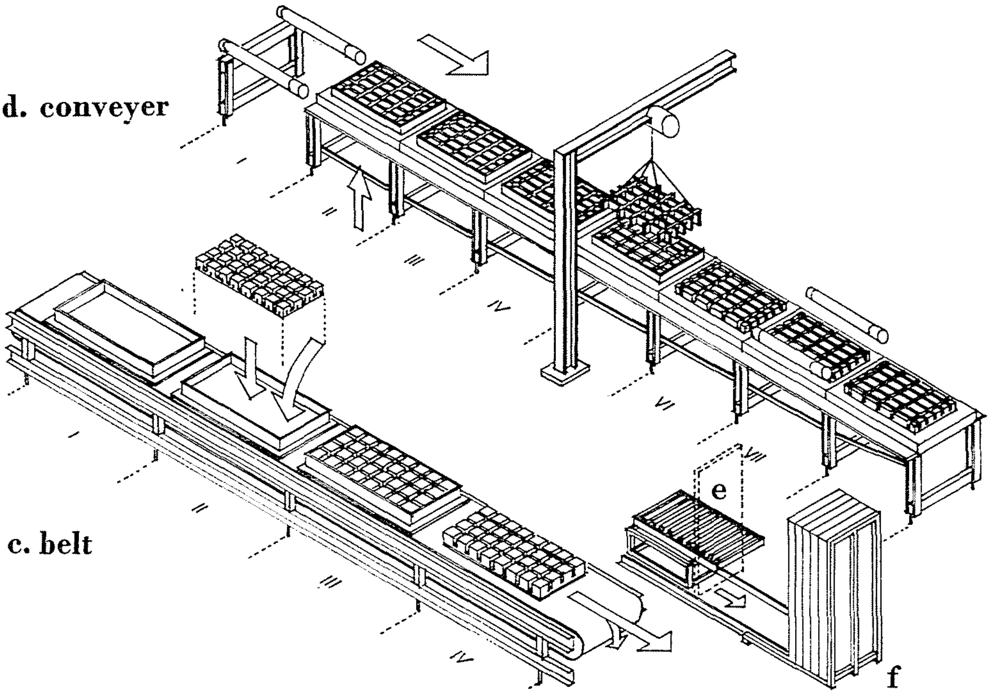
In case of *manufacturing surface elements* (in the course of which process — as we have already seen — we always produce the total system of non-tectonic bricks necessary for the realization of the buildings) the types of apparatuses may range from simple tilting tables (used for individual manufacture of surface elements) through machines supplied with rolling pouring plates up to the apparatuses working on the principles of battery, assembly line, conveyer belt or carrousel (used for mass-production of surface elements), whereas in case of *manufacturing structural elements* the range extends from the simple reinforcing-concreting apparatuses (used for even individual manufacture of tectonic plane elements) up to apparatuses working on the principles of stackplate, stack-frame or tilting stand (used for mass-production of structural elements).

From the aforesaid it becomes obvious that in the non-tectonic systems the applicable manufacturing apparatuses — as far as their degree of complexity, principle of operation, production costs, planned life-span, etc. are concerned — cover an exceedingly wide range. This fact may be led back to two main groups of reasons:

— on the one hand to the fact that the manufacturing apparatuses do not simply depend on the building method, but, at the same time, they directly depend on the degree of complementarity and the technological relevance of the chosen building method, and on the volume, quantity, quality, etc. of the buildings to be produced;

— on the other hand to the fact that the products of the non-tectonic building may cover the total range of industrialized building, starting from individually produced indi-

Manufacturing apparatuses for producing surface elements



vidual products, though mass-produced mass-products, up to individual products produced by methods of mass-production, so *this* is the actual range to be covered by the manufacturing apparatuses. For our examples we chose this latter case, so — supposing mass-production of individual products — the possible types of basic manufacturing apparatuses are as follows:

Manufacturing apparatuses for mass-production of Gutenberg-principled non-tectonic surface elements

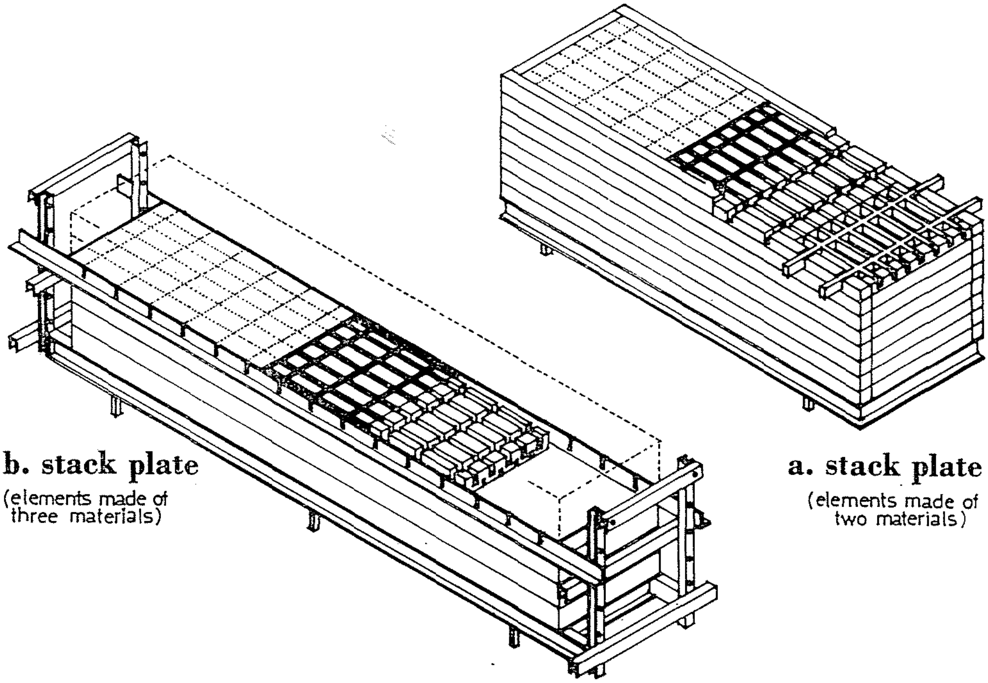
a) *The casting battery.* The manufacturing apparatus is actually a mould constructed of linear bars and plates, closed by pressure. In case of the casting battery illustrated in the figure, the necessary closed mould is realized through opening side doors, pressed to the back plate and closing frame (in this case as an additional unit of the battery a special trolley is used for the mechanical removal of the elements).

b) *The carrousel.* The manufacture is realized here through mould boxes, each constructed of a pair of doors closed by pressure, assembled on six cantilevers and rotated around a central vertical axis. manually or mechanically.

c) *The belt.* The manufacture is realized here with frames constructed of linear steel forming profiles, placed on an endless drum-driven rubber belt, also serving as a pouring plate.

d) *The conveyer.* The elements are manufactured here with moulds constructed of forming profiles, placed on a rigid pouring board, rolling on a rollertrack and driven by a pneumatic working cylinder. After removal of the element the pouring board rolls back to underneath position I. on a slanting lower track. (In both cases the apparatuses are supplemented with a tilting board (e) moving on rails between the belt or conveyer and the container, used for tilting the manufactured element into vertical position, moving it to the container and putting it down.)

