A CONCEPTUAL MODEL FOR CAAD.

Neuckermans Herman
University of Leuven - Belgium

Preliminaries

Computer-aided design in architecture is still in its infancy. Although numerous packages are sold for drafting, for computation, for text processing, one can hardly say that CAAD has had a significant impact on architecture till now. On the contrary, there is a serious gap between the ongoing debate on architecture amongst the leading theoreticians on the one hand, and CAAD on the other hand. While architectural theory emphasizes strongly the semantic approach using methaphor as generator of concepts, CAAD seems to be based mainly on the problem-solving paradigm, on functional and rational reasoning. Both domains need mutual fertilization to exploit fully the potentialities of computers, now and in the future, and to direct the use of computers in paths which are beneficial for architecture. Architects need software which enhances their capabilities, software which is in tune with their designerly way of thinking, software which makes a more intelligent use of computers. Such an approach, in which the computer really is integrated in the design process, requires a conceptual system for architecture at the basis.

The conceptual model: levels, entities, grids, tests.

Architects seem to use a great variety of concepts in designing: types, building elements, spaces, blocks, planes, volumes, structure, etc. Using these concepts some of them follow a top-down procedure, they start from an idea for the overall shape of the building, others proceed according to a bottom-up strategy, they solve the parts first and assemble them step by step.
Whatever the approach, the most important design decisions are taken in the early stages of the design process. That is the reason why a more clever use of computers should start from then. If so, computers can provide the designer with facts and data he could never produce by hand. If the model is built up right from the beginning on computer, it can be used for computing those tests the designer judges to be relevant at that moment. Doing so, at the same time the unproductive translation of a design made by hand into a digital version of it, is avoided later on.
The conceptual model, shown in scheme 1, can be seen as a plan of work capable of handling this reality in the sketch design phase.

Levels
In this model the building program is subdivided hierarchically in 3 levels. Each level is composed of entities of comparable size or importance, necessitating a similar treatment in the design process. These 3 levels span the normal scope of architectural design, but can be extended upwards so as to encompass the urban design scale. For our purposes we distinguish:
1. the level of the masterplan,
2. the level of singular building blocks,
3. the level of singular rooms or spaces.

Each level can be seen as an entry point to the model, allowing the architect to start at the bottom, at the top or in the middle, depending on his personal way of working and/or the nature of the problem at hand.
Along with the progress of the design process into preliminary and detail design, the model has to be extended downwards with another level of building elements.

Entities
On the level of the masterplan, the designer manipulates basic building blocks called BUILDING TYPES, they contain the larger functional components of the building program. The masterplan of a hospital, for example, shows the departments and their layout around the circulation pattern, taken into account the contingencies of the site.
On the level of the singular building blocks or types the designer operates on SPACES .
Spaces are designed by the positioning of BUILDING ELEMENTS.

Grids
All these entities are positioned on grids, that are also intertwined in an hierarchic way. The mesh widths follow the logic of modular co-ordination. This guarantees that entities of a smaller level fit into the larger ones.
On the highest level, the masterplan, the grid is sized according to the spacing of the structure or loadbearing parts of the building. Space dimensioning follows the logic of a grid with smaller meshes derived from anthropometry (60 cm) and ergonometry (90 cm). Building elements are positioned on a grid with even smaller meshes, 30 cm in horizontal direction in first priority and 10cm in second priority. These grids have to be 3-dimensional and finer in the vertical direction than horizontally.

Tests
For each level a number of tests relevant for that level and that design phase is proposed (scheme 1, column 3). These tests also depend on the specificity of the building program (hospitals, schools, offices, housing,...).So will the traffic efficiency, for example, be relevant for the masterplanning of hospitals, but not at all for housing. Decisions about layout of spaces can be checked on floor surface, outer wall and glazing surface, heat loss and heat

gain, cost, 2D and 3D visual impact, daylighting, sunshining and sometimes room acoustical qualities.
The masterplanning of complex buildings on the other hand needs other tests: built volume, gross-net surface proportion, compactness, global energy requirements, circulation network efficiency, expandability, endowed surface, zoning and layout of equipment,...
Some of these tests, although they look the same at first glance, differ from level to level and/or from design phase to design phase. The key issue here is that the calculation has to be integrated in the process and be in tune with the precision of the model at that moment. A good example is the cost calculation through the design process.At the beginning it is based on the estimated cost per m² or m³, later on making use of ratios and the element method, at the end based on quantities and prices per unit.
Computation methods based on incomplete data, as it is the case in course of the design process, still have to be developed. They can be derived from and checked against the precise methods existing now for post-design calculation.

