CAD COMPONENTS

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Abstract

CAD Components is a Swedish research and development project, which was finished 1994. It has resulted in a recommendation for how suppliers and other companies shall formalise the digital description of their products. Instead of using CAD system drawings to distribute components the CAD Components are defined in a neutral ASCII file. The components can have both graphics and alphanumeric information. In addition to a 3D description there are isometric 2D views defined to store a number of levels of detailing, to be used in different drawing scales. To make it possible to use components from the early design phase all the way to the use of the completed building, the components can be easily replaced by more precise supplier specific versions. For this reason each class of components has to have definition points and default rotation. The classification of the CAD Components is based upon the Swedish BSAB system.

1 INTRODUCTION

Three years ago, the Swedish Building Centre initiated a project to develop uniform rules for CAD Components. By that time several material supplier companies had started marketing their products by distributing floppy disks containing CAD graphics intended to be used in design drawings.
However, these libraries were not an immediate success, mainly for two reasons; the graphics were structured in an application-dependent way, and the detailing of

symbols was not suitable for the intended drawing types. As a result, the CAD Component project was met with interest from several companies including material suppliers, contractors, architects, structural engineers, HVAC consultants, as well as facilities management and software application companies.

Other, more sophisticated, projects are going on in other industries. In the ISO STEP standardisation project there are activities concerning part libraries [ISO CD 13584-10, 1994]. These part libraries are focused on very detailed 3D modelling for small components like bolts and nuts. This is not useful for the construction industry for the moment.

The motivation for taking part in the CAD Component work differed, from the material suppliers wishes to get their products out on the market, to the architects need for correct information and dimensions on available solutions.

Funding for the project was raised within this group of companies and the project has resulted in a report published in 1994 by the Swedish Building Centre, containing recommendations on how to specify a CAD Component [Svensk Byggtjänst, 1994].

All the approximately 30 participants formed a reference group, which met at a few occasions - at project start and when preliminary and final reports were presented. The actual work writing the recommendations was then performed by two experts aided by a working group of representatives from ten of the participating companies. This group met regularly to discuss the different issues of the project. The Swedish Building Centre appointed a project leader. A few companies were also involved in a test, which preceded the final version of the recommendations.

2 ISSUES ADDRESSED

In addition to overcoming the deficiencies of present component libraries, some issues essential to future applications were addressed in the project. The scope was broadened from simple CAD graphics to information of graphic as well as alphanumeric type, to be used in different applications throughout the construction process. Still, CAD applications would be the primary concern.

The components must fit into industry accepted information models. In figure 1 the CAD Components can be considered as Article/product (at the supplier) or Production result (the component in its final place fixed to connecting parts). On the generic level the components can represent the functional demands of Building objects [Tarandi, 1993]. Building Objects are complete walls, doors, ducts etc.

