"LIFT-FIELD" EXPERIMENTAL NON-TECTONIC HALL

By

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Introduction

An elaboration by the Author and his team, the experimental hall was completed in 1975, as an integer part and development of the research work done at the Institute of Building Constructions and Equipment since 1971 [1 to 10].

The author is indebted to his consultants: Prof. Dr. LÁSZLÓ GÁBOR, academician; Dr. LAJOS GARAY, structural engineer — and to members of his team (Mr. LÁSZLÓ HAJDÚ, architect; Mr. JÁNOS BARCZA, mechanical engineer; Miss RÓZSA KÖVESDI, architect; Mr. LÁSZLÓ RAJK, architect) for their valuable contribution to the experiment.

Short definition of non-tectonic systems

The presented "lift-field" experimental hall is a product of an open, light-weight, silicate based, non-tectonic building method.

The non-tectonic building method is defined as a specific building process where additivity (the axiom of building) makes use of the non-load-bearing properties and temporary instability of semantically meaningless (Gutenberg-principled) surface units. In this building method, the direct product of manufacture is not the load-bearing structure but its surface. Alignment of surface units of vertical and horizontal structures does not lead to immediately load-supporting, load-transferring (tectonic) joints between the surface units.

Nature and scope of the research 1971 to 1976

At the Institute of Building Constructions and Equipment, many years' research work has been spent on a new, coherent theoretical, technological and economic approach to mass housing for developing countries. Initial research strived to elaborate a theory of construction [1] proving scientifically that in the age of industrial building, the axiom of tectonics — the simple principle of superposing load-bearing members on one another — is not the only possible axiom of building but it has a working alternative. This is how a new, non-tectonic industrial building method, the system of non-tectonic structures, arose.

Success of the first two pilot tests — the experimental non-tectonic structural unit [2] and the experimental non-tectonic maisonette [3] — carried out 1971 to 1973 urged us to solve essential technology problems of different *adaptations* of the system, therefore since 1974, research had two main lines.

The first was the original line of research [4], concerned with adapting non-tectonic systems to low-cost housing in developing countries. It was given significant support by UNIDO which has for some time been in contact with the team of Hungarian experts. The new technology was considered worth of being sponsored by UNDP in form of a pilot plant for labour-intensive prefabrication, and the system to be ripe for testing under actual conditions in a developing country. This was the aim of the author's expert mission in Somalia [6], resulting in lessons and implications fed back to further research involving detailed studies and plans for prototype housing in hot-arid tropical areas [8], [9].

The other line of research was meant as a new phase of experimentation, aiming at the *adaptation of non-tectonic systems to communal buildings*. Partly, previous test results [2], [3] have been made use of, partly the recognition of inherent possibilities of so-called *relative span-indifference*, namely in non-tectonic systems, if surface units of the horizontal load-bearing structure are kept below parameter size, the span is independent of the manufacture: the span is not a question of manufacture but of additive alignment of surface units. From the point of view of technology, this may be a new approach to create large spans required for communal buildings. This is how at last the idea of "lift-field" building method took shape.

Design

The test building — the "lift-field" experimental hall — is an undivided large space, a self-contained structural unit, a non-tectonic cellular construction, of a total area of 284.26 m^2 and a total volume of 1108.61 m^3.

The project was primarily intended to give simultaneous proof both of the relative two-way span indifference of cellular systems, and of the feasibility of the "lift-field" method. By erecting a beam grid structure with large spans and cantilevers in two directions it has been proven that cellular systems built underneath final position can be lifted in final position by hand, through mechanical transmission.

To this aim a structural and technological variation has been elaborated on a system of non-tectonic bricks [10]. The product — the experimental hall — practically proved the adaptability of non-tectonic structures to communal buildings.

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The structural and technological concept was embodied in a simple, single-storey structure, an undivided large space, featuring:

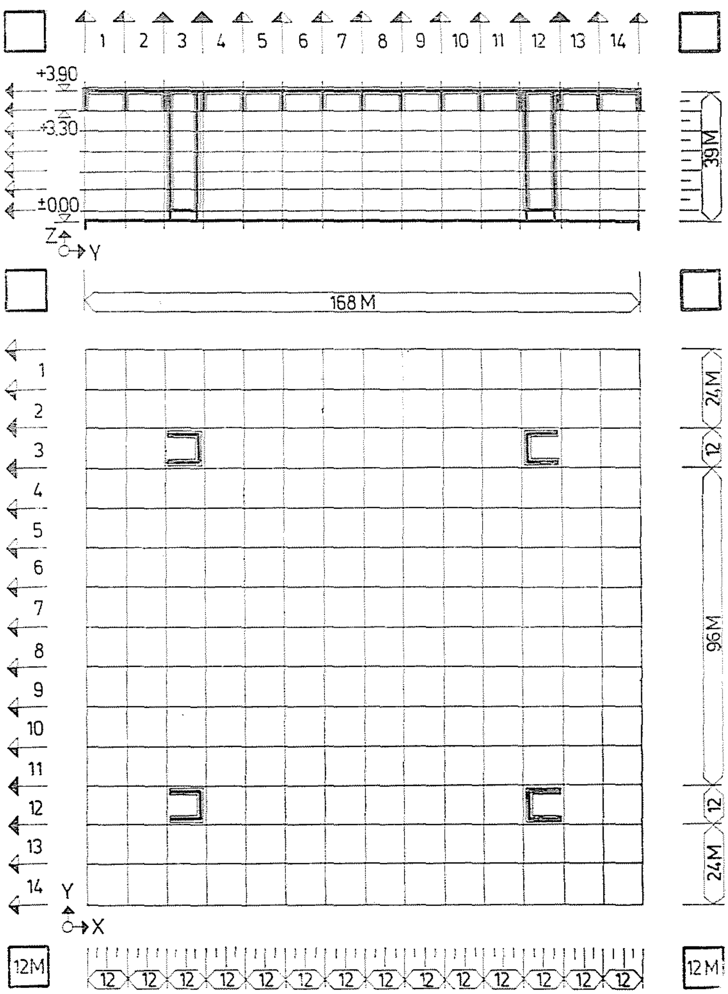


Fig. 1. "Lift-field" experimental building: the system of primary and secondary grids on plan and in section

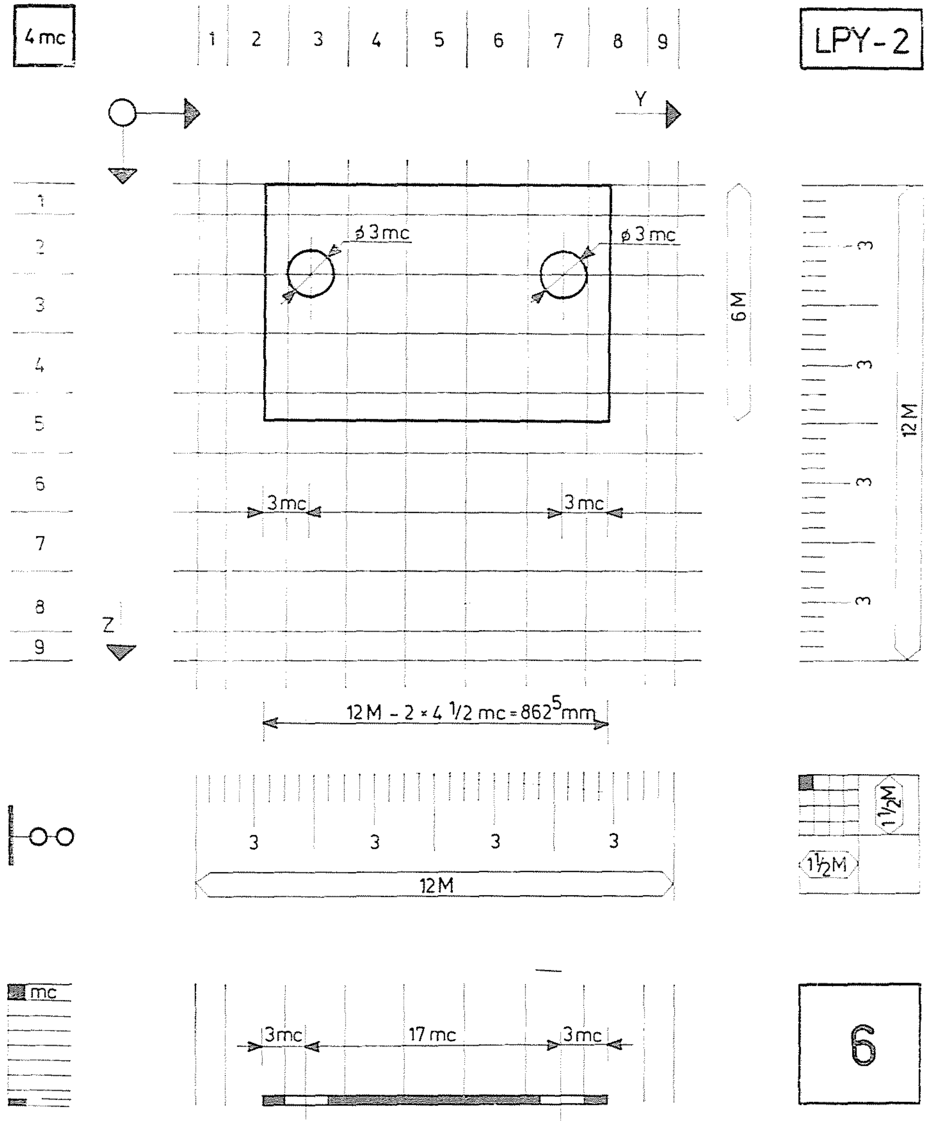


Fig. 2. Wall-of-pillar unit (negative): plane gypsum surface units on the tertiary grid (basic grid of surface elements). The ∅ 3 mc = 112.5 mm holes are for the exact location of heterogeneous joints, structural connection between pillar and beam grid (see Fig. 5)