Manufacturing apparatuses for producing structural elements

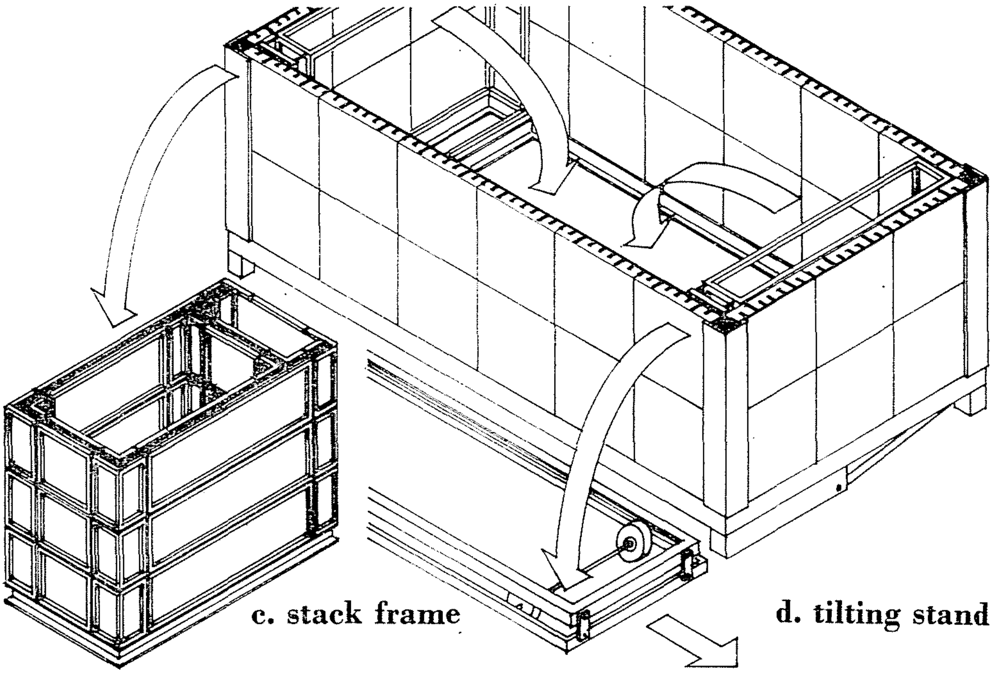


Manufacturing apparatuses for mass-production of mechanization-principled tectonic structural elements

a) *Stack-plate for producing tectonic wall or floor plane elements composed of two materials (gypsum + reinforced concrete).* Its characteristic parts are as follows: the *bottom plate:* a three-functional pouring board used for manufacturing, storing and moving; a rigid plane frame constructed of linear steel profiles stiffened with ribs, covered with a steel plate, standing on four or six "legs", used for manufacturing appr. 10 elements on top of each other; *side profiles:* placed on top of the bottom plate, adjusted to its perimeters and also jointed to each other for forming first the gypsum and then the concrete; *forming grids:* regainable "keys" to shape the two-way channel system of the periodic gypsum elements; *co-ordinators:* linear steel profiles supplied with a periodic hole system for exact location of reinforcing wires within the channels; and finally the "foils" for separating the elements from each other. The apparatus itself is used in a *transplantable factory*, the geographic relevance of the technology applied, namely, is connected with arid tropical or subtropical areas.

b) *Stack-plate for producing tectonic wall or floor plane elements composed of three materials (polystyrene + gypsum + reinforced concrete).* The apparatus itself is used in a planted factory and produces appr. 5—6 elements on top of each other. Its characteristic parts are as follows: the *bottom plate:* (basically corresponds to the bottom plate expounded in a); *co-ordinating frames* jointed to the bottom plate, supplied with periodic holes to determine the thickness of elements and to fix the side profiles; *bridges* to support the side profiles, and finally the separating foils. In this case only concreting is done on the stack, the polystyrene-gypsum surface elements are produced on a belt or a conveyer.

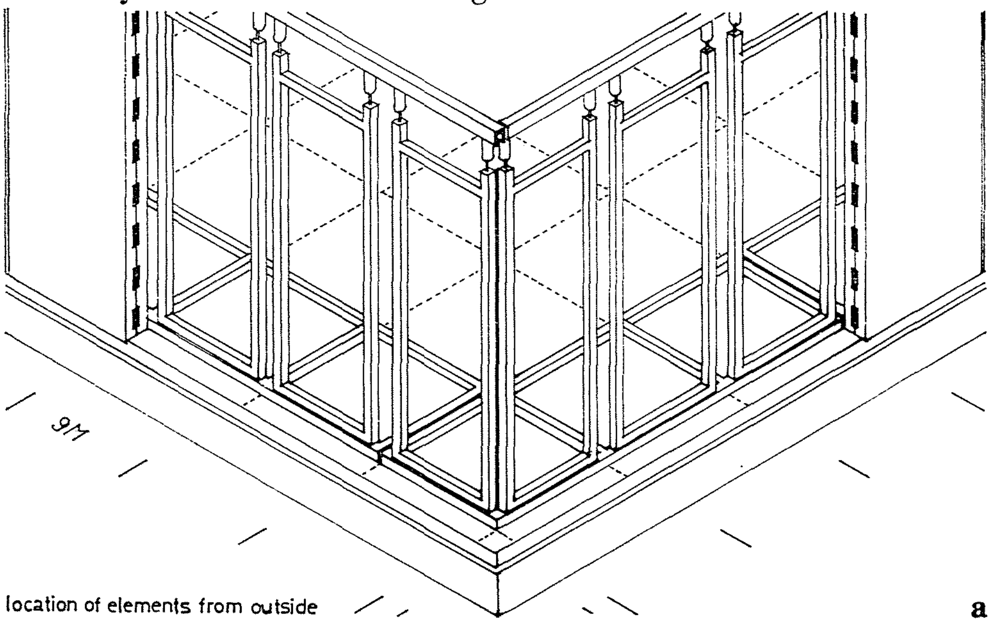
Manufacturing apparatuses for producing structural elements



c) *Stack-frame for producing tectonic small box-units for pillar box-frames or beam box-frames composed of two materials (gypsum + reinforced concrete).* The apparatus is used in a transplantable factory and produces appr. 3—4 units on top of each other. Characteristic parts: the *bottom frame* is again a three-functional steel frame; *forming frames,* that is empty steel frames for temporary supporting and fixing the plane or profiled gypsum surface elements for pillars or beams; and finally the different clips to keep the elements and reinforcement in proper position.

d) *Tilting stand for assembling box units in the factory.* The box units are assembled from factory-produced plane tectonic elements composed of three materials (polystyrene + gypsum + reinforced concrete) in a position turned by an angle of 90 degrees. This means that the floor elements resting on their span-directional edge are in a vertical position on the tilting stand. Thus the beams uniting the walls and the floors into a monolithic box unit are also in a vertical position on the tilting stand. After the hardening of the reinforced concrete beams, the box unit is tilted into a "normal" position onto a transporting carriage and moved to the storing place. The characteristic parts are as follows: bottom frame with fixed "legs"; hydraulic working cylinder; convertible cross-beam; turnable adjusting frame; and finally the transporting carriage (independent of the tilting stand). *The factory is planted.*

Auxiliary structure co-ordinating from inside



a

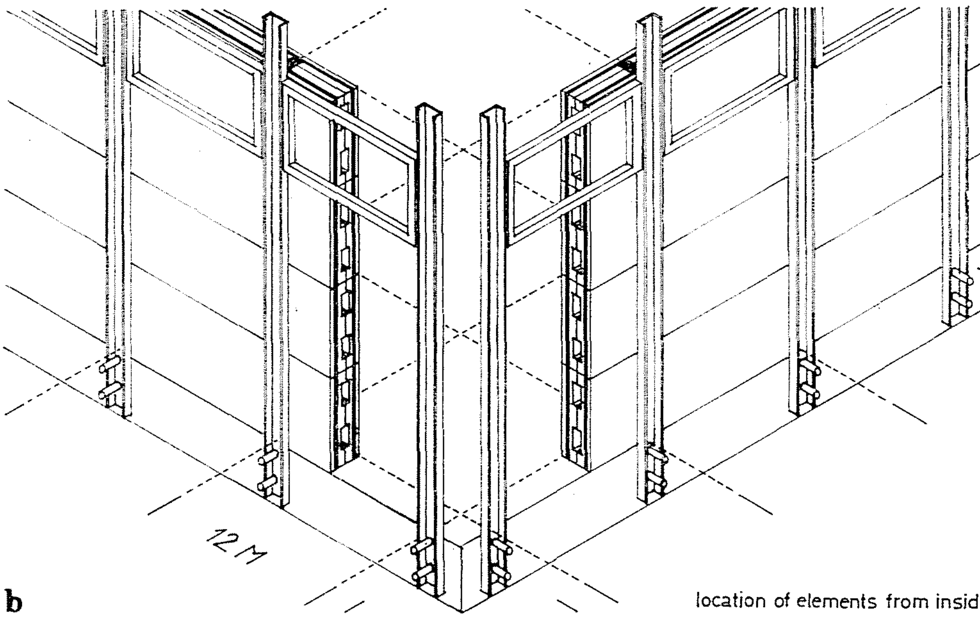
Basic auxiliary structures of the non-tectonic systems and their classification