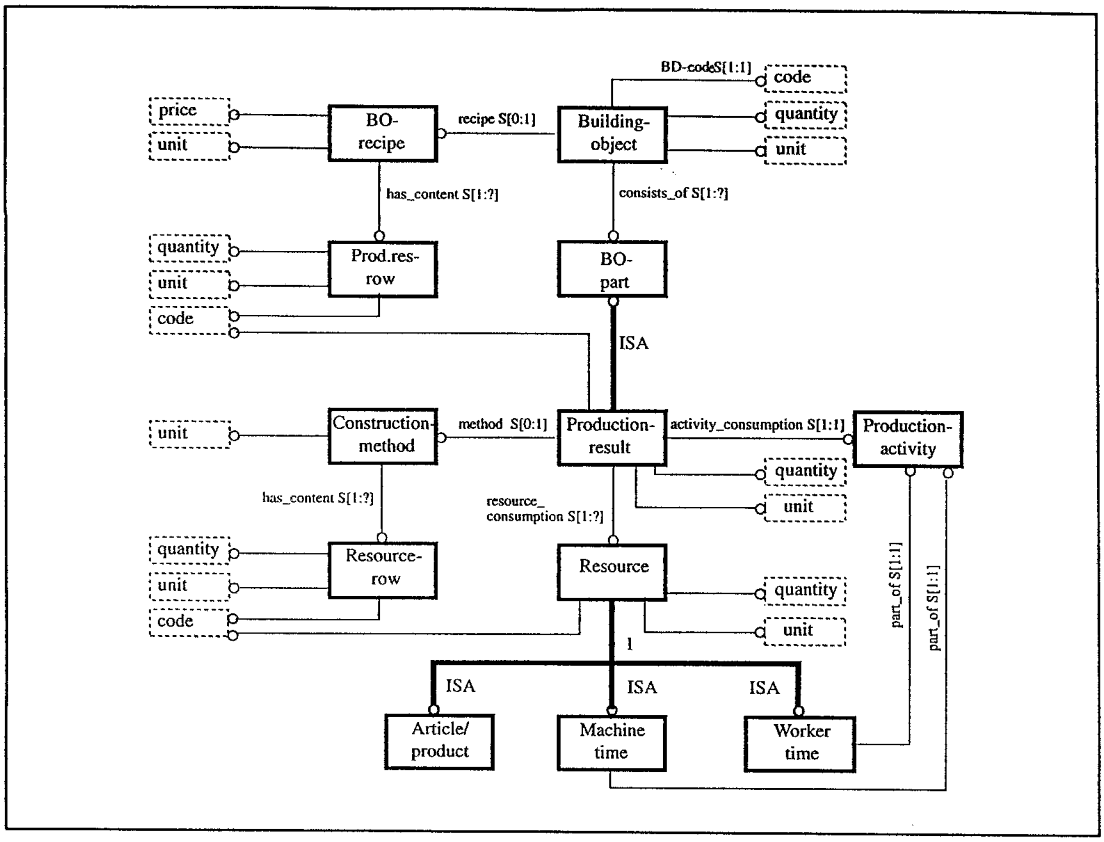

Figure 1. An information model for the Swedish construction industry.

CLASSIFICATION OF INFORMATION

The layering in CAD-applications are not standardised. Different applications name layers differently, use different delimitations for layers, and even divide into layers by different properties such as building elements, graphical elements, colour and/or line-types. The approach decided was to use separate classifications for each of these properties, thus allowing applications to sort information of components into its own layering structure. Also, existing classifications, whether standard or common practice, should be used when suitable.

REPLACING COMPONENTS

In order to use components from the early design phase all the way to as built documentation, it would be necessary to replace simple, generic components with gradually more precise and comprehensive information as represented in supplier specific components. In figure 2 the process of gradual determination of the components is shown.