— r.c. folded-shell pillars built *in-situ*, "frozen" between plane gypsum surface units;

— r.c. shell beam grid "frozen" between profiled gypsum surface units built underneath final position, lifted gradually by hand with lifting

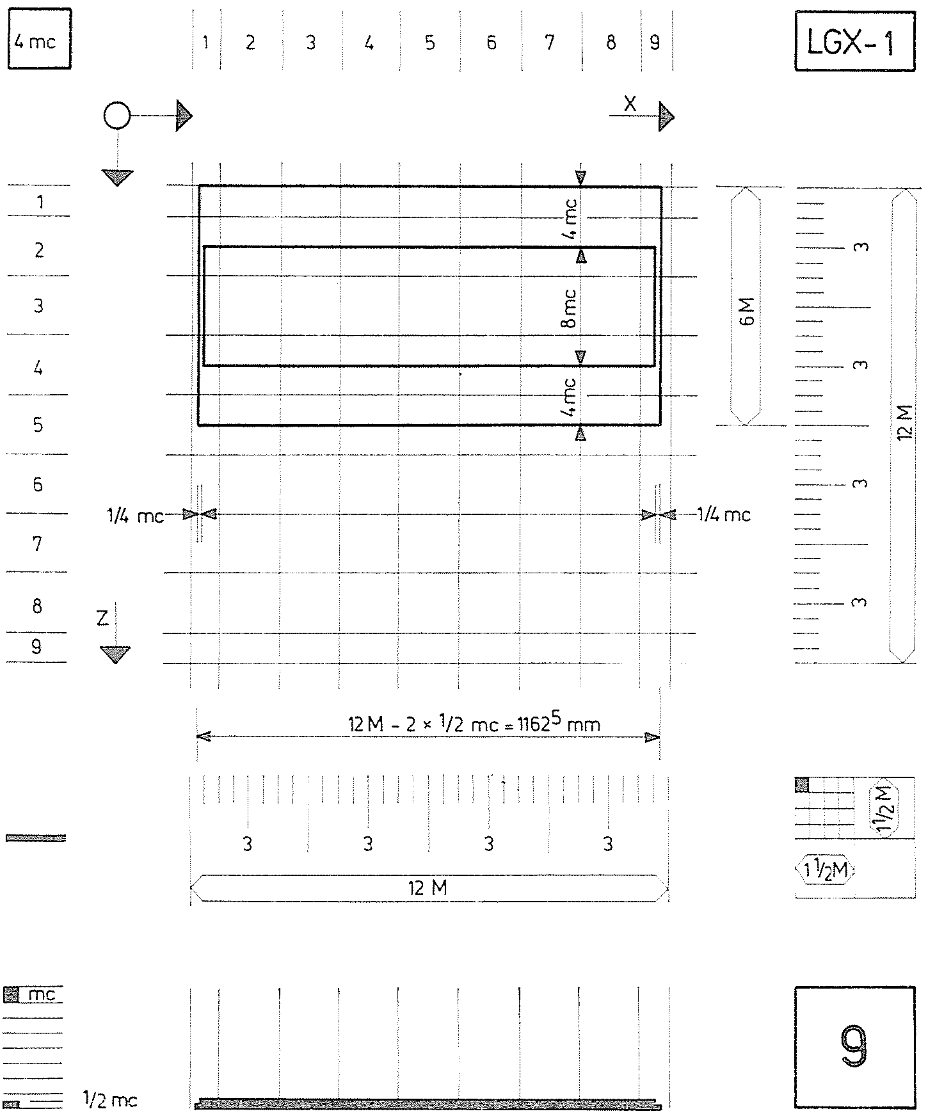


Fig. 3. Wall-of-cell unit (negative): profiled gypsum surface unit (basic grid of surface units). The pattern determines the shape of the r.c. frozen-shell primary and secondary beams

mechanisms and fixed in final position with heterogeneous joints mounted on top of pillars;

— pilot test on site prefabrication.

Thus, the vertical load-bearing structure consists of four U-section pillars, and the horizontal one of a single, large-size r.c. frozen shell beam-grid field, with large span and cantilevers in two directions.

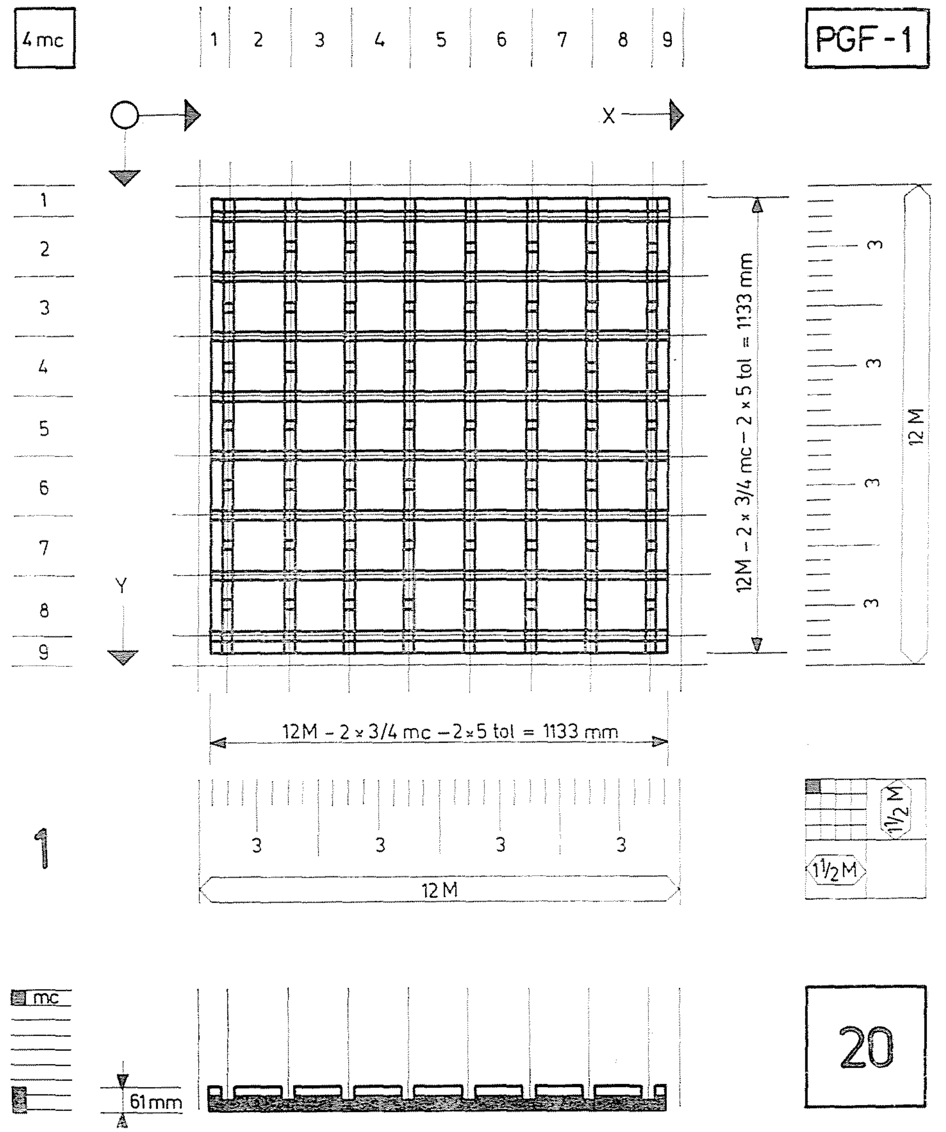


Fig. 4. Floor unit (floor negative): periodic gypsum-polystyrene surface unit on the tertiary grid (basic grid of surface units). The two-way channel system fits the 4 mc × 4 mc = 150 mm × 150 mm grid

*Characteristic co-ordination dimensions of test building**

Overall dimensions:

$$(14 \times 12 \text{ M}) \times (14 \times 12 \text{ M}) = 168 \text{ M} \times 168 \text{ M} = 16.80 \times 16.80 \text{ m}$$

* The formula of double co-ordination: 3 M = 8 mc means that 3 basic module grid units (M = module = 10 cm) in the structural system correspond to 8 micro grid units (mc = = microcell = 37.5 mm) in the manufacturing apparatus.

