Interior design in a full-scale lab: implementing Lego-like Building Bricks for and Infrastructural Aspects of an Experimenting Level

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Abstract
This paper deals with the present state of the full-scale laboratory at the Vienna University of Technology. Regarding 1:1 simulations in the lab simple and quick-performance solutions for all of the horizontal and vertical terminating planes (walls, ceiling and planes) are a prerequisite. Therefore, the development of an experimental level is illustrated first by implementing the Meroform-System. Then the working material of Lego-like building bricks is described. Thereafter, the possibilities resulting from the present laboratory infrastructure are considered by means of projects having already been performed. Finally, the medium-term extension plan for the experimental space within the Vienna Full-Scale Lab is presented and combined applications of different simulation techniques are enumerated.

Developing an Experimental Level
Only after total completion of adaptation work in the late autumn of 1992 being followed up by the opening of the full-scale laboratory on Dec. 9, 1992 the planned experimental level was constructed in the spring of 1993. The intention thereof is the alteration of elevation of the floor and the ceiling, respectively, the upper and the lower side of the level being suited for utilization thereby. One prerequisite for the operation of this installation was that the supporting elements were able to be hung into the lateral wall girders with the help of only a few people. The entire construction of the experimental level, however, is to be devised as to enduring repeated changes of a configuration. The requirements regarding the performing level were already taken into account during adaptation work: the wall girders were dimensioned accordingly and provided with holes fitted for the intended modifications of the plant. Several different types of supporting elements, such as shelf brackets, are available on the market, the use of which seems rather restricted when considered closely. Either major problems are becoming manifest when considering the required length of 6.60 m or the mounting to the wall girders are proving difficult and awkward. Attaching the floor panels to the girders may also entail constructional difficulties. Taking all these requirements into account the Meroform-System seemed most suitable for our purposes. The advantages of this system developed by Max Meier in Vienna are as follows:

1 - availability of standardized joints and frames (space framework),
2 - lightweight construction (light weight of individual pieces),
3 - addition of a floor used at exhibitions (closing possibility),
4 - on the market since 1942 (continuity, possibility of expansion).

1Legos are well capable of bearing, but lend themselves only to use from the top.
2Based on a supportless traverse of 6.60 m and a floor load of at least 225 kg/m². The distances of vertical holes correspond to the Austrise mounting of a step of 17 cm.
3The name Mero is derived from Meroform®—10xmoore
The lowest-most elevation represented the basic condition of the experimental level (fig. 1). Then brackets were attached acting as rests for the spatial Mero-framework which are hung into the lateral wall girders. Then the space framework is mounted; normally the wooden floor panels are attached to supporting frame rods by means of a...
for utilization of the available system elements (fig. 3).
Meanwhile we found out that the sequence of (de-)mounting requires careful scheduling as some parts can only be removed or assembled after one another. Therefore, the possibility of a dissemble of the space framework into particulate girders is being studied. This variant will call for the use of 12 further brackets making, however, an ample amount of Mero-rods and -knobs available. This surely could prove very effective as previous building experience has shown and considering the advantage of having a greater amount of additional elements readily disposable.

Selecting Special Building Bricks
The second most important decision - in terms of lab-infrastructure - surely was the purchase of wall elements in 1993. Building systems qualified as 'suitable' were to be divided into two main groups: clamped joint panels and building bricks or blocks. A fact to be taken into account is that sometimes considerable restrictions arise from the use of one system when, e.g. slanted walls, planes and roundings - all configurations deviating from the orthogonal - are practically not to be accomplished.

Clamped joint panels are wall-like elements which are clamped between floor and ceiling in a vertical direction (fig. 5) The particular arrangement chosen makes for a spatial termination. The height between floors of the Full-scale Lab at Eindhoven University of Technology in The Netherlands is 260 cm (a standard dimension regarding Dutch building construction). The width of the clamped joint panels may be 30, 50, 60, 70 and 90 cm, door- and window elements with inset parapet have also been developed. The floor was equipped with an auxiliary grid (30 cm). The set room height does not really prove favourable regarding projects not within the field of residential building. Despite this limitation a ground plan can be reconstructed easily.

Building bricks or building blocks represent small-unit elements which can be used in order to come up with building parts with various dimensions. Assembly and dismantling is not accomplished as quickly as with clamped joint panels. A panel-like system, however, has to be sawed into pieces according to desired size. As far as mobility is concerned a panel-system also lends itself to testing in situ-constructional adaptations, i.e. not within the lab itself, e.g. the mock-up system in Copenhagen.

In Bologna, Italy building blocks with a very sophisticated construction were developed for the full-scale lab Vekcos (fig. 6). Individual blocks are connected by means of a special wrench. Three basic types with the dimensions 10x30x10 cm, 30x30x10 cm and 10x10x10 cm as well as corner elements (modifications of 10x30x10 cm) are at their disposal. Though this patented product so far has exclusively been used in Bologna, exporting them could be negotiated.
The Full-scale Lab of the ETH-Lausanne (LEA) has developed creme-coloured (injection moulded) building bricks for teaching and research purposes (fig. 7). As of yet three different types exist: a rectangular one (20x10x10 cm), a cubical one (10x10x10 cm) and one rounded on one side (for the erection of curved walls). Walls can be put up quickly on a plane surface, assembly is achieved easily up to a height of approximately 3 m; an auxiliary scaffolding is required for heights exceeding this. Problems of stability occur from a certain building height onwards which will call for double-width wall thickness. Overspans can only be achieved with the aid of additional auxiliary means.

