MODEL OF DESIGN PARTS AND ITS USE TO THE DESIGN TEAM

MINA POPOVA
Department of Building Design
Chalmers University of Technology
412 96 Gothenburg, Sweden

Abstract This paper discusses the impact of the choice of representation on the final result in design and construction projects. Representation is an integrated part of the design process used by architects as a communication tool to help them present a concept to their clients and other consultants. The representation choice, in addition, reflects the professional's perception of the design process and the architectural artefact. Architects' offices work with a wide range of problems - aesthetic and spatial issues, detailing, choice of materials, and systems design. The multiplicity of representations enriches the understanding of these issues. Today, the model-oriented approach in design is common among both architects and leading software producers for the construction industry. While STEP (Standard for the Exchange of Product Data) aims at developing very comprehensive product models, we examine the possibility of building up a small-scale model responding to the information needs of a design team. In our research work, we view a model of design parts as a suitable carrier of information allowing the designers to store data reflecting their accumulated and refined professional knowledge and experience. Besides, the team of architects can later easily retrieve information needed for future design reuse from the model. To reuse design solutions and learn from previous work is an essential part of the professional culture. The construction industry as a whole has been slow in implementing information technology to improve the work methods. Neither have architects' offices used the full potential of this technology to structure information and rationalize the design process. The objective of this study is to examine whether information technology makes it possible to organize all the design information in an office archive. The proposed model of design parts relates to national standards and universal models for product data representation and exchange, such as STEP. Today, the construction sector is becoming increasingly aware of the potential of the model-oriented approach both to rationalize the design and construction process and offer designers new options to store, broaden and reuse professional knowledge. We have used the information modelling language EXPRESS to describe our concept.

Keywords: design and construction process, model-oriented approach, representation, information technology, STEP.

CAADRIA '98 : Proceedings of The Third Conference on Computer Aided Architectural Design Research in Asia.
eds. T. Sasada, S. Yamaguchi, M. Morozumi, A. Kaga, and R. Homma
April 22-24, 1998. Osaka University, Osaka, Japan. Pp. 233-242

1. Background and Objective

Many researchers have studied communication in the design and construction process, which is characterized by an intensive information flow and shifting roles of the participants (Landsdown and Maver, 1984). Up to the present moment, architects have not used the full potential of information technology to structure information and rationalize the design process. The objective of this study is to examine whether it is possible to organize all the design information in an office archive which we called *a model of design parts*. The subject discussed here is related to research for a licentiate thesis presented at the Department of Building Design at Chalmers University of Technology (Popova, 1997). The information modelling language EXPRESS is used to describe our concept. It is chosen because it is a part of STEP (Standard for the Exchange of Product Data) since 1993, the language definition being given in the document ISO 10303-11. In addition, the language is platform-independent and sharable (Schenck and Wilson, 1994).

An architect is concerned with topics of diverse nature - aesthetic and spatial issues, detailing, choice of materials, and systems design (Lindgren, 1992). Since the architectural artefact with all its aspects is a part of an extremely complex reality, the need of a model - a representation - describing the artefact is indispensable. Different representations, such as sketches, drawings, 3D models, photos, simulations, digital videotapes, and alphanumeric documents, are chosen to convey the information in the most appropriate way. These representations must always be interpreted and for this purpose the designer relies on shared and empirically validated knowledge as well as on subjective knowledge based on taste, judgement, preferences (Carrara, Kalay, et al., 1992). Representations are not limited to the visual aspects of an architectural artefact; they should rather be regarded as information carriers providing ground for discussion, evaluation, and feedback in a design project. Knowledge representation in the design process is also referred to as an 'explicit, symbolic expression of some reality or idea for the purpose of communication and representation' (Carrara, Kalay, et al., 1992). Thus, from an architect's point of view, representations are a communication tool and an integrated part of the design process.