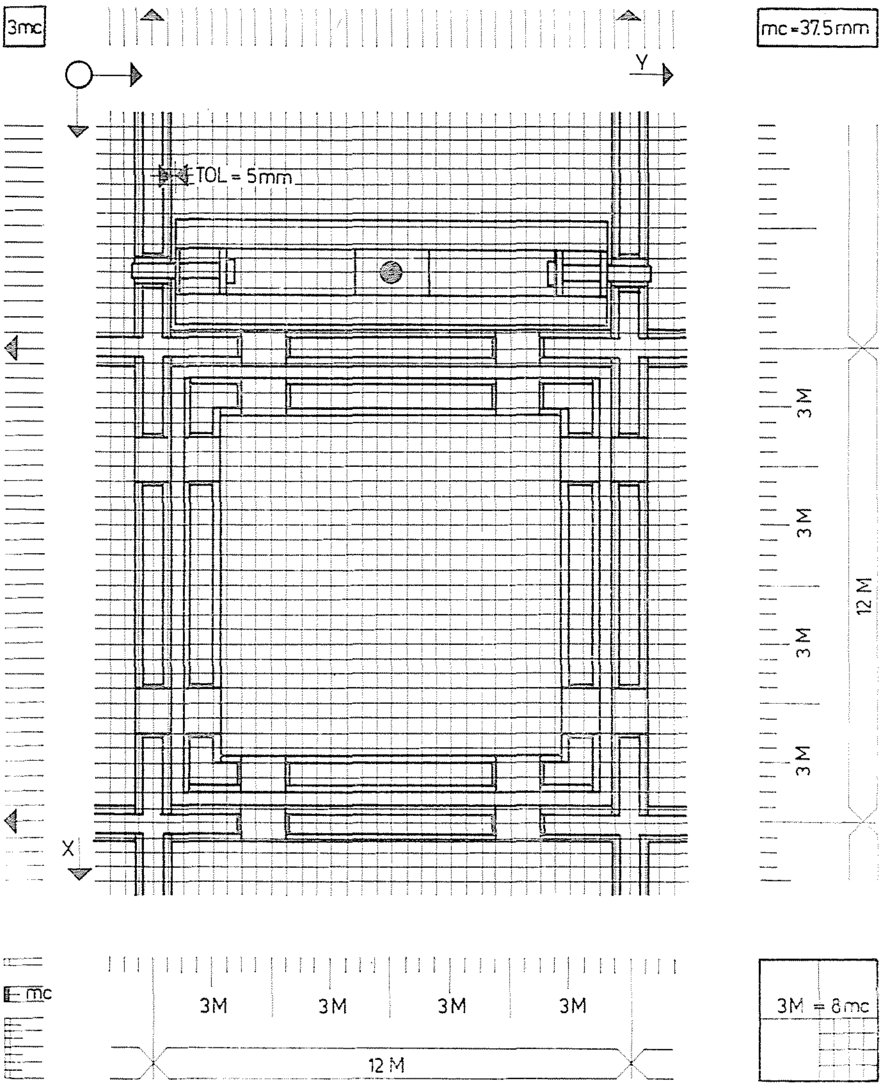


Fig. 5. The system of primary and micro grids in plan. The location of head of pillar, and the lower bridge of lifting apparatus in the system of micro grid

— Co-ordination dimension of span: 8 × 12 M = 96 M = 9.60 m
— pillar zone: 1 × 12 M = 12 M = 1.20 m
— cantilever: 2 × 12 M = 24 M = 2.40 m
— grid of spans (primary grid dimension): (8 × 12 M) × (8 × 12 M) = = 96 M × 96 M = 9.60 × 9.60 m

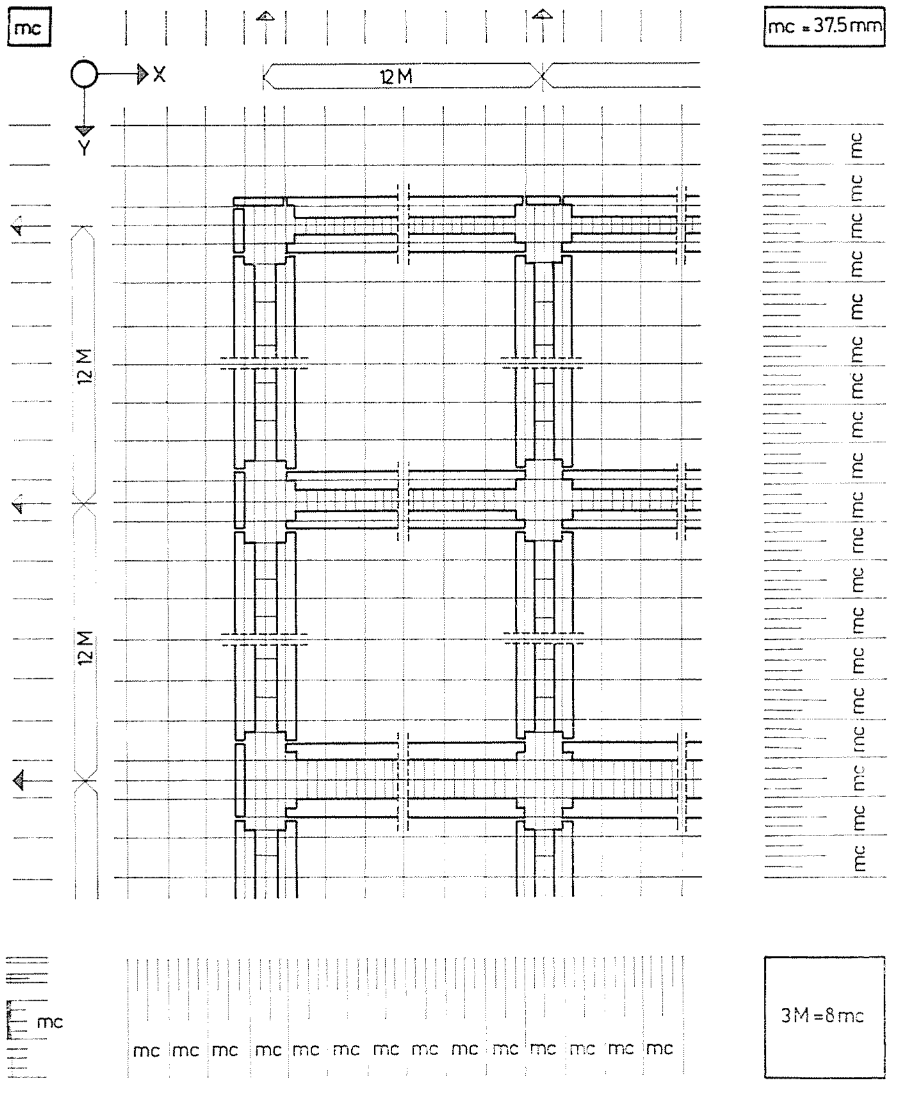


Fig. 6. Micro grid: horizontal section through beam grid. Corner detail. The location of profiled gypsum surface units (wall-of-cell units) in the system of grids

— grid of cells (secondary grid dimension): 12 M × 12 M = 1.20 × 1.20 m
— grid of structural tissue (tertiary grid dimensions): 1.5 M × 1.5 M = = 15 cm × 15 cm
— grid of structural details (micro-grid dimension): mc×mc = 37.5 mm × × 37.5 mm.

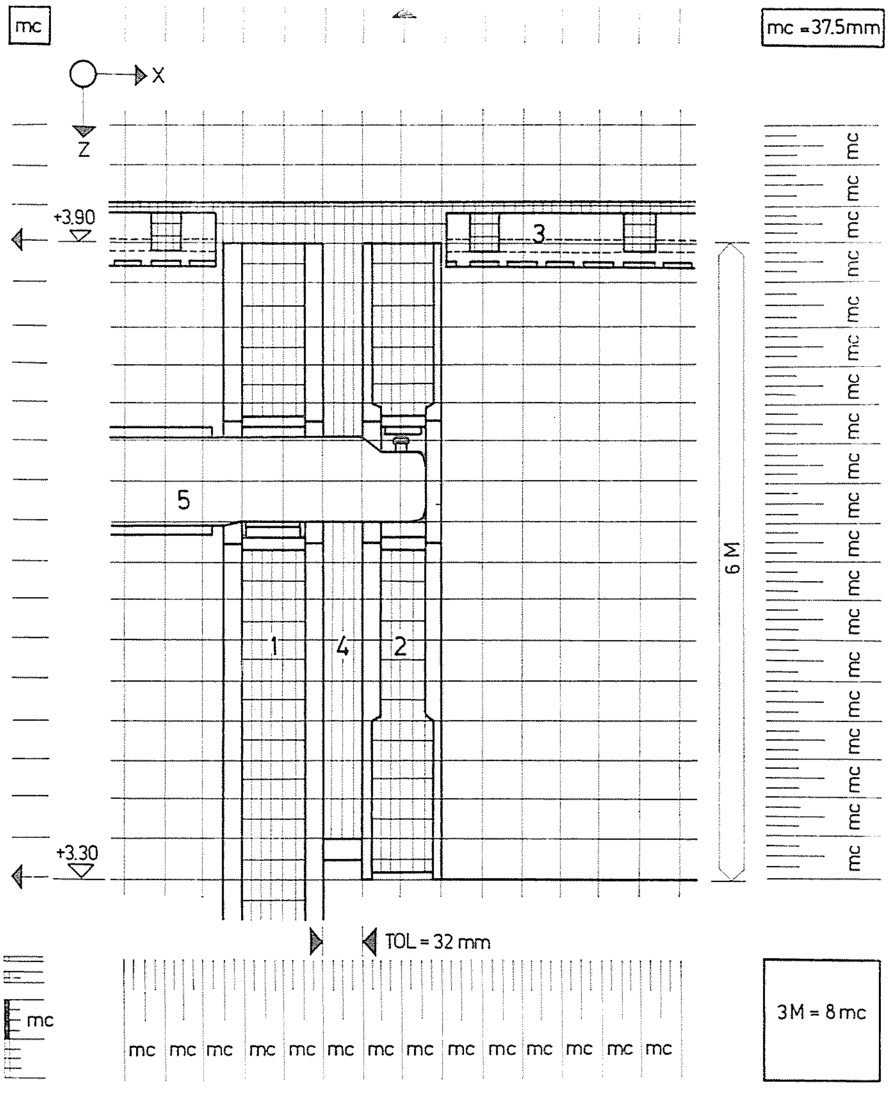


Fig. 7. Micro grid: vertical section through beam grid and head of pillar. The location of the heterogeneous junction between primary beam and head of pillar in the system of grids

Heights:

— Headroom from top of floor to bottom of grid: 33 M = 3.30 m;
— Height of cell from bottom to top of grid: 6 M = 0.60 m;
— Total height of building from top of floor to top of grid: 39 M = 3.90 m.