The Brik building bricks having been developed in The Netherlands, not within a sim-lab though, are an alternative to the Swiss product (fig. 6). These patented building bricks, looking like over-dimensioned Lego building bricks at first sight, are produced under license in the USA. So far two types are available (20x10x10 cm and 10x10x10 cm) which can be connected with connector pins. Thus overspans and cantilevers can be accomplished. This is an industrially manufactured lightweight product made of polypropylene-synthetics and lends itself to recycling. The standard range comes in the colours yellow, red, green and blue, particular colours, however, can be manufactured subject to a specific minimum purchase quota. As far as we know the Brik-Building bricks have been mainly used in elementary schools and kindergartens up to now. According to information by the inventor Joop Westenbarger originally (three-) quarter-building

* Upon inquiry at the LEGO-headquarters in Billund (Denmark) whether large-dimensioned building bricks were being produced or planned to be this was denied.

** Ruud van der Veer ( Wageningen University) discovered this product in the course of his investigations (US-Patent 4,823,330; European patent 028,103). The mock-up system used at Wageningen University consists of wooden building blocks of the dimensions 25x25x5 cm and 2.5x25x2.5 cm. Connections are accomplished by means of connector pins, curved walls cannot be erected. The white point of the building blocks proved rather unattractive, as they are inclined to look dirty in the course of time, therefore alternative working means are being carefully studied.
LEA-building bricks can be purchased at the ETH-Lausanne, to be regarded as a special production run, as a commercial production quantity must be achieved than there is calling for a minimum purchase quota. The final decision which brick to purchase - the LEA one or American one - was determined by questions as price quotations, minimum purchase quotas and terms of delivery. In the end the Brik building bricks were decided upon, particularly on account of the fact that delivery of small quantities is also possible. Thus the Vienna University of Technology has 10,000 whole and 4,000 half building bricks of a light grey colouring at its disposal (Fig. 7).
The first working experience was particularly directed at determining possibilities of the new bricks some of which of major importance are as follows:
- suitability for horizontal terminations and ability to walk over (ceiling constructions, vaults, etc.);
- possibility of erecting slightly coved walls (fig. 8);
- use of a wooden deal board as 'lintel' when covering larger overspans (fig. 9);
- double wall width only required when exceeding a specific building height;
- tubes, wires, etc. can be placed;
- high resistance to breaking and light weight.

When creating a sequence of space on the basis of the De Stijl 'Theory' it became apparent that a more or less skilled combination of colour patches in space was not to be regarded as the ultimate goal of activities. The main aim was directed at the dissolution of the closed space and the abstraction of the volume-defined elements. The topic of the 'dissolved cube' was soon found. The existing space within the 1:1 area acted as working fundament. The aim was to transfer a conceptual space lattice into elementary volume-determining wall surfaces by means of drawing (fig. 10).

The structural interpretation using the Brik-building bricks gave rise to several constructive problems. Wall elements freely suspended in space and made up of individual building bricks resulted in both a constructive and a design challenge (fig. 13). Which width would the panels - made of building bricks - have to have in order to provide of sufficient strength of the construction? How could the...
Fig. 9 A lintel was constructed in addition.

Fig. 10 The metamorphosis of a space lattice.

Fig. 11 Suspending by means of steel cables.
direction change from horizontal to vertical be accomplished? How should suspending be achieved? The experimental and atypical construction with the bricks also lead to some unusual forms of appearance e.g. wall surfaces appeared perforated due to a rotation of the building bricks through 90°. Compared to the conventional building style they looked more differentiated and of a finer structure. Depending on construction and manner of placement differing surface effects resulted. Reinforcement by means of zinc-welded steel tubes and the use of greater amounts of steel cables finally made for the planned disposition (fig.11). By means of double-layered bricks bonded by connector pieces board-like elements were come up with. Due to the fact that three hanging elements were suspended by the travelling working platform forward- and reverse movements became possible which made for an opening and closing of the space structure (Fig.12).

Within the course of a 24-hours project of the Vienna Academy for Applied Arts with students of architecture and design the topic 'confession-box' was treated. The possibility of covered wall surfaces amongst others was looked into. A further project with students of the study field handicraft concentrated on the topic of the 1:1 minimal space (fig.13). Ruth Mateus describes her work experience in the lab as follows: 'You are taken back to your childhood with all its hide-and-seek playing and building of tree-huts. Some find it childish, haven't we already played sufficiently with Lego? Yet, it is fun to get acquainted with the material. How far can we take it? How high can we build?'
process was studied integrating children therein. Pupils of an elementary-school class worked with the building bricks and were observed as to how they conceive space and tend to design it themselves (fig. 14).