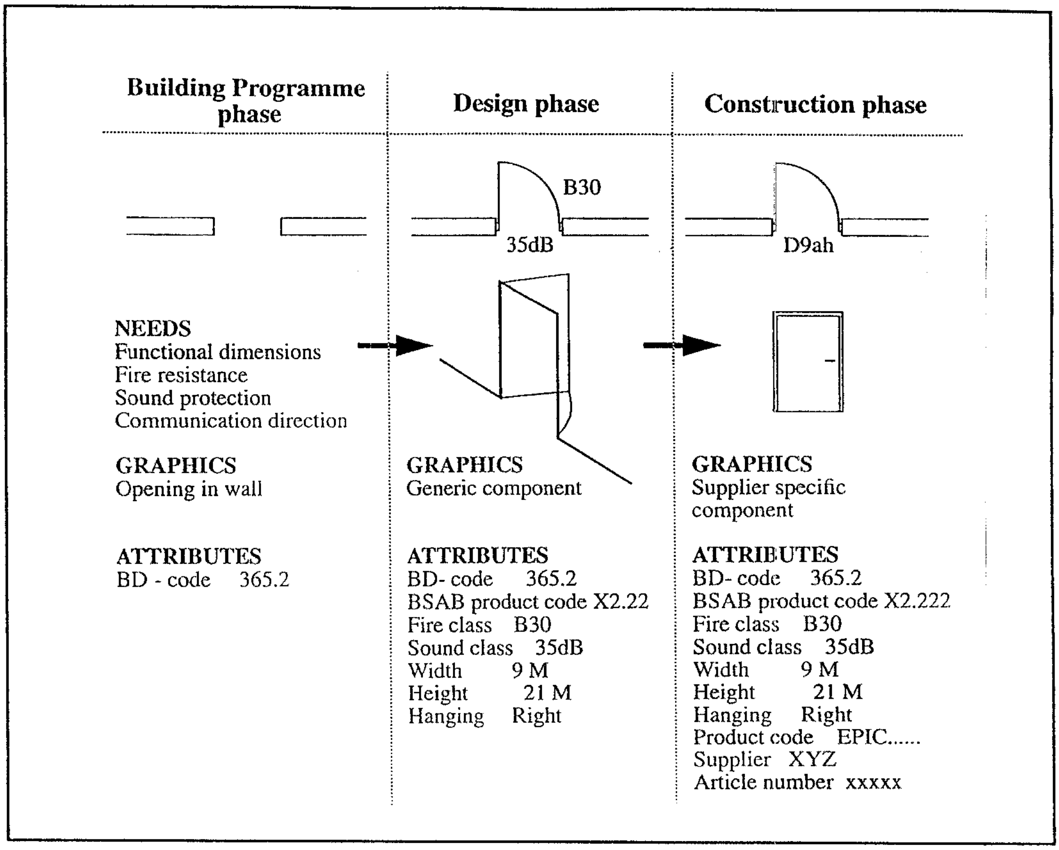

Figure 2. The process of gradual determination of components.

Essential to this would be the placement of insertion points and the default rotation of components. Alphanumeric information would have to be labelled in a uniform way.

PHYSICAL FORMAT

The requirements of CAD Components do not meet very well with existing CAD exchange formats, which aim primarily at drawing exchange. It was decided to use the NICC format, a neutral exchange format which was being developed in Sweden at the same time [Tarandi, 1993]. The NICC (Neutral Intelligent CAD Communication) format is model-oriented and uses building objects as the primary entities rather than graphics. The few extensions needed for CAD Components are now included in the latest version of the NICC specification. In the future, NICC will be redefined using STEP methodology.

GRAPHICS AND ALPHANUMERICAL INFORMATION

Uniformity in graphic appearance would need strict definitions of line types and line widths, fonts etc. Most of this is included in the NICC specifications, and the task was mainly to record a recommended usage. The three-dimensional part of NICC needed to be developed. Alphanumerical information defined as attributes should be labelled using tables of the CAD Component recommendations.

VIEWS AND DETAILING

There is limited usefulness in having a CAD Component broken down into parts consisting of real 3D solid objects. This is because of our way of working with simplified abstraction on our drawings and not the "real" views with hundreds of details. Another reason is that views of 3D solids don't give the right graphics on drawings, where there is a need for different line-widths and line-types to make it more easy to read the drawings and of course to correspond with standards and practice.

This results in the necessity to "draw" every view and level of detail of the component with appropriate lines. Of course you can use a 3D model view as background and part of the view. This also means that extra views, that are not available for a certain component, can't automatically be generated (see the part about views). Another implication is that an object like a CAD Component has to have both a 3D representation and 2D views if they are going to be used on traditional drawings. The connection between the object and it's 2D views for drawings is very important to define, see figure 3 [Tarandi, 1994].