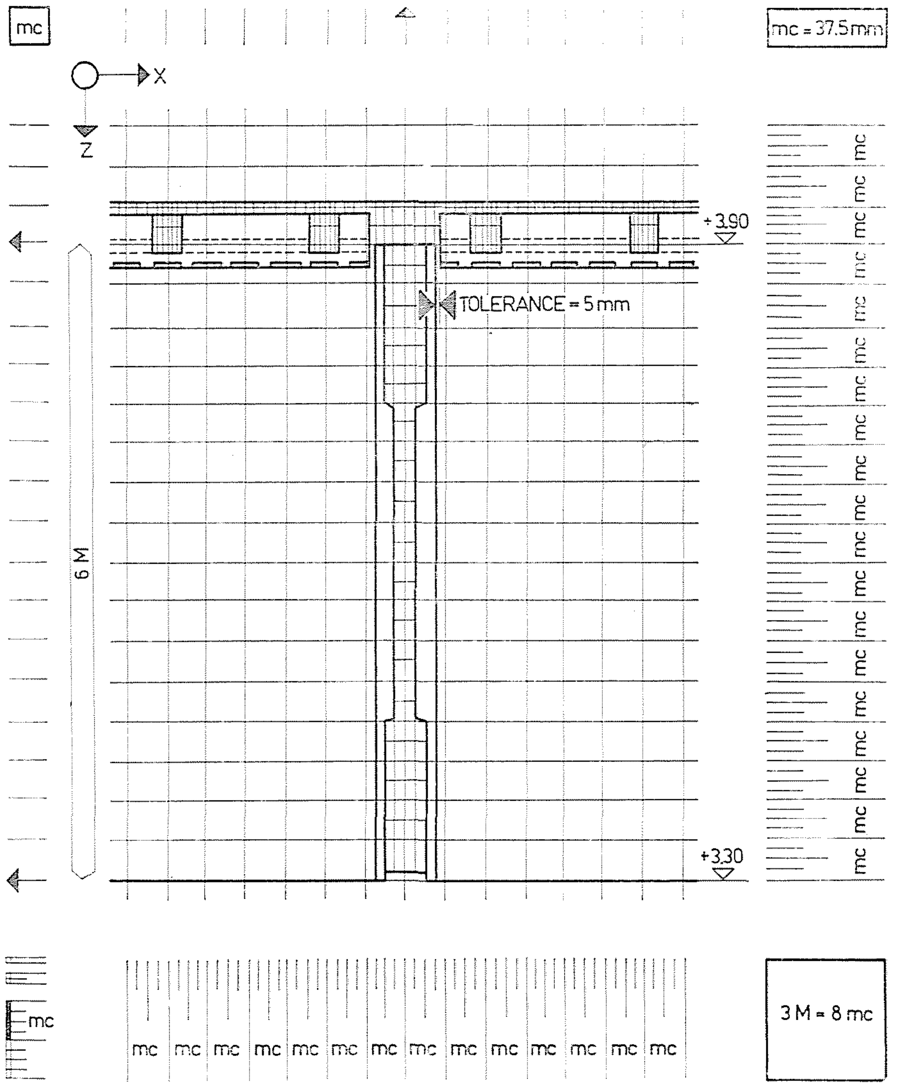


Fig. 8. Micro grid: vertical section through beam grid and floor. Location of secondary beam and r.c. tissue in the grid system

Basic dimensions of gypsum surface units:

All wall units including wall-of-pillar units (plane gypsum surface units) and wall-of-cell units (profiled gypsum surface units) — fit into the 6 M × × 12 M secondary grid in section with constant height (6 M), constant thickness (0.5 mc = 18.75 mm) and variable widths. All floor units — i.e.: top-of-cell units (periodic gypsum-polystyrene surface units) — fit into the 12 M × × 12 M secondary grid on plan with constant thickness (61 mm) and variable widths in two directions. In open structural systems the number of unit varieties is theoretically irrelevant. In our case 8 different wall-of-pillar, 10 different wall-of-cell and 10 different floor units, altogether 28 different units have been produced by one convertible apparatus. (Total number of manufactured surface units: 1170.)

Basic structural thicknesses: (Figs 1 to 8)

— pillar	$2\frac{1}{2}$ mc = 9.375 cm
r.c. frozen shell within the pillar	$1\frac{1}{2}$ mc = 5.625 cm
— secondary beam	$1\frac{1}{2}$ mc = 5.625 cm
r.c. frozen shell within the secondary beam	1 mc = 3.75 cm
	$\frac{1}{2}$ mc = 1.875 cm
— primary beam	$2\frac{1}{4}$ mc = 8.437 cm
r.c. frozen shell within the primary beam	$1\frac{3}{4}$ mc = 6.562 cm
	$1\frac{1}{4}$ mc = 4.687 cm.

Key to symbols: modular dimensions

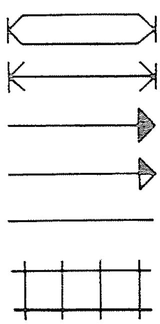
non-modular dimensions

primary grid line

secondary grid line

tertiary grid line

micro grid line



Manufacture

In non-tectonic systems the direct product of manufacture is not the load-bearing structure but its non-load-bearing, non-tectonic surface. These gypsum surface units are of low specific gravity, they have neither load-bearing capacity, nor stability in themselves, and irrespective whether they are plane, profiled or periodic, they are produced by casting in a workshop. Also tissue-structural floor units are concreted in a workshop.

Implication of the process of manufacture is explained below mainly by photographs.

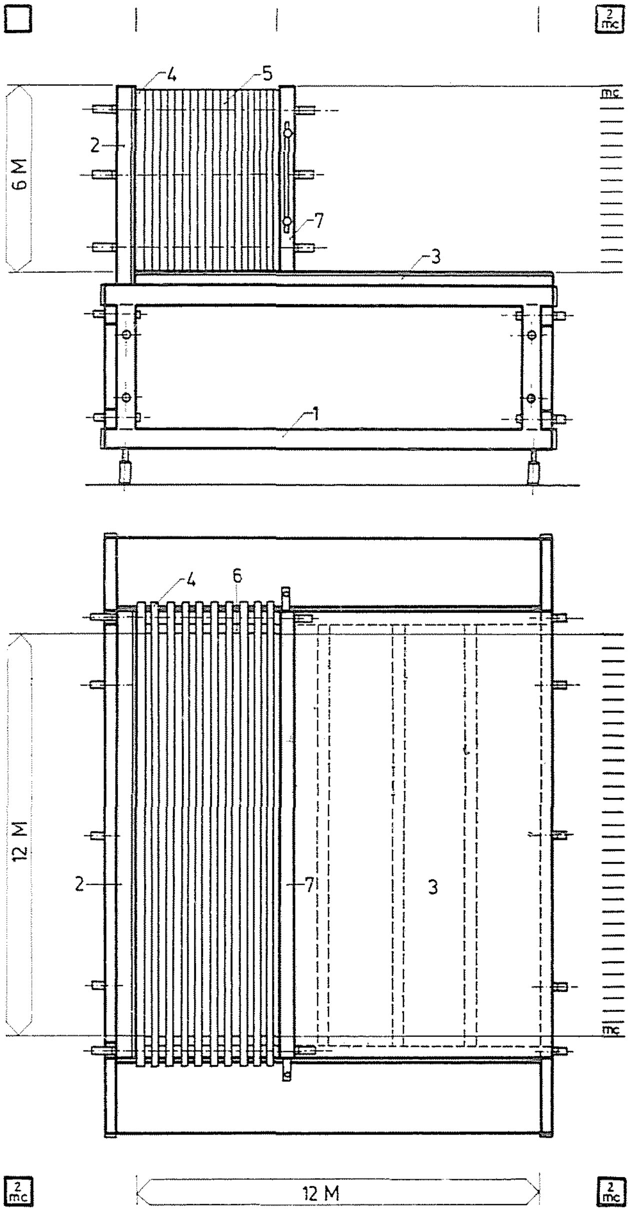


Fig. 9. The casting battery. Plan. Elevation. 1. frame with adjustable legs; 2. fixed back frame; 3. removable pouring board; 4. vinyl base-plates; 5. leading needle; 6. inlay elements; 7. closing frame

This apparatus produced 28 different units, an example of how to apply the principle of double co-ordination to the design of convertible apparatuses.

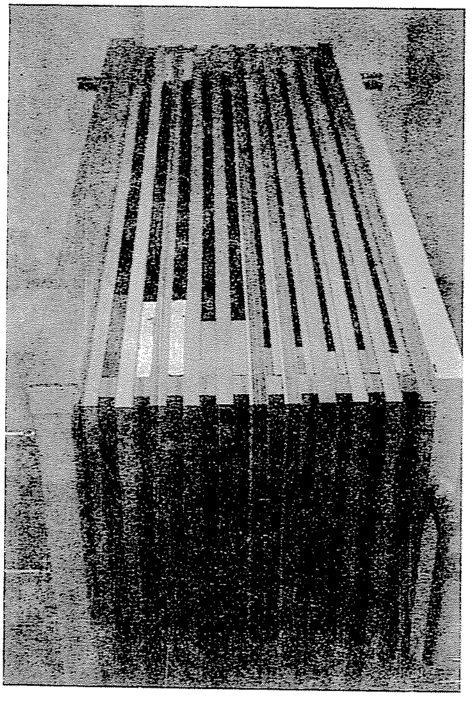


Photo 1. The casting battery, apparatus for manufacturing plane and profiled gypsum surface units. This was the first time of producing units in the vertical plane through group-casting, on pilot plant level. In principle, with one and the same apparatus ten units (differing in o/a dimensions and thicknesses) can be manufactured. As a matter of fact, the casting battery is a mould constructed of linear bars and plates, and closed by pressure. Component parts are: horizontally adjustable frame with fixed back-plate, removable stainless steel pouring board, vinyl base-plates crossed by leading needles, inlay elements to make the apparatus adaptable, and finally, the closing frame, uniting the component parts into a reliably closed battery by means of proper pressing screws. Photo shows the mould immediately before gypsum is poured in

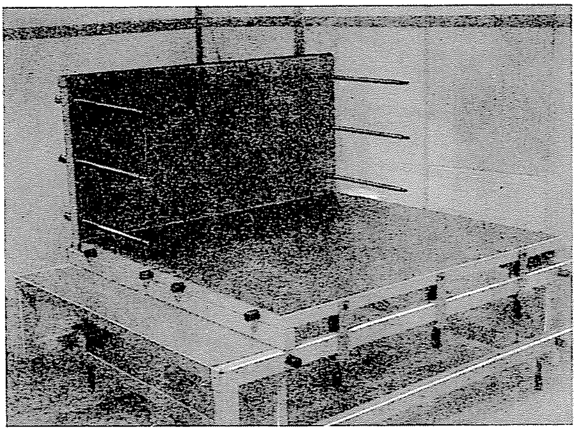


Photo 2. Main component parts of the casting battery. Frame with adjustable legs to help horizontal adjustment of apparatus; fixed back-plate with built-in adjusted "thimbles" for leading the needles; removable stainless steel pouring board. Situation preceding the assembly of battery.