Evolution of the model

During the design process, the model of the building evolves from an elementary description towards a complete and detailed specification, graphical as well as alphanumerical.This is reflected in the use of drawings on increasing scale, showing more and more detail.

Intelligent zoom
Architects are very familiar with this scale dependent representation.
In the sketch design phase the most important options are taken related to shape, layout, structure and equipment.The building model is essentially composed of 'trailers' or 'leader planes' with elementary alphanumerical data attached to it. In the drawings, on 1/200 or 1/100, they are represented by single or double lines, thick or thin.
Preliminary design drawings are made for negociating the agreement of the owner and for asking the building permit. They show the layout and use of spaces, their access and openings, the facades, characteristic sections through the building, the materials and colour of the facades. Drawings, on scale 1/50, show these choices. In a layered external wall, for example, the layering will appear now.
Working drawings show precise dimensioning, materials and technology. These drawings on 1/20, 1/10 or 1/1, show full detail.
The proposed system has an intelligent zoom built in. It is a stepwise zoom with scale dependent representation, co-existing with the normal zoom (for positioning and better seeing) required to overcome the small size of computer screens, figure 1. The intelligent zoom adds information

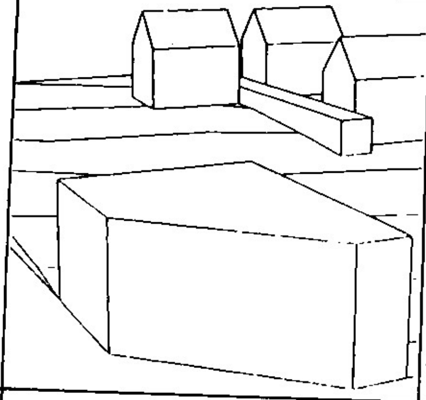
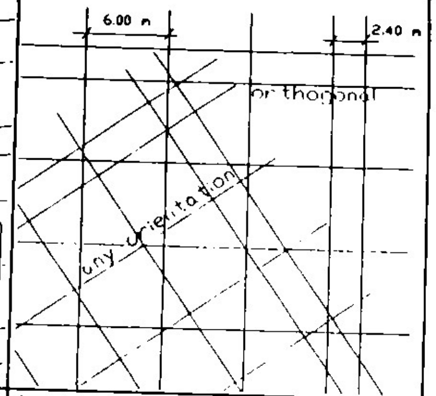
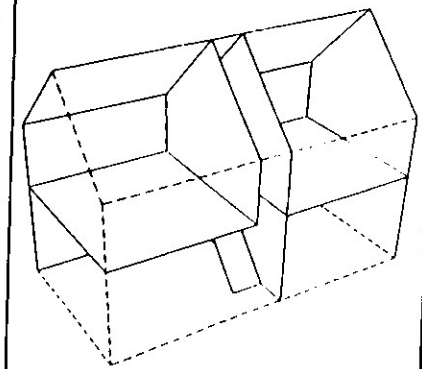
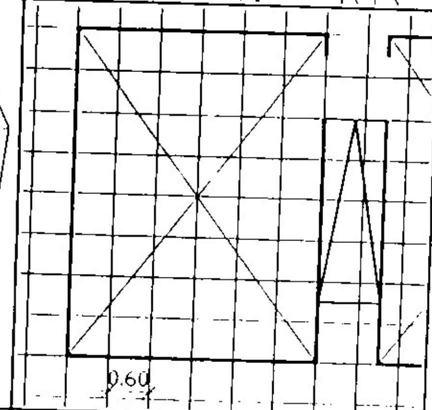
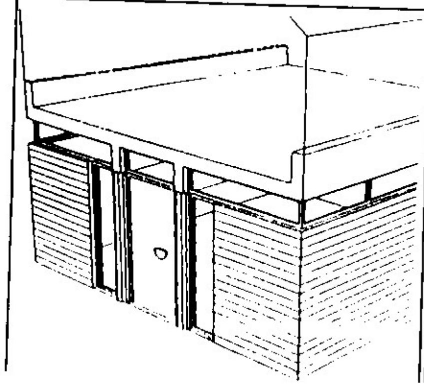
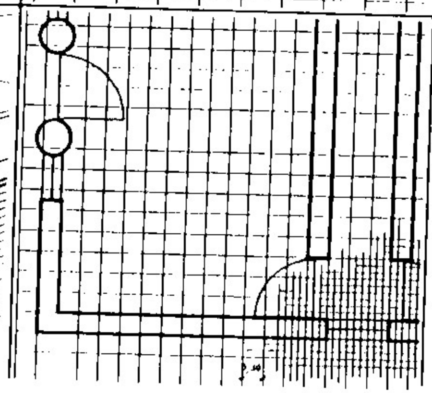
along with the increasing scale. It replaces primitive descriptions of building elements by more elaborated ones copying them from a reference library which is structured in an hierarchic way according to the principles of the international CI/SfB classification system, it is both graphical and alphanumerical.