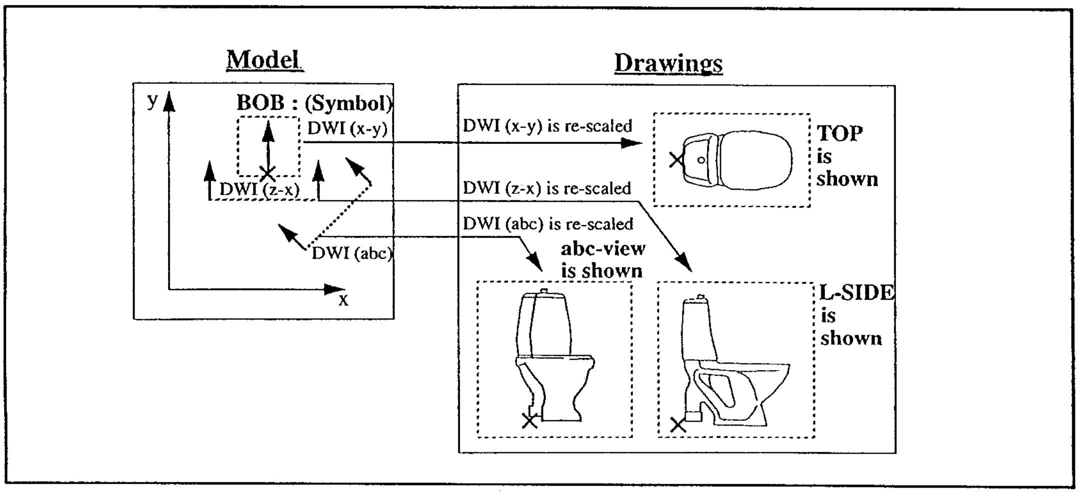

Figure 3. Relation between model and drawings.

Also there are different levels of detailing, to be used in different drawing scales. Views and detailing levels were to be defined and named (part of which is already included in NICC specifications).

VARIANTS

Many products are available in several dimensions, colours and/or material variants. These should be possible to describe within one component definition, in order to avoid unnecessary repetition. Different dimensions could be discrete as well as continuous within an interval, and should affect dimensions of graphics. Complex components could be partly or altogether assembled from sub components by reference to external symbols. Variants that do not affect graphics could be accomplished by alternative values for attributes.

3 UNRESOLVED ISSUES

LIBRARIES

The project only deals with the definition of each CAD Component. In many cases it would be convenient to have these collected in libraries, perhaps together with other product information. A library structure could look like the figure 4, where it is possible to find supplier specific components based upon product groups or find generic components for different Building Object classes according to the Swedish BSAB codes.