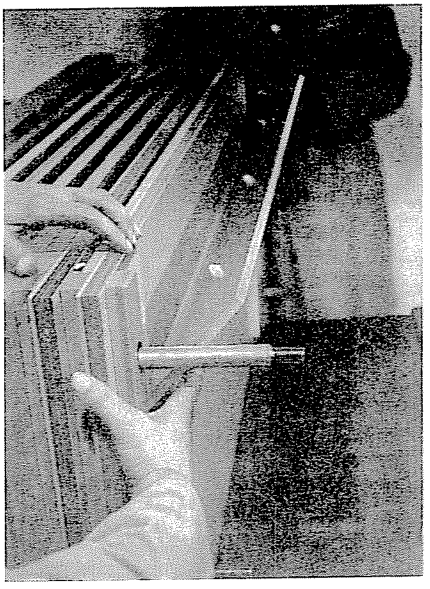


Photo 3. Assembly of the casting battery. The process of battery assembly involves ten repetitive elementary cycles, such as: 1. location of vinyl base plates by passing leading needles through them; 2. placing closing inlay units; 3. placing forming inlay units next to the closing units (if necessary). The finishing cycle comprises 1. location of the last vinyl base plate; 2. location of closing frame; 3. closing the mould by pressing screws led to the end of the needles

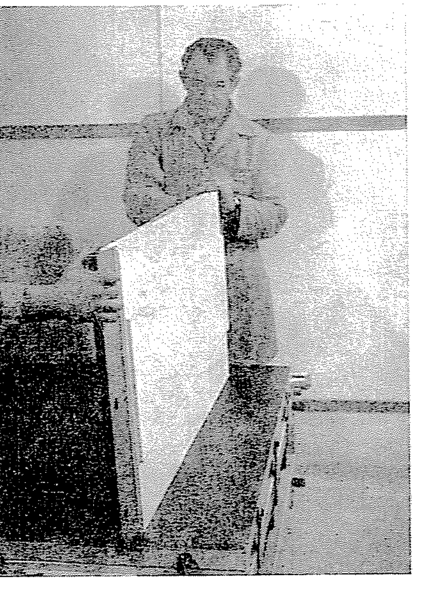


Photo 4. Disassembly of casting battery. Removal of a manufactured profiled gypsum surface unit (wall-of-cell unit) from the vinyl base plate

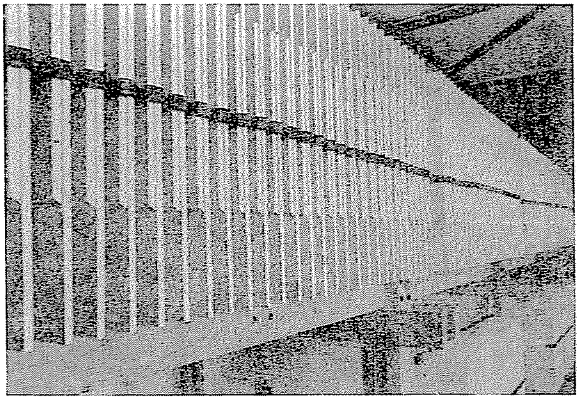


Photo 5. Storage of gypsum units on timber frames according to their types. Simple steel clips used at the same time as fasteners and spacers stored whole set of units

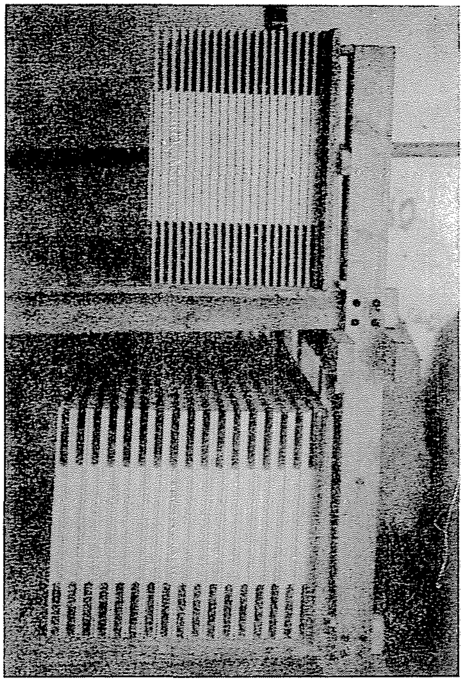
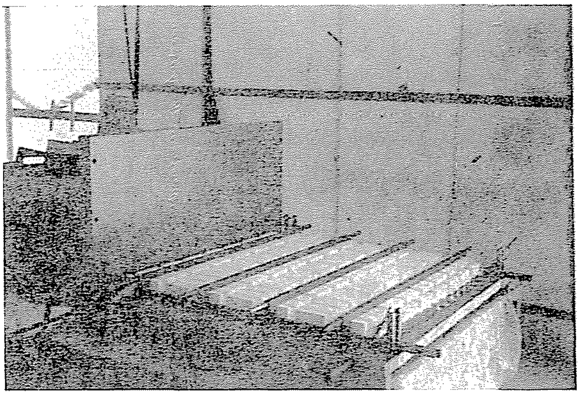


Photo 6. Storage of gypsum units. Two possible types of "densely storing" profiled gypsum units have been tried out experimentally. This type of storing perfectly eliminates the use of clips

Photo 7. Manufacture of periodic polystyrene-gypsum surface units (floor negatives). The same apparatus was used for the manufacture of periodic floor units. Simple square forming bars, or rather, a series of calibrated L- and U-sections and linear rods were placed on top of the pouring board and parallel clumps applied to get a great variety of dimensions for the periodic polystyrene-gypsum floor units. High precision was easy to achieve since the gypsum poured in filled closely the mould. The basic polystyrene units were provided with two-way periodic channel systems on both sides sunk into the still fluid gypsum. Exact unit thickness was provided by "bridges" on top of the forming bars



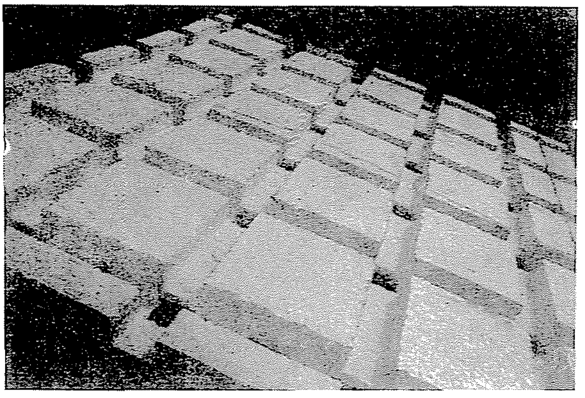


Photo 8. Basic periodic polystyrene floor unit. Close view of the unit with a two-way periodic channel system on both sides. When sunk into the gypsum, the two-way channel system on the one side will be left open for the r.c. tissue, whereas the channels on the other side will be filled, providing the exposed smooth lower surface, the bottom of the cell

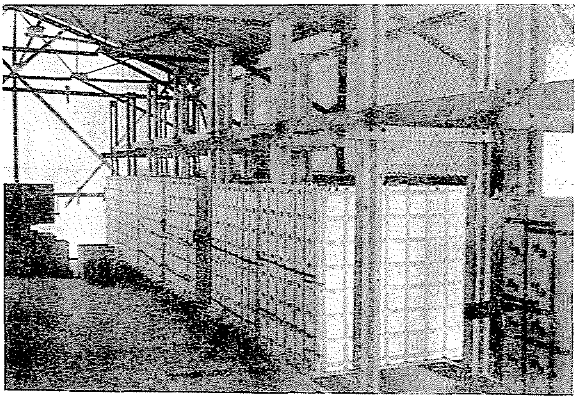


Photo 9. Storage of polystyrene-gypsum units. The periodic polystyrene-gypsum surface-of-floor units were stored by pairs on the same timber frames

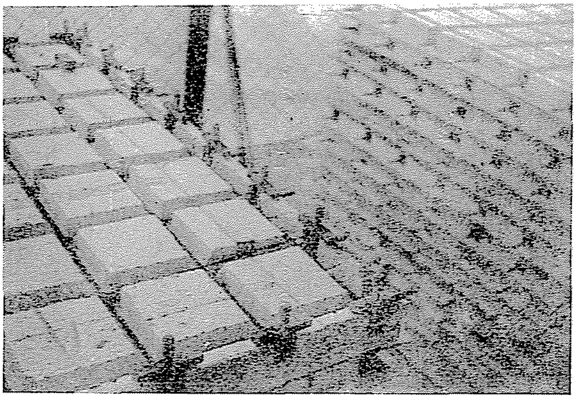


Photo 10. Reinforcement for polystyrene-gypsum units. Small vinyl inlay pieces — "spacers" — exactly fitting and pinned into the end of the channels serve for the precise location of the reinforcement (reinforcing wires) within the channels, thus, a high degree of precision can be achieved by unskilled labour. The heterogeneous joints (small steel jointing points embedded into the r.c. tissue) necessary for transporting and hoisting the units are mounted by welding on the reinforcing wires

Photo 11. Concreting polystyrene-gypsum floor units. The dry and hardened floor units are sorted according to types and concreted superimposed in stacks. The units are separated from each other by corrugated cardboard sheets. The r.c. tissue arises from pouring concrete into the two-way channel system

Building

The process of non-tectonic building

Let us remind that the process of non-tectonic building is exactly the opposite of the usual tectonic building. Normally the sequence of operations starts with positioning the reinforcement. This is followed by the assembly of the surface, resulting in the negative of the load-bearing structure, be it vertical or horizontal, and then, in the *in-situ* operation of pouring cycle the surface elements are united by the primary structure into a r.c. frozen shell structure. The moisture absorbing capacity of the gypsum eliminates the hydrostatic pressure of concrete: the concrete poured in gets immediately stabilized; it "freezes" on the gypsum.