Parametric building elements.
Graphical data are stored in the library in parametric form or as idiosyncratic solutions. They are copied in the project library, accepting the default values or they are instanced interactively or accepted as such. Nodes between different building elements appear to have to be solved manually, unless one uses prototype details which can also be stored and retrieved. Scheme 2 shows a part of the reference graphical library for walls and, as an example, 2 versions of cavity walls instanced in the project library.
Alphanumerical data or specifications are kept in the reference library, which is structured in descriptions of:
- Elements (E): parts of the building with the same function, structured according to table 1 of CI/SfB.. eg. windows, walls, floors,..
- Realizations (R): working units in which elements can be subdivided.
- Materials (M): structured according tables 2/3 of CI/SfB.
- Tests (T): on materials, realizations and elements.

This proposal for structuring or restructuring the existing reference documentation creates the opportunity to link the system with computerized technical building documentation codified according to CI/SfB.

Menu monitored choices.
The transformation of building elements into more and more detailed descriptions of it is monitored by menus like the one shown in scheme 3 for walls. These menus highlight the crucial choices in sketch design and preliminary design phase.They follow the logic of CI/SfB.
At the beginning of a worksession the designer chooses the design phase and scale he is working on. He can switch scale temporarily by hitting the appropriate menu item.
The options <u>view</u> and <u>section</u> give access to the appropriate graphical representation. <u>Materials</u> give access to a list of materials and/or realizations in case one likes to choose not within the proposed list. The option <u>characteristics</u> allows choices of properties, performances, qualities.
The idea behind these menus is guiding the architect through the relevant choices in that stage of the design and doing so to activate progressively those bits of information which ultimately will be needed for a full description of the building model.
The system is built on top of an existing drafting package. It remains primarily graphical, open, not deterministic but interactive.It aims at serving the designer, not at steering the process.

This paper is based upon a research project elaborated for the Ministry of Public Works - Brussels published in: Neuckermans,H., e.a. Rapport C : BB/SfB en de grafische voorstelling van ontwerpbeslissingen bij het computergesteund ontwerpen. K.U.Leuven, Afdeling Architectuur, Leuven (België), dec 1989.

program	name	geometry & attributes	grids: topology & attributes	tests
level 1 MASTERPLAN	- basic building types - masterplan blocks - circulation axes - site contingencies			. cost /m² or cost/m³ . surface / block . compactness . energy requirements . traffic . morphology . views and sights . shade and shadowing
level 2 BLOCK or TYPE	- rooms or singular spaces			. cost /m² based on ratios . surface and volume / space . temperature fluctuations . level of insulation . morphology
level 3 ROOM or SPACE	building elements: - wall - column - beam - arch - opening - door - window - stair - chimney			. gross-nett surface / space . cost based on elements method . comfort prediction . daylighting . sunshining . morphology . elementary stability