To start with the definition: the auxiliary structure is a system, more accurately, a co-ordinated system of auxiliary elements used in the non-tectonic building process for adjusting, bracing, supporting, propping up etc., and its prime function — as we have seen — is to keep the non-tectonic *surface* elements (which in themselves have no carrying capacity and no immediate stability) in exact, proper position during pouring in and, occasionally, hardening of the concrete. Thus the auxiliary structure is a means for building, a means through which the additivity of surface elements becomes technically realizable on the building site.

Non-tectonic building as a process is based on the principle of double-additivity (that is additivity equally applicable in the factory and on the building site). In case of additivity applied in the factory the auxiliary structures are regainable at all events without exception, and as such they may become organic parts of the apparatuses for manufacturing mechanization-principled tectonic structural elements, and that is the reason why they were dealt with there and, consequently, in the following by auxiliary structure we shall always mean auxiliary structures applied on the building site.

In case of additivity applied on the building site the choosable auxiliary structures depend on the one hand on the quality, quantity and volume of the buildings to be erected, on the other hand on the chosen primary structures (walls, pillars, floors, etc.) and their forms of construction (e.g. straight unbroken walls, folded shell pillar, beamgrids, etc.), and as such they may again be of an extremely wide range as far as their degree of complexity, production costs, planned life-span, etc. are concerned.

Auxiliary structure co-ordinating from outside



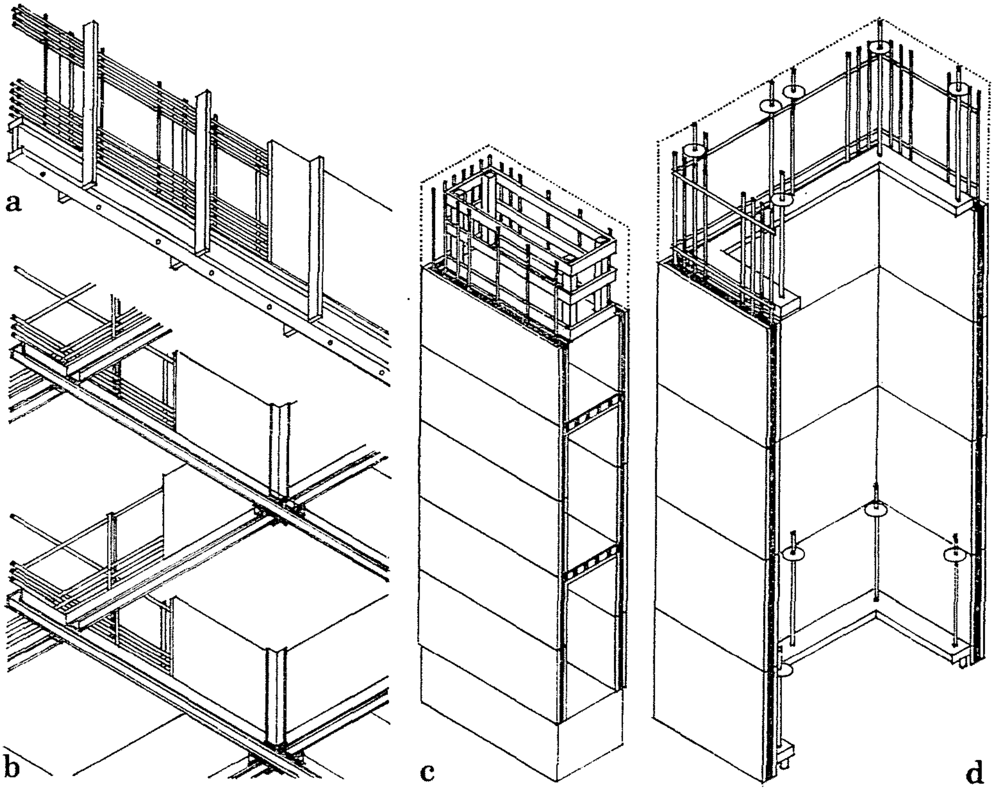
b location of elements from inside

According to the *material* applied the auxiliary structure can be made of wood or metal; according to the *geometric shape* of its elements it can be constructed of *linear*, *plane* or *space* units; according to the *way of application* it can be *lost* or *regainable;* according to *function* it can be *onefunctional* (e.g. used only for supporting) or *multifunctional* (e.g. used for determining a plane, adjusting a height and for supporting) or *function-changing* (e.g. used as auxiliary structure for keeping wall elements and reinforcement in position during the erection of the structure and becoming a curtain wall in its final stage; or used as auxiliary structure in the course of erection of walls and becoming wall reinforcement in its final stage); according to the *method of co-ordination* it can be a) *co-ordinating from inside* (e.g. determining the interior plane of an exterior wall); or b) *co-ordinating from outside* (e.g. determining the exterior plane of a wall); finally according to *designation* it can be an auxiliary structure used for determining the place for foundations, for erecting walls, pillars, floors, etc.

From what was hitherto said it becomes clear that the auxiliary structures applied in the non-tectonic building will depend on the one hand upon the type of operations on the building site (foundation, erection of wall, pillar, floor, etc.), on the other hand upon the forms of the structures applied (unbroken, tissue-structural wall, floor, reinforced concrete frozen shell pillar, beam, beam-grid, etc.). This is a very important statement, because hence it directly follows that the auxiliary structures do not depend on the building method itself, but *depend immediately on the degree of complementarity of the chosen building method;* it calls for no proof, namely, that the higher the degree of complementarity in the factory (i.e. the higher the ratio of the additivity in the factory to the total building volume), the less the demand of auxiliary structures on the building site.

Up to the zero level of co-ordination each building method, without exception, applies auxiliary structures for the foundation and, occasionally, "etalon" (sample) auxiliary structures for determining the exact position of the vertical structures. The need for auxiliary structures reaches its maximum in the in-situ building methods of low degree of complementarity, whereas in the box unit or box-frame unit building methods — characterized by

Auxiliary structure as an attached subordinated subsystem



a high degree of complementarity — it may be reduced to a minimum or even totally eliminated. In this latter case the volume of auxiliary structures integrated with the manufacturing apparatuses increases, as a matter of course.

The auxiliary structures for erecting walls, pillars, beams, beam-grids, floors, etc. can be made independently of each other, in this case the auxiliary elements are individual, and operate as an *attached subordinated subsystem*, but they can also be made in close connection with each other, in which case the auxiliary structure is a coherent *self-reliant*, *co-ordinated system*. These constitute the two basic groups of the auxiliary structures and in our examples we tried to illustrate both cases properly.