In case of the "lift-field" experimental hall, the U-shaped r.c. frozen shell pillars were erected first. This was followed by mounting the lifting spindles on pillars' tops (Fig. 10). The spindles were driven by hand through mechanical transmission and were used for lifting in the almost 300 m^2 cellular field unit — a r.c. frozen shell beam-grid structure of nearly 36 tons made on the ground. Thus in this system the connection between the vertical and horizontal

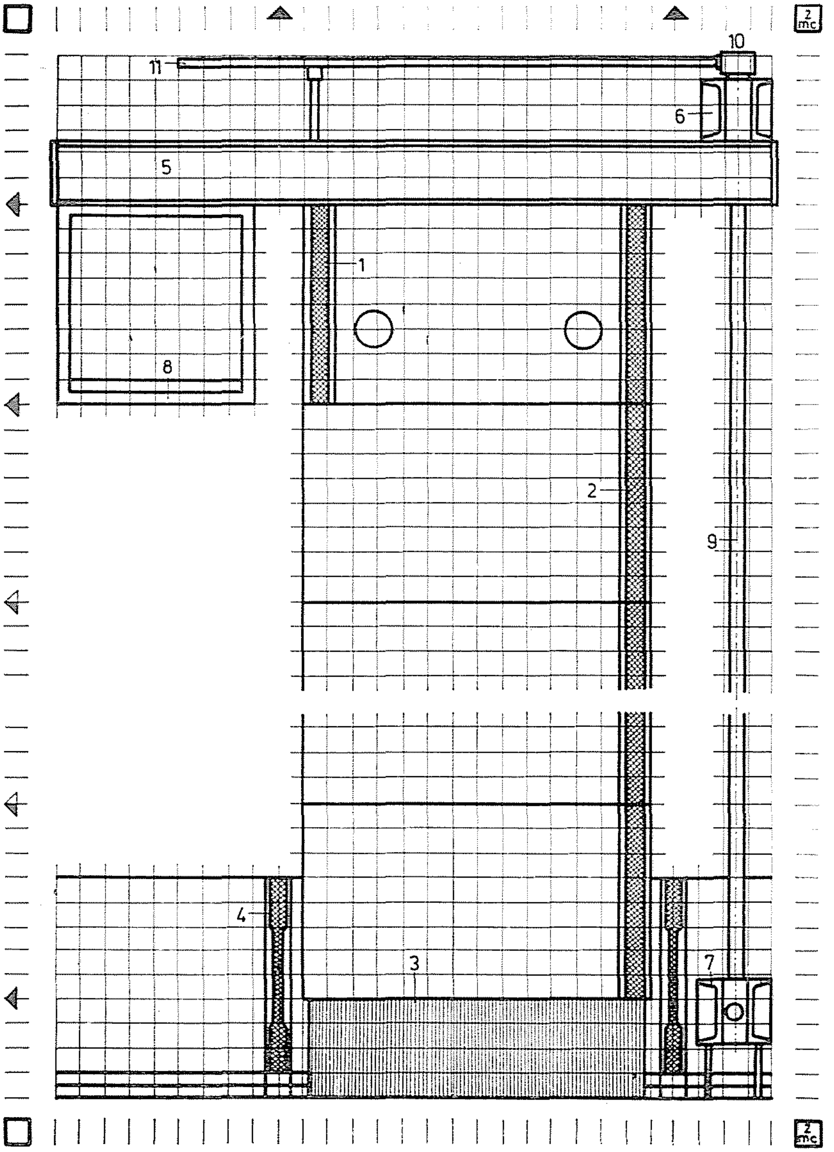


Fig. 10. Apparatus for lifting the beam grid. Vertical section through pillar. 1. head of pillar; 2. wall of pillar; 3. footing; 4. beam grid; 5. steel beam of lifting head; 6. upper lifting bridge; 7. lower lifting bridge; 8. suspended basket; 9. lifting spindle; 10. head of spindle; 11. crank rod

load-bearing structure is not the normal tectonic joint based on support, but a non-tectonic one based on shear.

Implication of the process of non-tectonic building in course of erecting the experimental hall will again be presented on photographs.

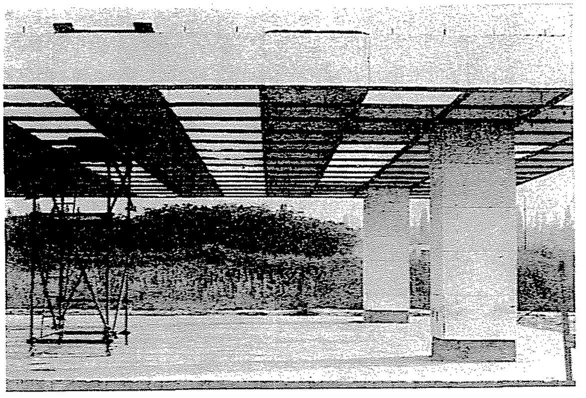


Photo 12. Experimental hall before completion

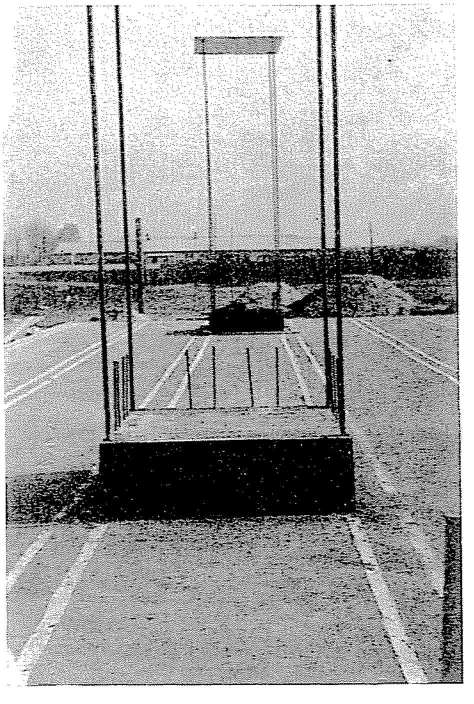


Photo 13. Pillar footing. The "lift-field" experimental hall is supported on four points. Pillar footing (from 0.00 to 0.30 m) is held by steel sections which at the same time ensure the exact position of the longitudinal reinforcement of pillars. These ∅ 22 mm reinforcing bars anchored into foundation were used for fastening the lifting mechanisms on pillar tops. The ∅ 8 mm "pins" protruding from the footing established reliable structural connection between r.c. folded shell pillar and foundation
The parallel twin battens are embedded into the concrete at zero level for the exact placing and temporary fastening of auxiliary beam-grid structures (see: *Photo 19*)

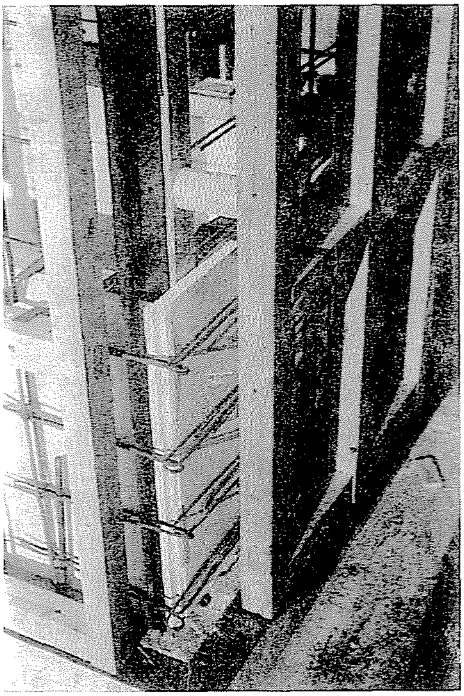


Photo 14. Erection of U-section pillars: mounting the auxiliary frames. Close view. Lower corner detail: inner element and reinforcement positioned. Erection of pillar starts with the assembly of auxiliary timber frames whereby the position of each surface of the pillar is exactly determined. Accuracy required from thin r.c. folded shell structures was provided by using simple cylindrical spacers. The pillar is built of six rows of units of a height 6 M = 60 cm. This basic repetitive cycle is composed of two main phases: 1. the assembly of surface (negative mould of the load-bearing structure) a) placing inner surface elements; b) positioning of reinforcement; c) placing outer surface elements; 2. pouring in concrete resulting in the actual r.c. folded shell structure