scheme 1

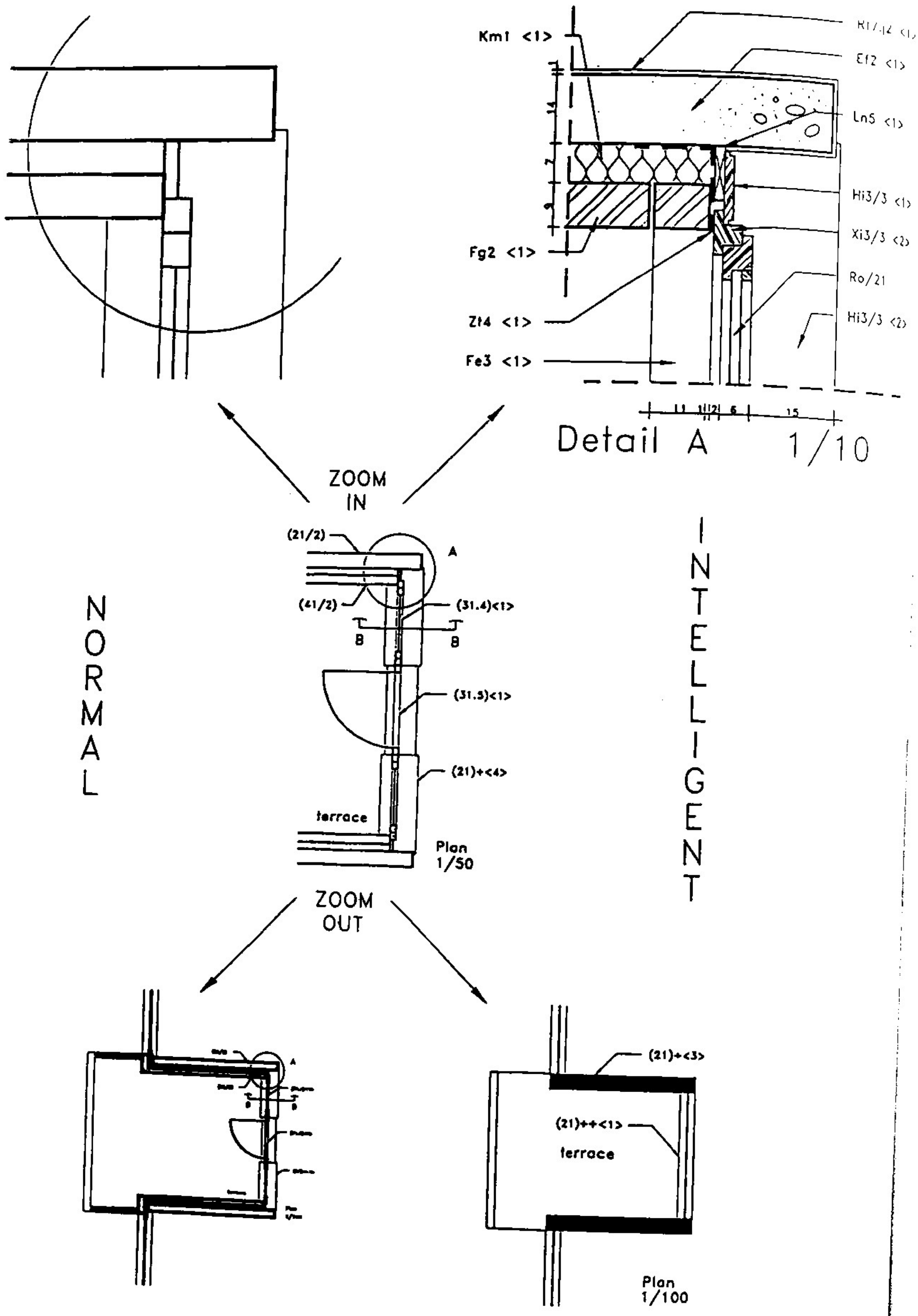
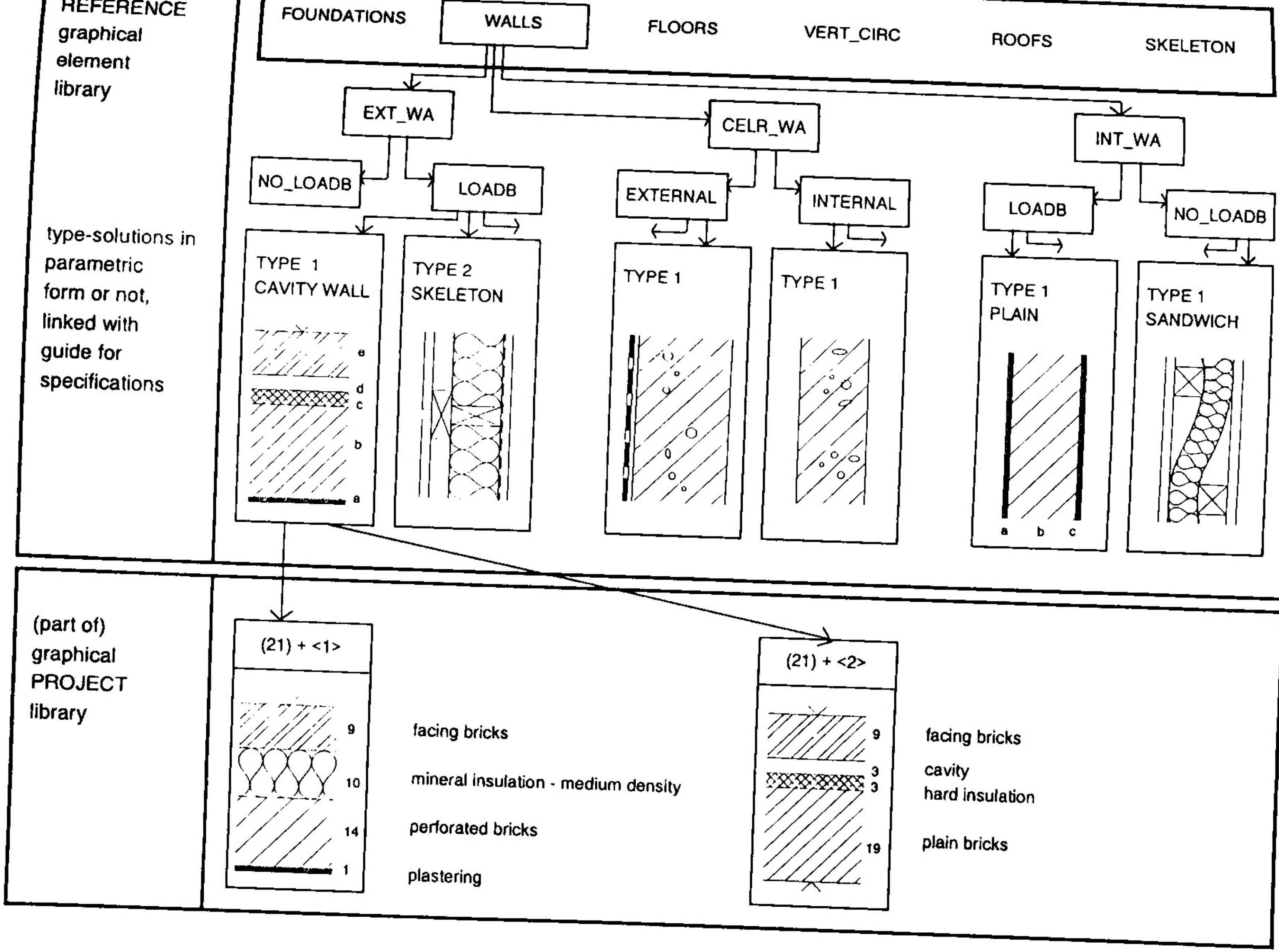