It can be stated with a general validity that the bigger the volume of auxiliary structures needed in the process of building, that is to say, the lower the degree of complementarity of the building method, the more it becomes expedient to aim at conceiving the auxiliary structures as a self-reliant co-ordinated system. The following cases were chosen as examples:

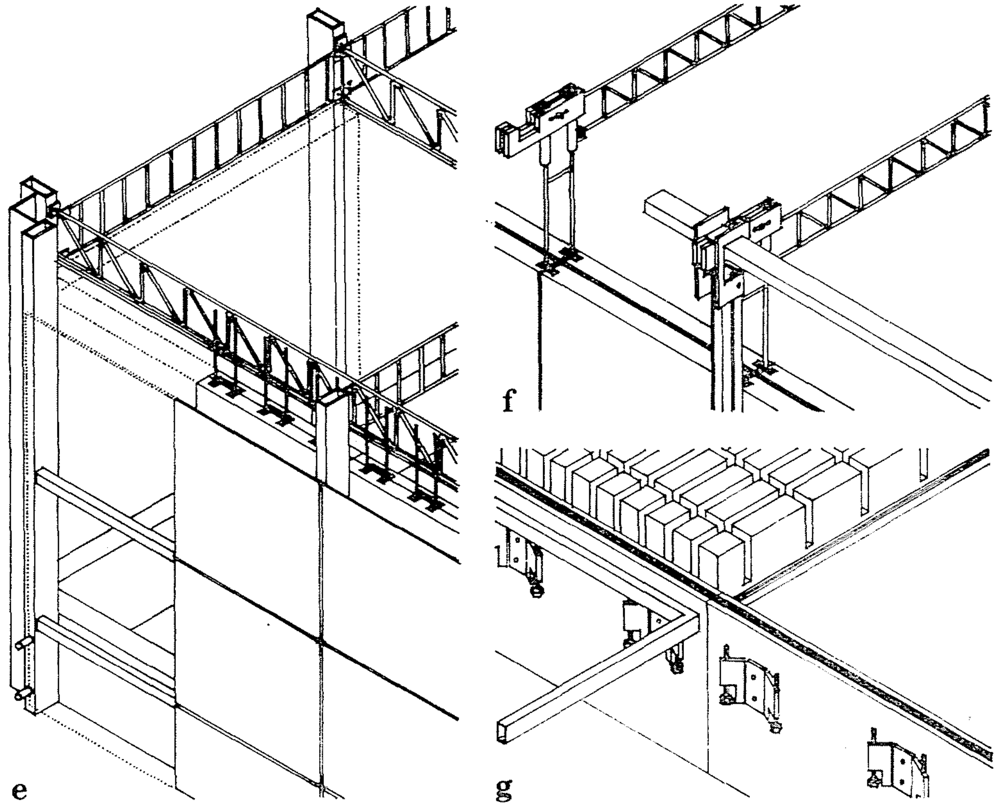
Auxiliary structure as an attached subordinated subsystem

a) Linear, multifunctional (plane determining, supporting and reinforcement co-ordinating) regainable auxiliary structure made of wood (detail, seen from below).

b) The same, made of steel profiles (detail, seen from below).

c) Auxiliary structure made of wood, used for erecting folded shell pillars by rows;

Auxiliary structure as an attached subordinated subsystem



this regainable, multifunctional (plane determining, thickness determining, reinforcement co-ordinating) structure with its tongues that can be pushed out rests immediately on the surface elements.

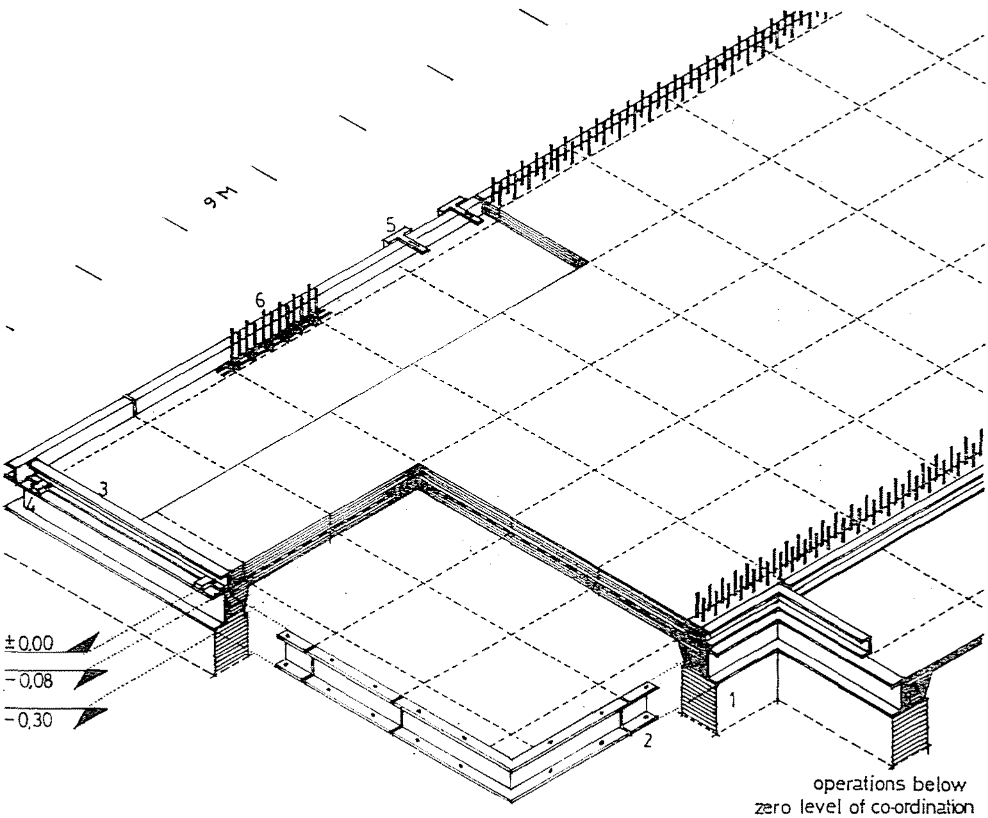
d) The same made of aluminium.

e) Function-changing auxiliary structure for erecting walls, made of aluminium; while erecting the primary structure the closed rectangular profiles perform the function of determining the plane of the wall and co-ordinating the reinforcement, whereas later on as lost (built-in) structure they act as a curtain wall.

f) Function-changing auxiliary structure for erecting walls, made of steel; in the course of erecting the walls the plane-determining, regainable special steel cantilevers are here immediately mounted on top of the preassembled reinforcement, the vertical reinforcement of the ribbed r.c. shell walls is co-ordinated by heterogeneous jointing points embedded into the foundation, the auxiliary structure precisely determining the plane of the wall is constructed of linear profiles and is regainable, whereas the reinforcement to which it is fixed becomes a part of the final structure, as a matter of course.

g) Auxiliary structure for floors, made of steel; the frames constructed of closed rectangular profiles are here supported by "winged" steel pieces, fixed through a system of periodic holes built into the reinforced concrete shell walls or beams, these "winged" steel pieces serve at the same time for adjusting the exact lower plane of the floors as well.