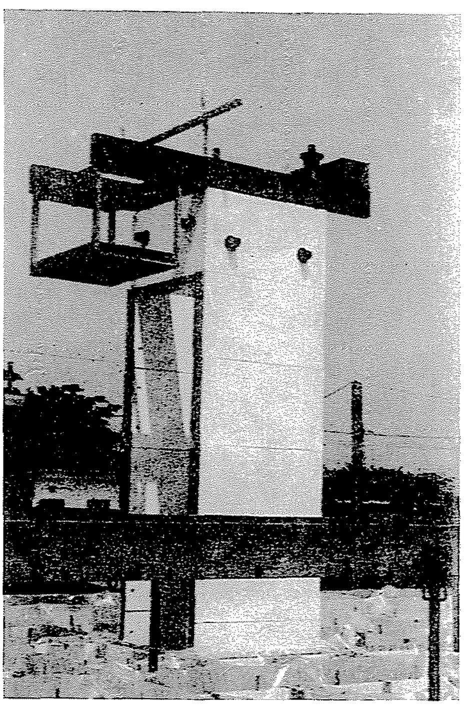


Photo 15. U-section pillar completed: mounting the lifting apparatus on pillar top. The heterogeneous jointing points creating final structural joint between pillar and beam-grid are incorporated in the sixth row, the head of pillar (see also Figs 2 and 5). The lifting mechanism mounted on pillar top is composed of linear parts and assembled by "stacking" (following the principle of "pile of logs"). Twin beams of lifting-head are immediately screwed to the longitudinal reinforcing rods (Photo 13). The upper lifting bridge is fastened to twin beams from above, whereas the manipulation basket at the open side of the pillar is suspended on the beams

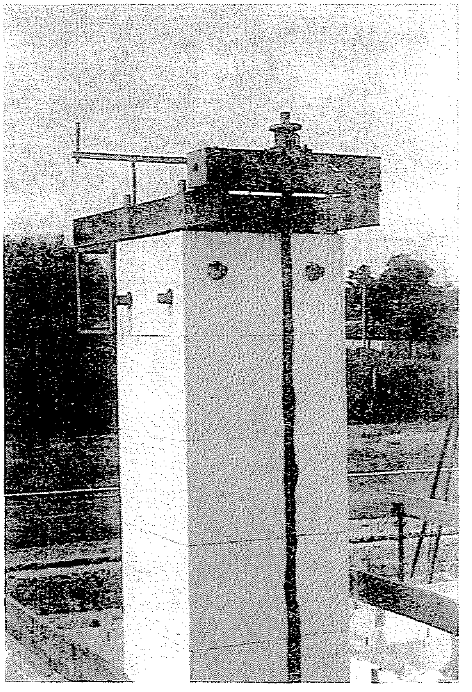


Photo 16. The heterogeneous jointing points and lifting mechanism seen from the closed side of pillar. The ball-and-socket jointed lifting spindles hinged with the upper lifting bridge are driven by hand through mechanical transmission. Crank rod is manipulated from the suspended basket. In the "lift-field" method the lifting mechanism has been specially designed for the structure, as an integer part of the building construction

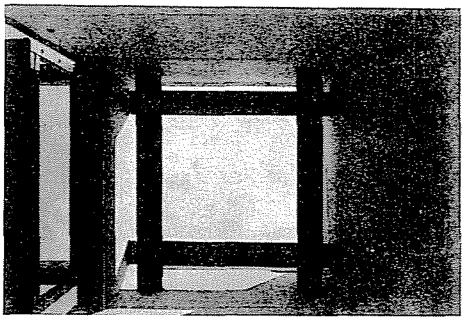


Photo 17. The system of heterogeneous jointing points seen from underneath, from inside the pillar

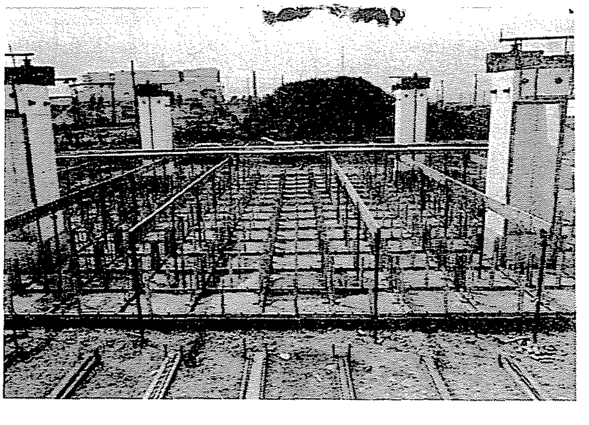


Photo 18. Erection of beam grid. Assembly of auxiliary structures. The beam grid of the "lift-field" experimental hall was constructed on zero (ground) level. After temporary scaffolding being placed for material transport, the auxiliary structures of the beam grid have been assembled of only linear timber elements with a system of co-ordinated holes for exactly placing and fastening the reinforcement, and the vertical battens, "legs" to keep the non-load-bearing, instable gypsum surface elements in position until concrete is poured in

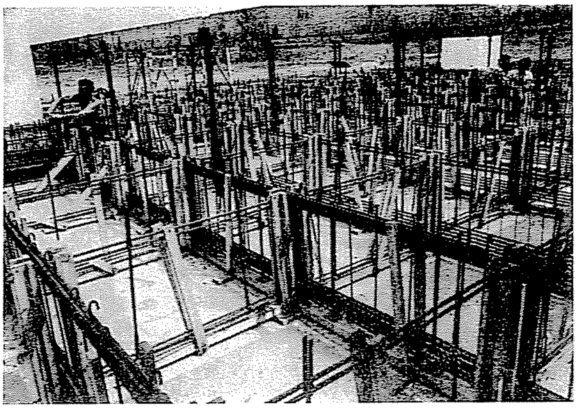


Photo 19. Assembly of the beam grid on zero level. Assembly of "stack" reinforcement. First, the "leading rods" are screwed to the co-ordinated heterogeneous jointing points fastened to auxiliary beams. The two-way "stack" reinforcement consists of straight threads, ∅ 12 mm wires (of beam length). The strict system of the co-ordinated leading rods maintains the straight wires in a predetermined stack at mm accuracy

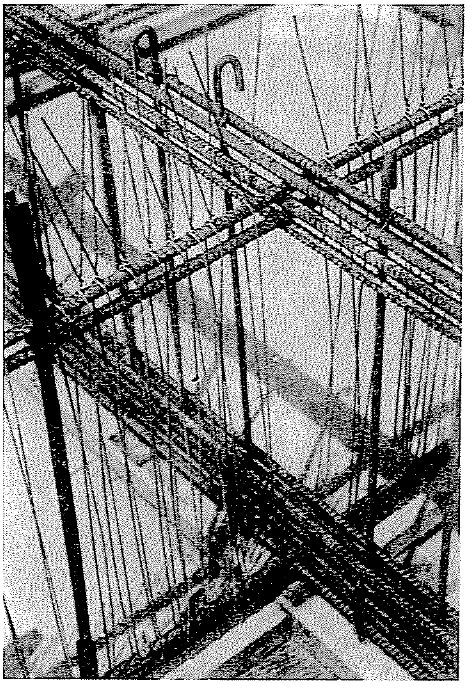


Photo 20. Close view of intercrossing reinforcements of a secondary and a primary beam. Thanks to the co-ordinated system of auxiliary beams and leading rods, mm precision was maintained in each direction.
The "stack" reinforcement is built from below upwards in recurring cycles, in a definite order

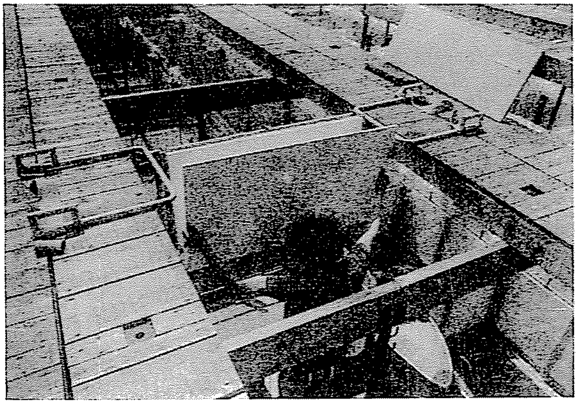


Photo 21. Assembly of surface. The wall-of-cell gypsum surface units (i.e. of the beams) properly arranged in containers are carried on a gangway placed on top of the respective cells, and fixed temporarily until concreting

Photo 22. Concreting. The units are clipped to the "lugs" of the timber auxiliary structure. Moisture absorption by gypsum immediately stiffens the concrete, eliminating thereby the hydrostatic pressure

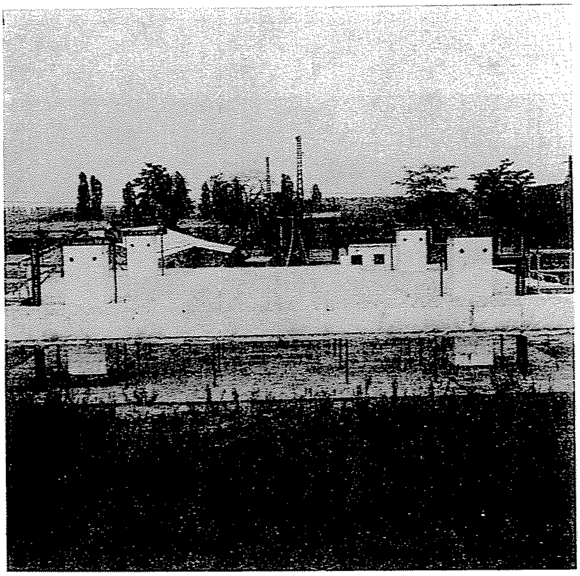


Photo 23. Lifting, intermediate position. The beam grid field on four points is lifted by hand through mechanical transmission. The actual operation lasted eight hours