Combined Use of Simulation Techniques
The service range of the Department of Spatial Simulation comprises various simulation techniques divided into two areas: Service range of the lab as of 1994 (fig. 15). The connection between the two areas is going to be increasing in the near future. A 3D-computer model of the 1:1 experimental area in the full-scale lab is to be regarded as a major contribution in this respect. The digital model can then be used for the preparation of 1:1 simulations. The simpler variant of a photo-montage has already been used. The existing 1:50 model of the sim-lab has also been used as an vicinity.

A first trial with elementary-school children was also performed. Within the framework of a research project regarding the possibilities and methods of civic participation at the Institute for Regional and Urban Planning at Vienna University of Technology a planning model for endoscopic purposes.

In the course of the above described project of a sequence of space on the basis of the 'De Stijl-Theory' computer-aided simulation techniques were used for comparison purposes. Both proportions in size of the individual building members in their relation Fig. 15 Service range of the lab (as of 1994)
the surrounding lab space were determined. The overall effect of light sources could also be demonstrated in the simulated space. When making up an image the user has numerous possibilities at his/her disposal, e.g. the tinting of specific parts or the definition of differing surface structure (fig. 16). Due to the ease with which ideas can be represented, the impression tended to be that the actual building of the plantings would be as easy. However, possible technical problems deriving from the translation into the 1:1 simulation were not taken into account.
Expansion Plans for the 1:1 Experimental Area: A full-scale lab is never complete. Apart from a few exceptions, a considerable extent of autonomous development of the required work- and auxiliary tools for 1:1 simulation is registered in the full-scale labs themselves. The European Full-Scale Modelling Association (EFMA) makes for their compilation and also acts as a 'conceptual tank' regarding this field. A full-scale lab is never complete. Therefore, it seems wise not to insist on a specific tool. Though basic equipment seems inevitable stocking of equipment can also be achieved step by step. At present there are plans at the Vienna University of Technology for the erection of ceiling- and staircase- constructions.

Movable light-weight ceiling construction

Users of the sim-lab have repeatedly demanded a 'boundary on the top'. In order to enable effective handling low weight of construction is a must. Presently, a construction of square-shaped tubes is being studied which is suspended by a tackle line and in the most ideal case could be manipulated by electronic motor. The solution of the 'problem of the oblique plane' is inevitable. As soon as a horizontal plane is rotated in space in an oblique direction this results in an enlargement of surface: the present rectangle might even become an irregular quadrangle under circumstances. Thus a telescopic extension possibility would have to be envisaged (minimum 0.5m, maximum 0.8x1.0m / Fig. 17). Depending on the specific execution even the simulation of double-curved surfaces could become possible. The insertion of a 'hinge' in the middle part might also be of specific advantage.

Adjustable or Accumulative Staircases

In order to overcome differing heights or angles some considerable efforts had to be taken, e.g. to enable the connection between floor and experimental surface during the 1:1 simulation. The purchase or development of a staircase building-kit would become necessary (Fig. 18,19). Oskos in Bologna has already developed a staircase with adjustable...

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*The second stronghold of the Department for Spatial Simulation (Full-scale Experimental Laboratory) at the Vienna University of Technology dealt with simulation techniques such as, e.g., and staircase. By the end of 1984, the first expansion stage of the area had already been completed.*
angle. A similar product is being produced by the Dima-co company in Attrang-Puchheim (Austria). If a variable length is desired this can be achieved by using cemented diamond plate elements. Individual elements can be stacked, in order to save storage capacity.

Expansion of the Teaching Range in the Lab
Comprehensive ideas on the integration of the full-scale lab into the study-activities were made. In the framework of the design teaching subjects the representation of so-called 'space characters' in full-scale was carried out as the first major attempt with the students in the study year of 1992/93. Valuable working experience was gained in this course as the new curriculum also was being developed simultaneously. Thus the possibility of resorting with a tailor-made teaching range for the full-scale lab was utilized. When developing the teaching range the working circumstances in the 1:1 experimental area requiring capacity restrictions were taken into account, i.e. that a number of no more than approximately 15 students per study course can be realistically handled. Furthermore, the 1:1 work as such is connected with risks calling for a working discipline by all those involved. In order to meet the demand of participation the study course is held in parallel sessions, however some study courses are held twice by a different lecturer. Exercises with study aims related to 1:1 of other institutes or institutions are taken into consideration in the schedule as far as vacancies are available. The extended teaching range as of study year 1994/95 is divided as follows (see fig. 20).

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3 The full-capacity operation of the full-scale lab is practically non-achievable with the present personal structure. As additional laboratory costs have not been assessed at all yet the present staff, expanded by lecturers and those invited to hold lectures lies to suffice. Around 12 assistants with numerous craftsmen's skills would prove particularly beneficial for the operation of lab.
Fig. 17 Movable ceiling with modifications of shape.

Fig. 18 The principle of a staircase with adjustable angle.
The principle of a staircase with variable length.

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The teaching range at the full-scale lab (1994/95).
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