Auxiliary structure as a self-reliant, co-ordinated system

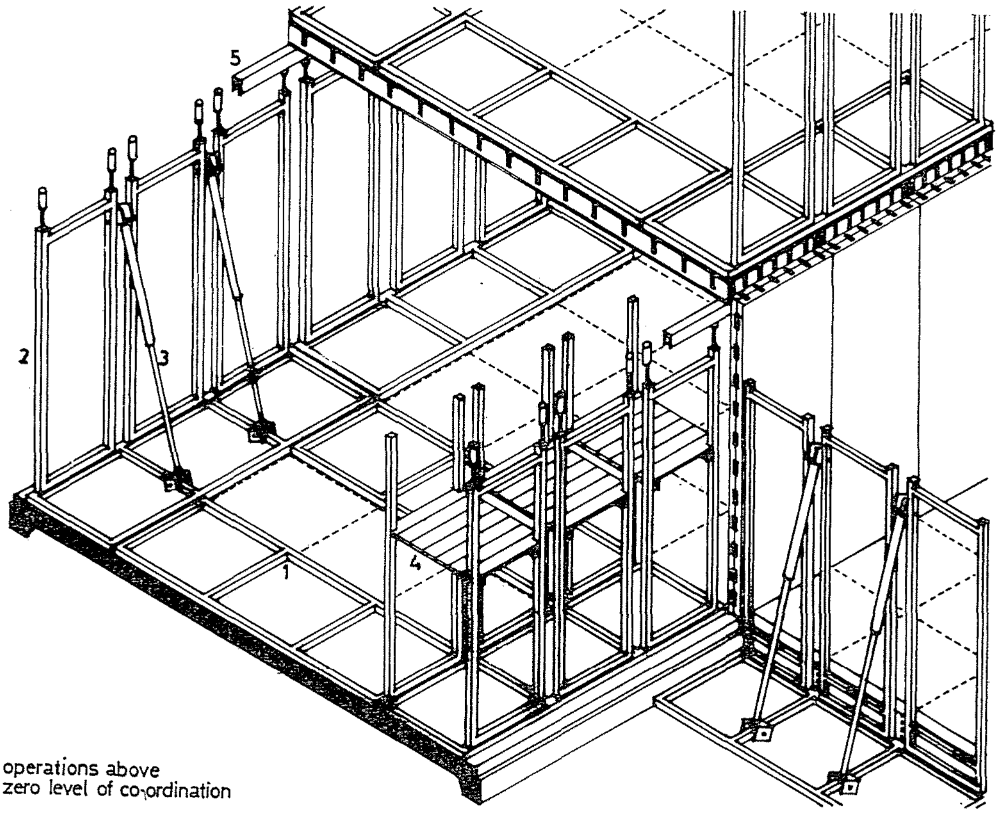


Auxiliary structure as a self-reliant, co-ordinated system

a) *Auxiliary structures for operations below zero-level of co-ordination.* Formwork (2) starting off from an unprecise foundation (1) constructed of U-profiles, supplied with a system of periodic holes, composed of linear and corner elements; and another formwork (3) connected with it for precise determination of the outline and upper plane of the zero-level of co-ordination, also constructed of U-profiles and composed of linear and corner elements, finally the supplementing pieces for jointing, adjusting, fixing and the reinforcement co-ordinators (5) for precise positioning of the "needles" (6) anchoring the vertical reinforcement of the tissue.

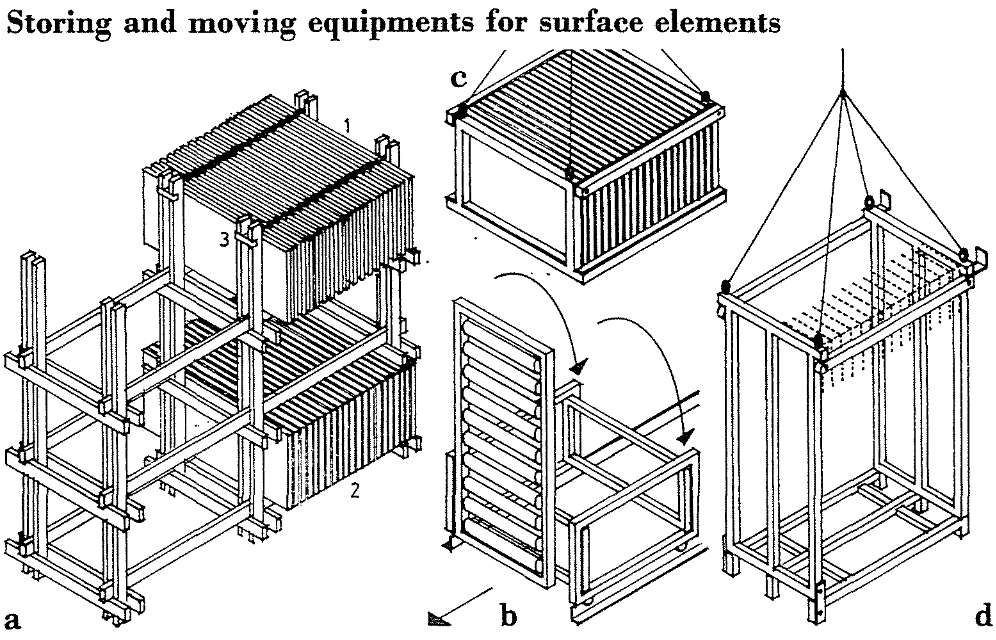
b) *Auxiliary structures for operations above zero-level of co-ordination.* Basic "etalon" frames of different overall dimensions constructed of □-profiles (1), assembled on the zero-level of co-ordination or on the upper level of the floors, for marking out the secondary grid system (that is the system of grids determining the location of wall and floor elements); auxiliary frames for erection of walls (2) adjoined to the periodic holes of the basic "etalon"

Auxiliary structure as a self-reliant, co-ordinated system



frames with strutting rods (3) to adjust the vertical plane of the walls; auxiliary frames for building (4) adjoined to the periodic holes of the "etalon" frames and the wall frames; and finally the co-ordinating bars (5) for determining the lower plane of the floors, the exact level of which is assured by the supporting cylinders (6) screwed out from the wall frames.

The auxiliary structure constructed as a self-reliant co-ordinated system enforces, of course, the principle of "etalon"-tolerance in the process of assembly, since it assumes the system of auxiliary structures as "ideal", which means that it accepts the actual dimension arising as a result of the closed alignment of the basic "etalon" frames as exact required total dimension, be it as it is. From this it clearly follows that in such a case, in the manufacture (and consequently also in the assembly) of the non-tectonic surface elements or tectonic structural elements we have to work, as a matter of course, with "minus-tolerance", in other words, we have to establish a manufacture, where the actual dimensions of the elements are always smaller than their theoretical (nominal) dimensions.



Basic storing and moving equipments of the non-tectonic systems

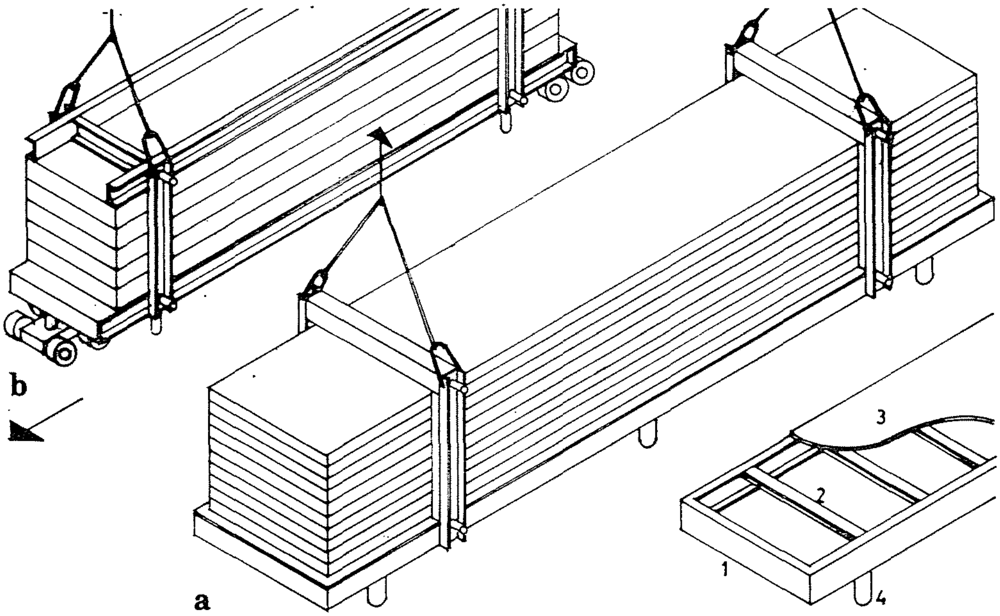
In the non-tectonic building the basic storing and moving equipments applied can be simultaneously classified on the one hand by the *principle of disintegration*, on the other hand by the *method of moving*. By the principle of disintegration we may distinguish two main groups: a group for storing *Gutenberg-principled* non-tectonic surface elements, and another one for storing *mechanization-principled* structural elements. Now, as concerns the *method of moving*, this will obviously be in direct connection on the one hand with the operations *in the factory*, more accurately in the planted or in the transplantable factory, on the other hand with the operations *on the building site*, consequently the storing and moving equipments, in this sense, may create a system closely interrelated with one another, or occasionally, integrated with the very manufacture, since they have to deal with the most different forms of moving, on the one hand *within the factory*, on the other hand *between the factory and the building site*, and finally *on the building site* itself. It is not by chance therefore that the storing and moving equipments, as regards form, dimensions, material, solutions, production costs, degree of complexity etc., may move on the same exceedingly wide range as the elements or their manufacturing apparatuses — as already expounded previously. Finally it seems important to mention here that, naturally, this enumeration does not include moving equipments, which — although participating in the act of moving — are independent of the elements and structures, and the various fork-lifts, lifting drums, overhead trolleys etc. serving for different purposes.