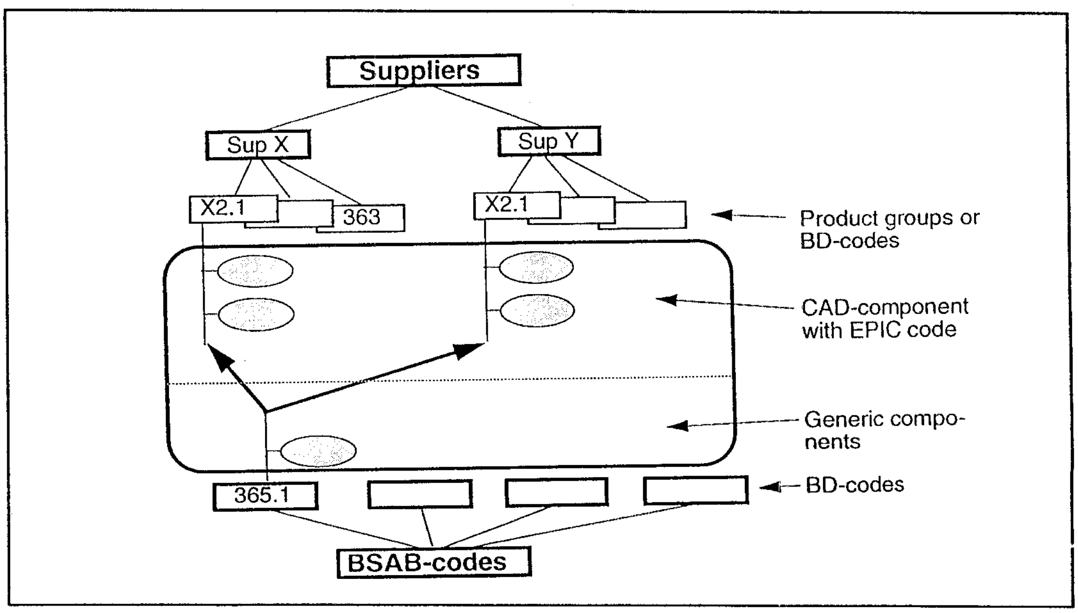

Figure 4. A possible library structure.

SOFTWARE

The creation of commercial software for conversion of components and handling of libraries is left to the initiative of application software companies. The recommendations were only to describe some possible methods to handle CAD Components. Unfortunately, the present depression in the Swedish construction industry has decreased the interest to create this software to an absolute minimum.

AUTHORISATION

Another problem with commercial application of the recommendations is the lack of an official body which can assure proper use of the recommendations, for application software as well as for the components themselves. Almost certainly there is also need for support on how to use the recommendations.

DISTRIBUTION

For now, CAD Components can of course be distributed in the "traditional way", directly from material suppliers or software application suppliers. However, a higher degree of usability would be possible if all - and updated - information was available from one source. Then users could in each instant search for appropriate components on the market.

DEVELOPMENT AND COMPATIBILITY WITH EMERGING STANDARDS

When the recommendations have been used for a while, there will most probably be a need for revisions based on user reactions. Also, the STEP standard as well as other international and national standards (for example new Swedish building element tables and "EPIC" European product code tables) will call for an update. Today, there is no organisation that will take care of these tasks.