Km1 <1>
Ef2 <1>
Ln5 <1>
Hi3/3 <1>
Xi3/3 <2>
Ro/21
Hi3/3 <2>
Fg2 <1>
Zt4 <1>
Fe3 <1>
Detail A 1/10
ZOOM IN
(21/2)
A
(41/2)
(31.4)<1>
B
B
(31.5)<1>
(21)+<4>
terrace
Plan 1/50
NORMAL
INTELLIGENT
ZOOM OUT
(21)+<3>
(21)++<1>
terrace
Plan 1/100

Figure 1


REFERENCE
graphical
element
library
type-solutions in
parametric
form or not,
linked with
guide for
specifications
FOUNDATIONS
WALLS
FLOORS
VERT_CIRC
ROOFS
SKELETON
EXT_WA
CELR_WA
INT_WA
NO_LOADB
LOADB
EXTERNAL
INTERNAL
LOADB
NO_LOADB
TYPE 1
CAVITY WALL
e
d
c
b
a
TYPE 2
SKELETON
TYPE 1
TYPE 1
TYPE 1
PLAIN
a b c
TYPE 1
SANDWICH
(part of)
graphical
PROJECT
library
(21) + <1>
9
10
14
1
facing bricks
mineral insulation - medium density
perforated bricks
plastering
(21) + <2>
9
3
3
19
facing bricks
cavity
hard insulation
plain bricks

scheme 2

scheme 3

VERTICAL WALLS

MENU STRUCTURE