By reason of the aforesaid the basic storing and moving equipments are as follows:

Storing and moving equipments for the Gutenberg-principled non-tectonic surface elements

a) *Storing stands:* one-functional equipments serving only for storage, empty frames constructed of linear wooden or steel profiles on the principle of stack for "loose" (1) or

Storing and moving equipments for structural elements



"dense" (2) storing of plane or profiled gypsum surface elements. In case of "loose" storing the necessary minimum spacing between plane elements is assured by fastening clips, whereas in case of "dense" storing this minimum spacing is enabled by "nipples" manufactured into the surface elements.

b) *Tilting board:* multifunctional equipment used for removing the periodic surface elements from the belt or the conveyer, tilting them into vertical position, then moving them on rails to the container and putting them down.

c) *Containers:* two-functional equipment used for storing and moving; empty space-frames constructed of linear steel profiles and plane frame-units for "dense" storing of different plane elements and for moving them within the factory, between the techory and the building site and on the building site.

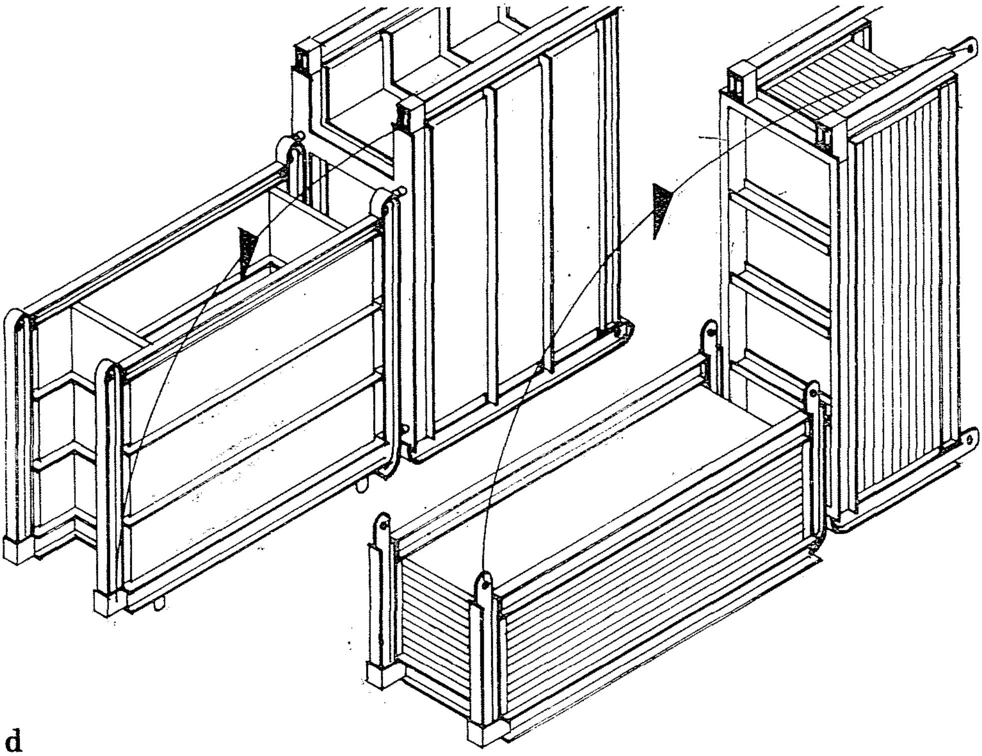
d) *Containers:* empty space-frames identical with c) as regards their function; serving for "dense" storing of periodic gypsum wall and floor elements or periodic polystyrene-gypsum wall or floor elements, for moving them within the factory, between the factory and the building site and on the building site.

Let us remark finally that the different transporting carriages, positioning frames etc. not illustrated in figures also belong here.

Storing and moving equipments for the mechanization-principled tectonic structural elements

a) *Bottom plate for floor elements composed of two materials.* Let us start here with the definition: the bottom plate is a three-functional equipment, used for manufacturing, storing and moving; a rigid plane frame constructed of linear steel profiles (1), stiffened with ribs (2), covered with a steel plate (3), standing on four or six "legs" (4) as we have already seen. The large size floor elements composed of two materials (gypsum + reinforced concrete) are

Storing and moving equipments for structural elements



d c

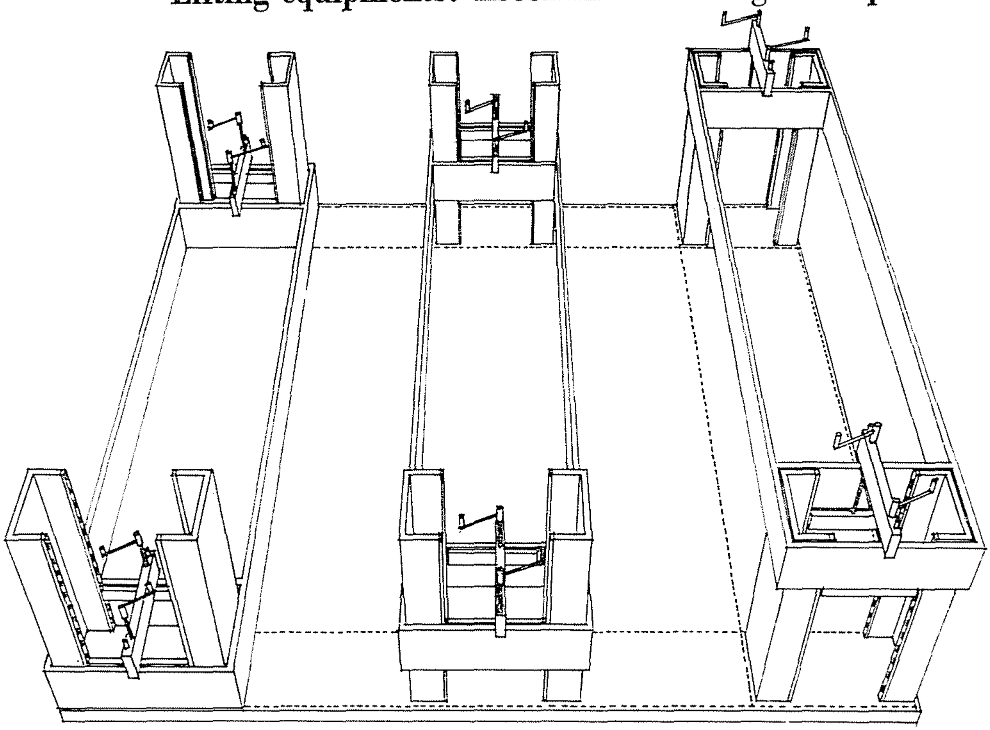
produced in a *transplantable* factory, the stack containing appr. ten elements is placed with a *lifting frame* on a truck which carries it to the neighbouring building site.