Usually, consultants from several different firms take part in a construction project, forming a design team which dissolves once the work is accomplished

(Kalay, 1997). Since no single person can possibly survey an entire project, much valuable professional knowledge and experience are lost. Moreover, many architects' offices do not systematically document work results, nor do they store project information in a structured fashion. Yet, reusing design knowledge and learning from previous work are essential parts of the professional culture of both architects and engineers (Johansson, 1996). What kind of representation designers choose depends on how they regard the architectural artefact and what information they consider useful to exchange, store, and reuse. The richer the information content and the greater the complexity of these representations, the more urgent the need of a formal system which provides rules to navigate through the model and manipulate it (Kirkby, 1990). Architects should also keep in mind that an artefact has a relatively long life cycle during which other professionals will need to access the design information when making decisions about facilities management, reconstruction, and recycling. This is probably the main reason to consider storing and retrieving sharable information in the design and construction process an issue of crucial importance.

2. Proposal

This text after another first order heading begins at the left-hand margin.
We propose a model of design parts i.e. a tool to structure all kinds of information and representations used in a project. The metaphor used when discussing the contents of the model of design parts has been the project archive of the architects' office. Our starting point was the working situation of the architect and the kind of references used. We have also taken into consideration the developed international standards for computer-interpretable representation and exchange of product data. The STEP community works on 'a neutral mechanism capable of describing product data throughout the life cycle of a product, independent from any particular system' (Haas and Burkett, 1995). International Standard ISO 10303-225 'specifies an application protocol (AP) för the exchange of building element shape, property, and spatial arrangement information between architecture, engineering, and construction (AEC) application systems and related systems using explicit 3D shape representations' (Haas and Burkett, 1995).

Although STEP defines very comprehensive models, not all the information designers need in their work is standardized here. For instance, the above mentioned standard states that the following are outside its scope:

'- 2D shape representations and draughting presentations;

- The contents of building standards;

- Implicit representation of building element through selection of standard parameters;
- Structural analysis of building structures, including loads, connections, and material properties;
- Thermal analysis of buildings;
- The assembly process, joining methods, and detailed connectivity of building elements;
- Approval, revision, and design change histories;
- Building elements without explicit shape representation;
- Bills of quantities.’

Our efforts were focused on conceptualizing a tool to structure information not included by international standard but, nevertheless, essential for the work of a design team. The proposed model of design parts will serve as a supplement to the universal STEP models. We found support for our ideas in the work of other researchers who state that product models have to be developed as systems to fit various needs (Björk, 1993). Originally, we aimed at modelling a tool to store and retrieve technical solutions, which are approved according to a quality programme within the office or another validating process. The term ’technical solutions’ is used in a broad sense to mean the solutions used by the architect when dealing with aesthetic and spatial issues, and the systems design that are vital to the final result of the design process. Exactly how the model of design parts is built up and what it may contain should be a decision of the architects’ office.

At present, the whole construction industry is striving to reach a consensus on adopting a common standard for product data representations and exchange, thus achieving interoperability. Keeping this in mind, we propose a general outline for the model of design parts, which corresponds to the structure of the existing universal models the STEP community is developing. Since duplication of information causes ambiguity and hampers efficient communication, the model of design parts should contain only specific data, needed by designers but not found in a STEP model. *Figure 1* presents the basic structure of the model of design parts.