4 THE RESULTING RECOMMENDATIONS

PHYSICAL FORMAT

The NICC format used is represented in ASCII. Each record occupies one line, and can quite easily be interpreted visually (without computer software). Other CAD symbol definitions use CAD systems like AutoCAD, AES and Intergraph to store symbol sheets [BPS-publikation 107, 1992]. In figure 5 an example from a stove is shown. The view is the top view and the detailing level is the overview (2xx) suitable for scales around 1:100. LGR stands for Line Graphics and LCO for Line Co-ordinates.

```
VIE TOP
LGR 201   0.35   000000
LCO     0.00   -600.00   900.00 L V O
LCO     0.00      0.00   900.00 L V O
LCO   600.00      0.00   900.00 L V O
LCO   600.00   -600.00   900.00 L V O
LCO     0.00   -600.00   900.00 L V O
LCO   300.00   -200.00   900.00 L V O
LCO   300.00   -400.00   900.00 L V O
LCO   600.00      0.00   900.00 E I O
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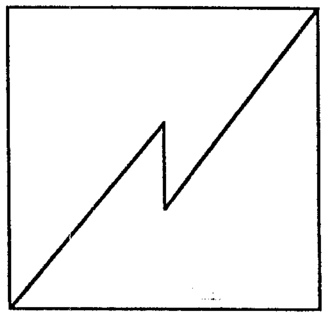


Figure 5. Part of NICC file for top view of a Stove.

GRAPHICS

Recommendations concerning line-types, line-width, colour and fonts are included. Line-types and line-width refer to Swedish standards for the construction industry. Colour can be set individually for each graphical entity using RGB values ranging from 0 to 99 for each primary colour. The colour is recommended to be used for illustrational purposes, while different CAD systems can use any attribute for screen colour. Fonts are restricted to ISO standard fonts normally used in drawings.

ATTRIBUTES

Components have been divided into classes equivalent to one building element or a few similar building elements. Each of these classes is given a set of mandatory and optional attributes. These tables, however, are not completed within the project, and have proven to present quite a large task in itself. This will of course be a problem with application, and limit the use of CAD Components, particularly in other than CAD applications. Nevertheless, the approach has been found relevant and the tables can later be complemented.

DETAILING AND ADDITIONAL INFORMATION

Four levels of detailing with respect to scale have been defined; contour for scale 1:200 and smaller, two overview levels for scale 1:100 and 1:50 to 1:20 respectively, and the most detailed representation meant for scales 1:10 to 1:1. Also there is an option for scale dependent symbolic representation, commonly used for electrical and HVAC components. All of these categories are supplementary, meaning that each representation contains all graphics to be shown in a drawing.

Additional complementary information, which is not connected to drawing scale, is defined for areas needed for operation and service, and points and areas for connections to other building parts and systems. The connections can have attributes to define the type of system they are connected to, pressure, current and so on. Also, there is a category defined for handles or snap points of the component.

VIEWS

Six orthogonal and eight isometric standard 2D views have been defined. Orthogonal views are TOP, BOTTOM, FRONT, BACK, LEFT and RIGHT, see figure 6. For components in openings (like doors) some of the views are replaced by sections. The isometric views have been defined at 45 degree angles horizontally and vertically, and are NWOVER, NEOVER, SEOVER, SWOVER, NWUNDER, NEUNDER, SEUNDER and SWUNDER. Each view can contain graphics with a number of the detail levels described above. In addition to this, user defined views in external files can be defined. These user views can be raster pictures.