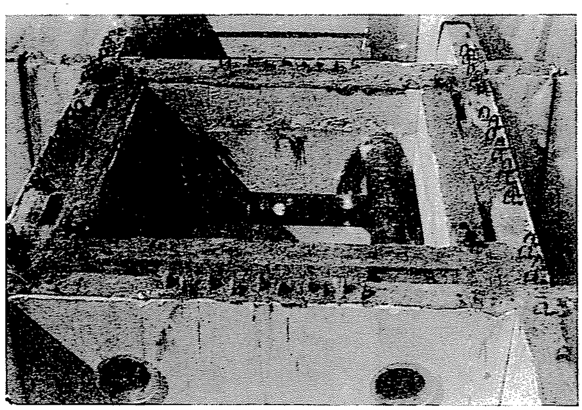


Photo 24. Heterogeneous joint between pillar and beam grid, seen from above

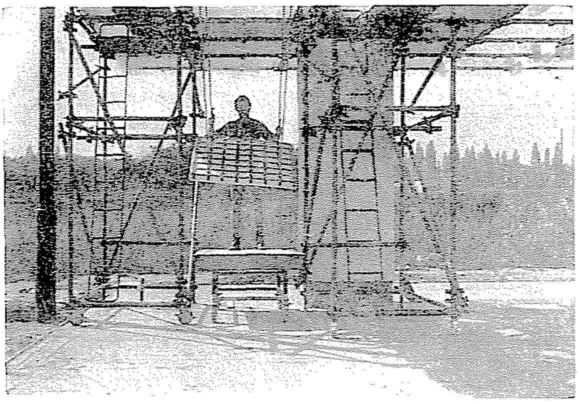


Photo 25. Placing floor units. The r.c. tissue-structural top-of-cell units weighing 54 kg each are transported by carriage and deposited first below the respective cell. The lifting ropes are lowered and knotted to the heterogeneous points embedded into the r.c. tissue. Lifting is done by hand. The units — threaded slantways through the cell above — are first slightly lifted above beam level and then positioned. In this position the units rest on the reinforcing wires protruding from the deeper channels

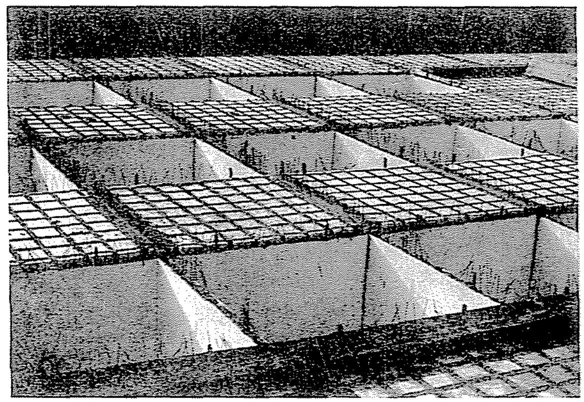


Photo 26. The tissue-structural top-of-cell units are placed by rows in the sequence shown. The units rest first on the protruding reinforcing wires. The channels formed between adjacent floor units are filled out with concrete, whereby the tissue becomes a one-way continuous structure

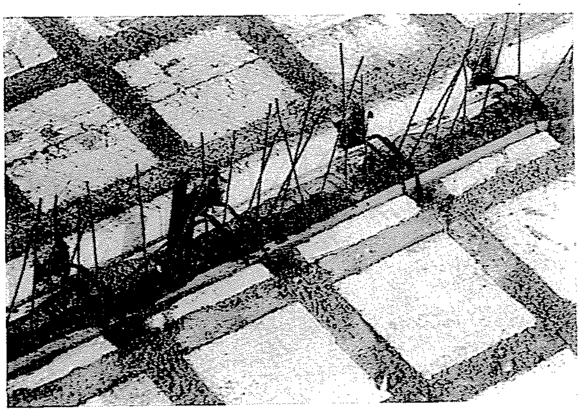


Photo 27. In the other direction, the reinforcing wires of the tissue get in the channels. Twinned wires take up shear stresses between beam and floor units. Situation before concreting in the channel

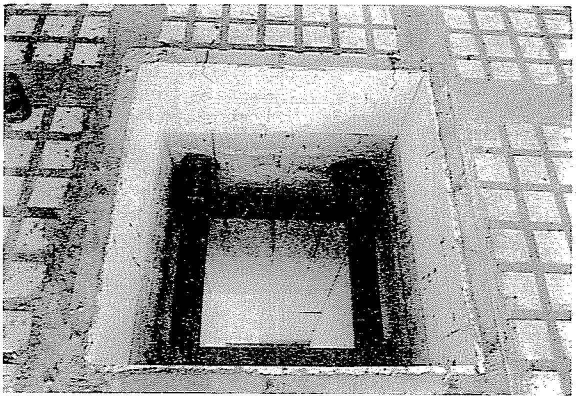


Photo 28. The completed floor. The r.c. tissue structures contained in the individual top-of-cell elements have got united by the concrete poured into the channels between adjacent floor units. Close top view of the r.c. tissue around the pillar top and the final heterogeneous joint between pillar and beam grid

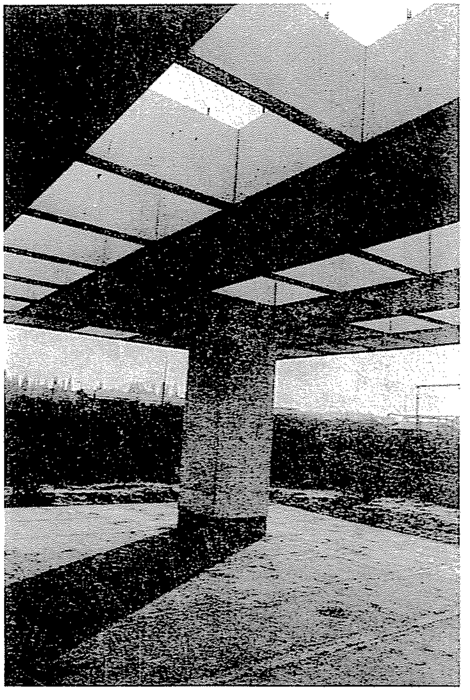


Photo 29. Interior view of beam grid field before completion

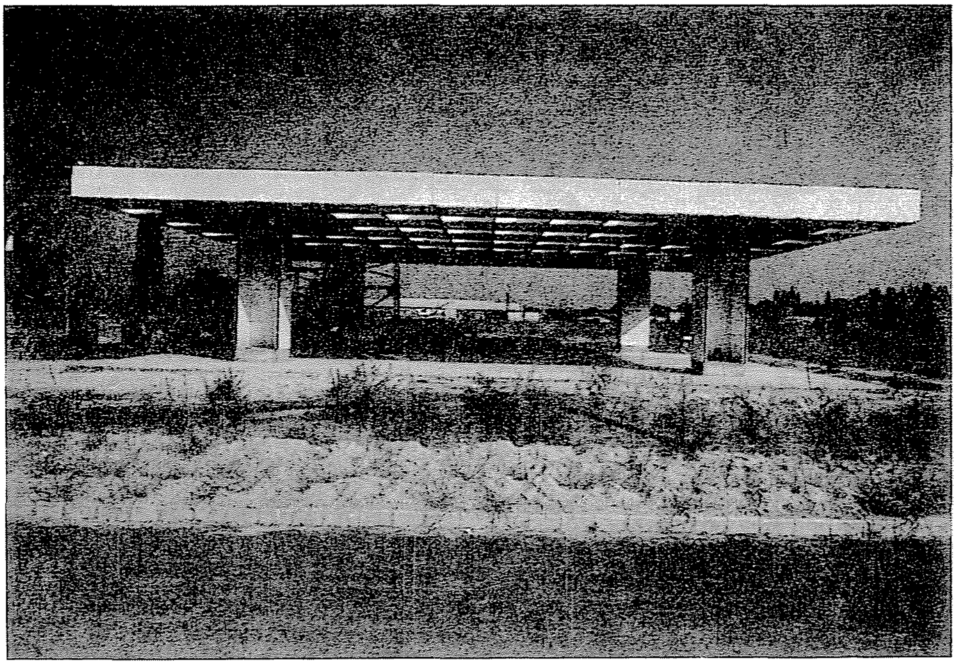


Photo 30. "Lift-field" experimental hall before completion. The test building with its simple undivided large space practically testifies the relative two-way span-indifference of non-tectonic cellular systems

Main data of experimental hall

a) Total floor area 284.26 m²
b) total volume 1108.61 m³
c) pillars:

concrete footing	1.23 m³	2949.53 kg
gypsum	1.69 m³	1359.91 kg
frozen concrete	2.52 m³	6048.00 kg
reinforcement		648.00 kg
steel heterogeneous jointing points		868.40 kg
Total weight of pillars		11 873.84 kg

d) beam grid:

gypsum	8.09 m³	7 694.09 kg
concrete	10.44 m³	25 056.00 kg
reinforcement		3 572.75 kg
Total weight of beam grid (weight lifted)		36 322.84 kg

Total length of ribs of beam-grid

primary ribs	134.88 m
secondary ribs	370.92 m
Total	505.80 m

Weight by running meter of beam-grid ribs

primary rib (gypsum)	15.21 kg/m
primary rib (concrete)	88.91 kg/m
Total	104.12 kg/m
secondary rib (gypsum)	15.21 kg/m
secondary rib (concrete)	44.86 kg/m
Total	60.07 kg/m

e) floor units:

gypsum	3 630.90 kg
concrete	7 956.00 kg
reinforcement	905.25 kg
polystyrene foam	480.40 kg
Total weight of floor units	12 972.55 kg

f) final pouring: concrete	2 400.00 kg
g) screed on roof: concrete	20 400.00 kg
reinforcement	435.83 kg
h) total weight of structure above 0.00 level:	84 045.06 kg
i) data per unit area	

gypsum	44.58 kg
concrete	217.62 kg
reinforcement	19.56 kg
heterogeneous jointing points	3.05 kg
weight of structure per unit area, h/a	284.81 kg
weight of structure per unit volume, h/b	76.14 kg

Summary

The "lift-field" experimental hall with its undivided large space exemplifies an application of non-tectonic systems to communal buildings, and gives a proof of the relative two-way span-indifference of the cellular systems. The beam-grid field of large span and cantilevered in two directions was built on the ground and lifted in position by hand through mechanical transmission.

Non-tectonic systems are founded on the elimination of the principle of tectonics from buildings, therefore they represent a fundamentally new building method. The system applies non-load-bearing, unstable gypsum surface elements assembled on the site and strengthened by pouring in concrete.

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