b) *Bottom plate for floor elements composed of three materials.* A three-functional bottom plate, basically identical with a), used for manufacturing, storing and moving; within the *planted* factory the stacks containing appr. 5—6 elements are moved by independent under-carriages, for placing it on a truck a *lifting frame* is used.

c) *Tilting bottom plate for wall elements composed of two materials.* Four-functional equipment for manufacturing, storing, moving and tilting into vertical position. The bottom plate itself is basically identical with the above said, the additional part of the equipment is the *tilting frame,* bolted to the bottom frame at right angle, serving for protecting the large size wall elements produced in a transplantable factory from slipping and toppling whilst the stack containing appr. ten elements is being tilted and the individual elements are located. The stack lifted with a balance frame is tilted into an almost vertical position on the building site.

d) *Tilting bottom-frame for pillar box-frames composed of two materials.* The equipment itself is basically identical with the abovesaid. On each bottom-frame 3 pillar box-frames can be produced on top of each other. In this case moving within the factory does not occur, for placing the stack on a truck a *lifting frame* is used. On the building site a special *lifting-tilting frame* serves for tilting the pillar box-frames into vertical position.

Lifting equipments: discontinuous lifting with spindle



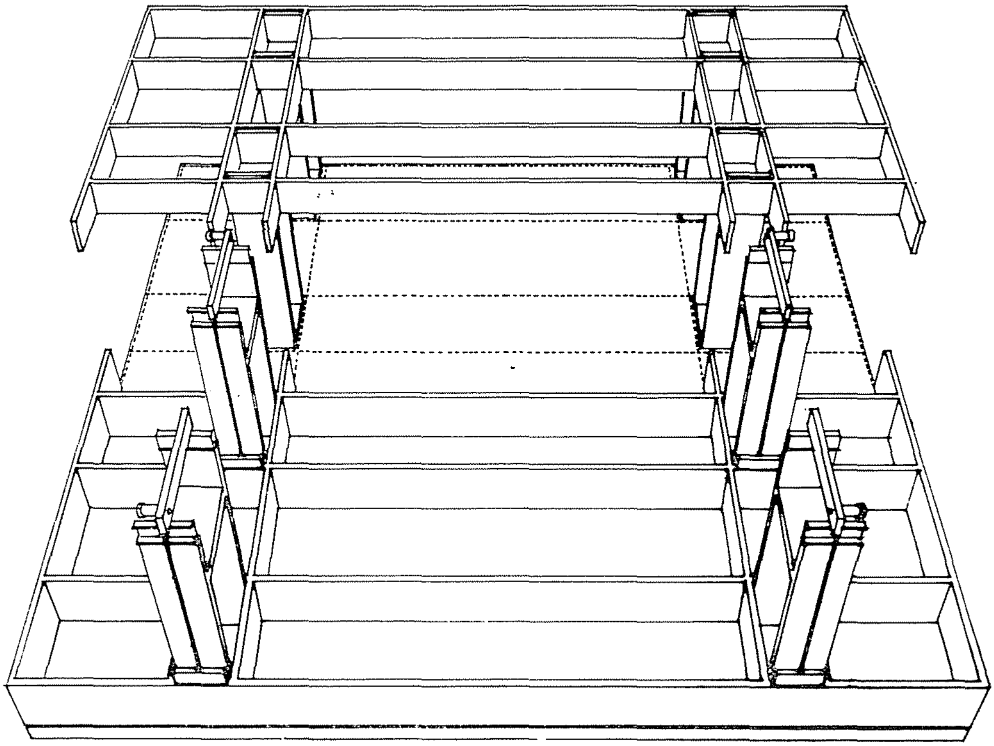
Basic lifting equipments of the non-tectonic systems

The lifting equipments applied in the non-tectonic building can be divided into two characteristic groups. On the one hand into equipments *independent of the structure* which thus, theoretically, can be applied in any other building method, on the other hand into those *integrated with the structure* which therefore — exclusively and specifically — are bound to the non-tectonic systems and cannot be separated from them. Our study evidently deals with this latter group, only.

Speaking of the lifting operations occurring in the non-tectonic building, however, we cannot be contented with a sheer classification of the applicable equipments, since this in itself does not answer the question most important for us, namely, *what makes lifting specific* in the non-tectonic building, and so it does not mark off the boundary lifting can occupy within the system.

It is known — and this has been proven both scientifically and practically by our experimentations — that the *non-tectonic building leads to calling into being the lightest structures producible on the silicate basis.* This is why particularly in case of building methods of low degree of complementarity — that is of low degree of readiness in the factory — there opens such an extremely wide range for the *manual moving, locating, lifting of small size, light-weight elements*, for which there is no precedent in the industrialized building. The Gutenberg-principled disintegration, the maximum reducibility of the weight of structure through reduction in material, the rich variety of the cellular and microcellular forms offer an almost

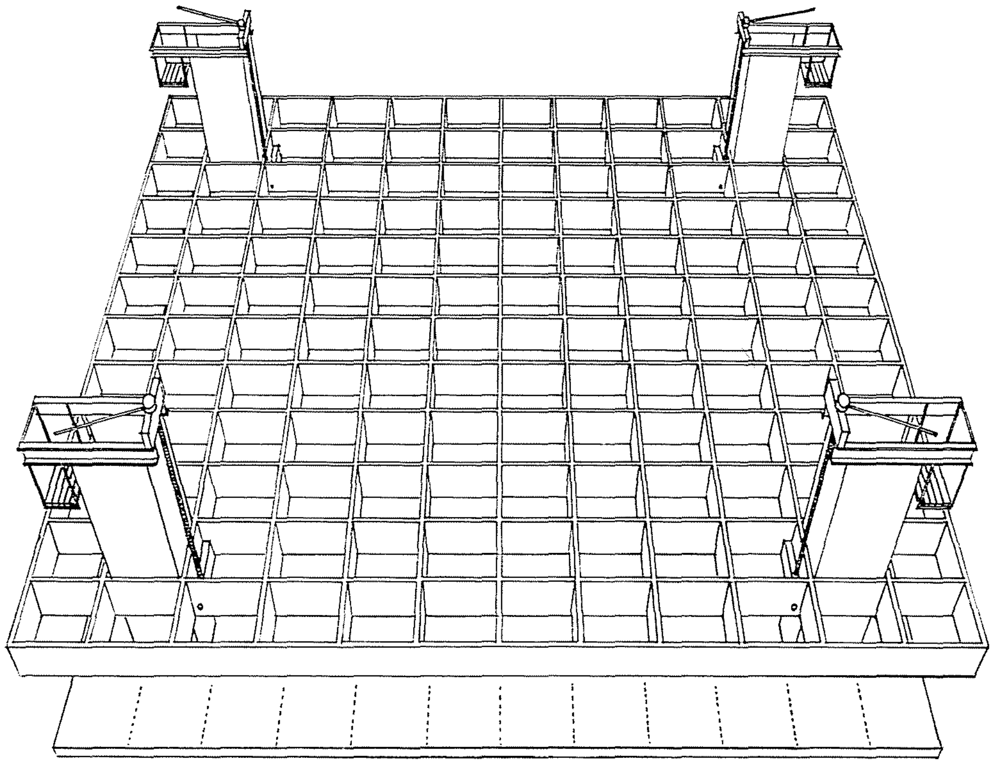
Lifting equipments: continuous lifting with flat-link chain



boundless possibility of producing elements that can be amnipulated even by hand, since by virtue of their dimensions, forms, volumes they do not surpass the lifting capacity of two or four persons. Even if in some cases occasional auxiliary tools are applied for moving, locating or lifting these elements, they still remain on the level of simple tools, because they are very light, can be placed by hand and manually operated, so they do not bear the marks of lifting equipments. Thus *in the non-tectonic building methods of low degree of complementarity lifting equipments are not required yet.*