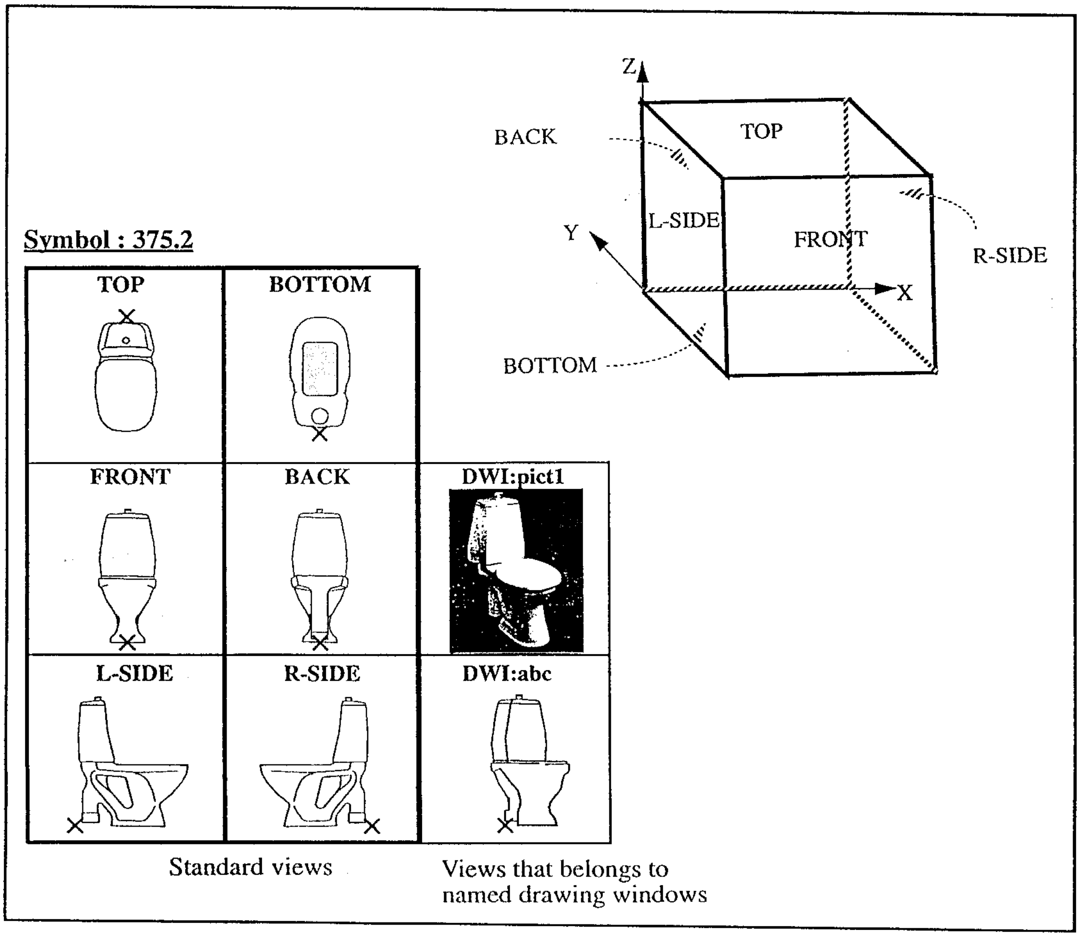


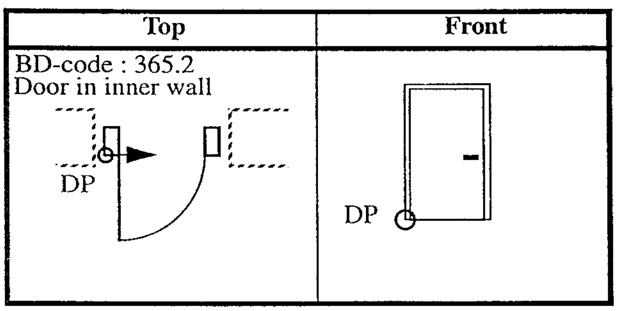
Figure 6. Six orthogonal views and example.

3D GRAPHICS

In addition to the 2-dimensional views, 3D graphics can be supplied as wire-frame or simple surfaces. Solid modelling or more complex surface modelling has not been supported, judging that it would be of very limited use compared to the effort. Eventually, STEP definitions for advanced 3D graphical elements will be available.

ORIENTATION

The graphics are defined in a local co-ordinate system of the component. Origo is situated at the definition/insertion point, and the views are projected on each side of a box with a size corresponding to the maximum values of the component in x, y and z directions. For each component class, as described above, the standard location and rotation of the definition/insertion point (DP) are defined. Figure 7 shows an example for the class of doors.



Attribut	
Identity	M
Height	M
Width	M
Frame thickness	M

Figure 7. Definition point and orientation for doors.

PARAMETRIC AND COMPLEX COMPONENTS

A simple method for parametric components has been included. Points and dimensions can be declared and used as variables in 2D or 3D graphics. For each variable, an interval or a list of permitted discrete values can be supplied. Lists of values are also supported for alphanumeric attributes. Complex components like suspended ceilings or walls can be defined as an assembly of standard parts arranged as arrays.

5 THE TESTING

Realistic testing of the specifications was accomplished as a validation before publishing the recommendations. In the testing material suppliers, an application software company, an architect and a client participated.

The tests consisted of producing documentation drawings for an existing hospital, using a number of CAD components. The application software company produced more than 100 CAD components and an application to convert and use them with the Medusa CAD system of the architect. The components originated from several material suppliers involved in the project.

Components were converted and inserted into the drawings. Inserted components were also exchanged, and quantities calculated from the alphanumerical attributes. The participants were then interviewed. In this procedure, no significant technical problems or shortcomings of the specifications were detected. Deficiencies of some "classical types" were spotted, though; lack of structure and inadequate detailing in the components, and the need for more user-friendly applications. This emphasises the need for an organisation to support producers of components and applications.

6 FUTURE ACTIVITIES

Now that the results of the projects have been published, they are free to be used by anyone who wishes to create CAD Components or software to handle them. However, in the present state of the Swedish building sector this will not be a self-generating process. The next step to encourage commercial use will have to be promotion of the recommendation.

Several features of the CAD Components have been integrated into the present release of the NICC format, which will also shortly be published.

The many experiences gained in this project are also being input into ongoing research at the Swedish institutes of technology [Jónsson, 1994], particularly in the areas of product models and document handling. Also, the experiences will influence coming standards in classification for the construction industry.

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