The *other speciality* of the lifting operations in the non-tectonic building directly follows from the abovesaid, namely, that even the *lifting equipments independent of the structure are actually specialized for moving only small volumes*, since even the large size tectonic plane elements or small box units (i.e. wall or floor elements, pillar box-frames, beam box-frames of parameter size in only one direction) do not surpass in weight one — one and a half ton, whereas moving or lifting elements of four-six tons can only occur in the box unit building method of high degree of complementarity. There is only one step to the *third speciality:* in those cases, namely, where the point precisely is to lift expressly big volumes, structural elements of 10—40 tons, *the non-tectonic system renders the very building method specific from the point of view of lifting, and — through integration of the lifting equipments with the vertical loadbearing structure itself —* it calls into being specific lifting building methods in which the horinzontal loadbearing structures of large area and big weight —;the different "linear" grid-units or "plane" field-units — are built exactly underneath the in-situ position and in which the *lifting of structures of big volume can be carried out "without momentum" and even by hand hrough mechanical transmission.*

Lifting equipments: continuous lifting with spindle



For our examples cases of the lifting building methods were chosen and in the following the specific lifting equipments *integrated with the structure* will be introduced with the respective non-tectonic lifting methods:

a) *Discontinuous lifting with spindle.* Empty linear grid—unit built underneath the in-situ position lifted discontinuously with spindle; the regainable leading rails are bolted to the in-situ built pillars (lift-grid I.).

b) *Continuous lifting with flat-link chain.* Grid unit built underneath the in-situ position, stiffened, if necessary, by floor elements, lifted continuously with flat-link chain driven by a hydraulic hoisting motor; the lifting equipments are fixed on top of the in-situ pillars (lift-grid II.).

c) *Continuous lifting with spindle.* Empty beam-grid (field-unit) built underneath the in-situ position lifted continuously with spindle, driven by hand through mechanical transmission; the lifting equipments are fixed on top of the in-situ pillars (lift-field).

h) The process of non-tectonic building: the making of a complementary building method in the factory and on the building site

In the non-tectonic systems building is a complementary operation, that is a process combining the production of surface elements in the factory with a kind of technology of pouring in of concrete either in the factory or on the building site for calling into being structural elements or structures.

Two basic types of the factory

The factory itself — theoretically — can equally be planted or transplantable. Which of the two possible types of the factory shall expediently be chosen in practice and on what level of equipments — this is a question to which a correct answer can only be given on the basis of a simultaneous consideration of all the relevant factors, that is, on the one hand the architectural, structural and technological, on the other hand the social, economic and geographic circumstances and requirements. (As a matter of course, the degree of complementarity of the chosen building method does not depend on the type of the factory.)

Types of operations in the factory

Manufacture of surface elements, whereby we produce — in each case without exception, and in every single building method — the total system of non-tectonic bricks necessary for realization of the buildings.

Manufacture of structural elements, whereby we produce — exclusively in building methods of medium or high degree of complementarity — tectonic plane elements or box units. This can be done in three ways. First in such a way that from the non-tectonic surface elements (that is from the plane or periodic gypsum or gypsum-polystyrene surface elements) we call into being a *tectonic plane element* (that is a wall or floor element) with its reinforced concrete microstructure (i.e. the structural tissue) through locating reinforcement within the channels and concreting it; secondly in a way that from plane or profiled gypsum surface elements we assemble *tectonic box-frame units* (pillar box-frames, beam box-frames) whereby we already create an element of the primary structure, or rather, a part of the structural system; finally in a way that from the tissue-structural plane element rendered already tectonic in the factory we assemble *tectonic box units* (space elements).

Types of operations on the building site

Creating the zero level of co-ordination. This operation follows the traditional foundation work and occurs without exception in each building method. Its object actually is on the one hand to determine exactly the zero level of co-ordination proceeding from the unprecise towards the precise through assembly of auxiliary structures of the zero level of co-ordination, and on the other hand to assure precise structural junctions for walls and pillars.

Assembly of auxiliary structures. This operation exclusively occurs in the in-situ and lifting building methods of low or medium degree of complementarity. Characteristic cycles of operations are as follows: *assembly of the basic "etalon" frames* serving for exact determination of the place of walls, pillars etc.; *assembly of auxiliary structures for walls* to assure a temporary bracing and fixing of the surface elements (which in themselves have no carrying capacity and no immediate stability) in a proper in-situ position before, during and, occasionally, after pouring in of concrete; *assembly of auxiliary structures for floors* on the one hand to determine the exact lower level of floors, on the other hand to keep the floor elements supported in in-situ position until the concrete hardens etc.

Assembly of the surface and reinforcement of the structure. The object of this operation is to create the negative of the final loadbearing structure by vertical and horizontal alignment of non-tectonic surface elements and to assure precise location of structural reinforcement. It occurs exclusively in the in-situ and lifting building methods.

Creating the loadbearing structure. Concreting operation, in the course of which the surface elements are united into a primary structure by pouring concrete between, within or on top of them. It occurs exclusively in the in-situ and lifting building methods.

Lifting. This operation exclusively occurs in the lifting building methods and its object is to move the structures built exactly underneath the in-situ position into their final position. The operation is concluded by creating heterogeneous or homogeneous junctions.

Location of structural elements. This operation exclusively occurs in building methods of medium and high degree of complementarity and its object is the location of the factory-produced tectonic structural elements, that is the positioning of the different plane elements, box-frame units and box units.

Final pouring. The operation serves for jointing the factory-produced tectonic structural elements. It only occurs in building methods of medium and high degree of complementarity.

Finally, let us remark that by changing the ratio of the "factory" and "on-site" operations within the total building process, an almost infinite number of technological variations can be created.

References

The publications enumerated below are only those immediately related to the subject matter or referred by the author.

1. Secretariat Paper on World Housing Conditions and Estimated Housing Requirements. U. N. Economic and Social Council Document E/C. 6/13 New York 1963.
2. Recent Trends and UNIDO Activities in the Field of Construction in Developing Countries. UNIDO/IO. 579, 26 March 1984.
3. MYRDAL, G.: Needs Versus Capacity. Towards Industrialized Building. Proceedings of the third CIB Congress, Copenhagen, 1965. Elsevier Publishing Company. Amsterdam, 1965.
4. PÁRKÁNYI, M.: Non-tectonic Systems. Periodica Polytechnica. Arch. *17*, 122 (1973).
5. PÁRKÁNYI, M.: Experimental Non-tectonic Maisonette. Per. Pol. Arch. *18*, 189 (1974).
6. PÁRKÁNYI, M.: "Lift-field" Experimental. Non-tectonic Hall. Per. Pol. Arch. *22*, 21 (1978).
7. PÁRKÁNYI, M.—HAJDU, L.—BARCZA, J.—KÖVESDI, R.—SZIRMAI, Z.: Feasibility Study. An Adaption of the Non-tectonic System to the People's Democratic Republic of Yemen. Manuscript, restricted. 107 pages.
8. GÁBOR, L.—PÁRKÁNYI, M.: Fundamental Questions of Theory of Construction of the Non-tectonic Building (in Hungarian). Publishing House of the Hungarian Academy of Sciences. Budapest 1985. 185 pages.

Dr. Mihály PÁRKÁNYI H-1521 Budapest

Summary

This abundantly illustrated report gives a dense account of a research work carried out in the Institute of Building Constructions, Technical University Budapest since 1971. Our researches and experimentations have led us to the fundamental recognition that tectonics is not the only possible axiom of industrialized building, and our study basically proves that such an axiomatic change is realizable, and that we may open new, hitherto unknown ways of industrialization of building if we break with the axiom of tectonics.