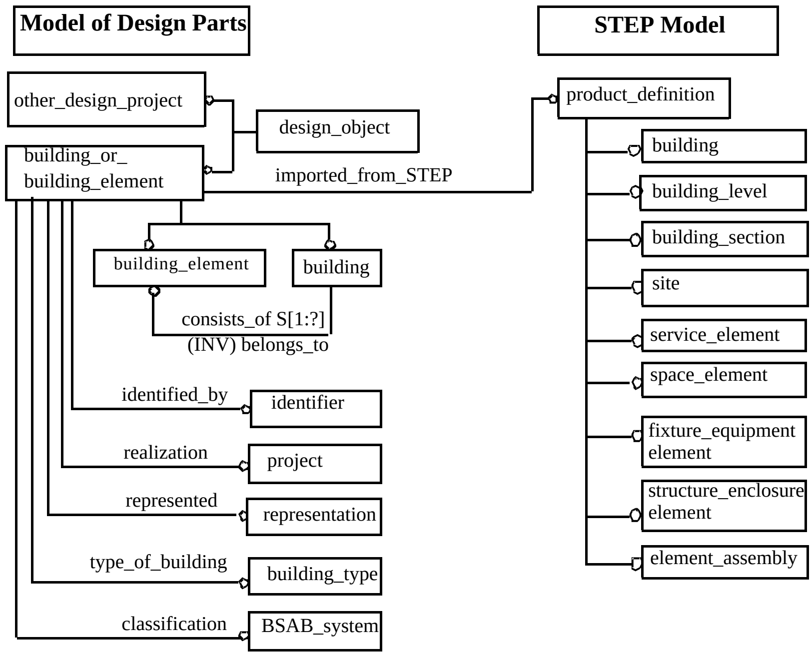

Figure 1. Basic structure of the model of design parts.

The very general supertype *’design_object’* is used to describe all design tasks in an architect’s practice. The majority of the projects are design and construction projects dealing with buildings or building elements. The terms ’building’ and ’building element’ are standard definitions used in ISO 10303-255 (Haas & Burkett, 1995). We have made an attempt to model the important attributes of the architectural artefact i.e. the ’building_or_building_element’ object as shown in the *Figure 1*. These attributes, besides representation, include identifier, project, building type, references to STEP, and probably to a national classification system like the BSAB system in Sweden or the SfB system in the UK, for instance (Svensson, 1990). Because these classification systems have been a part of the branch culture since the 1950’s, STEP allows integrating of information from them into a product model. We list ’representation’ among the most important attributes because of the role representations have. Representations are a communication tool reflecting an architect’s design concept, his/her perception of the artefact, as well as the significance of communication in the design and construction process.

In our model, all necessary information concerning a project can be structured and saved. We would like to demonstrate how a design team can store information about a window. Our choice is motivated by the fact that a window is an indispensable component of almost any structure. A team of architects will be able to store specific product data needed in work; here, one can find a designer's notes, descriptions, references, and all types of representations depicting a product. All standard information about a window can be imported directly from a STEP model, thus avoiding unnecessary duplicates of product information in the model of design parts. We also show how our concept refers to developed international standards in *Figure 2*.

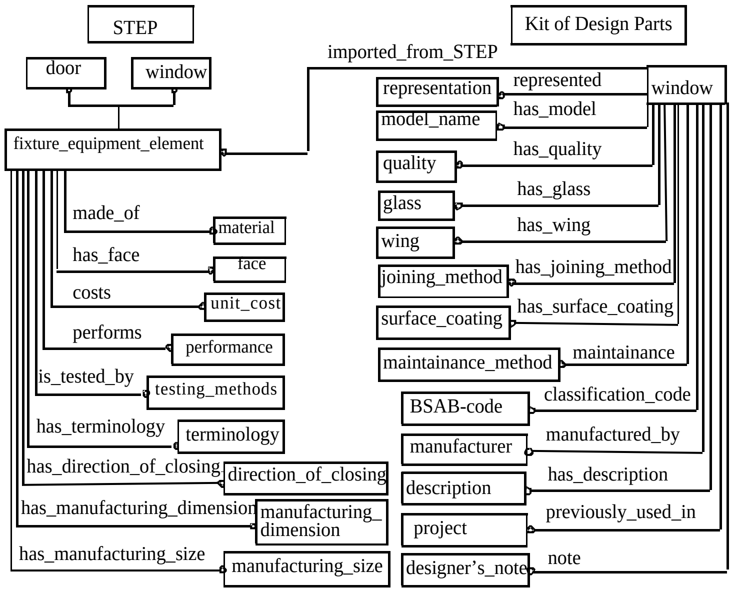

Figure 2. Illustration of information about windows that may be stored in the model of design parts.

Today, technical solutions may be represented in various forms such as sketches, digital drawings, 3D-models, descriptions, manufacturer's information, photos of tested details, records following up previous construction solutions, video-tapes. Nevertheless, a considerable number of paper documents are produced in a project and our intention was to include even these in the model of design parts. Representation forms serve different purposes and the user should decide himself/herself how to save information, depending on the specific needs. *Figure 3* below illustrates further what kind of information the representation object may contain according to our concept. The user of the model of design parts is thus able to search the database using a STEP-code, a classification code, a project name, a product category, a directory or a combination of the above.

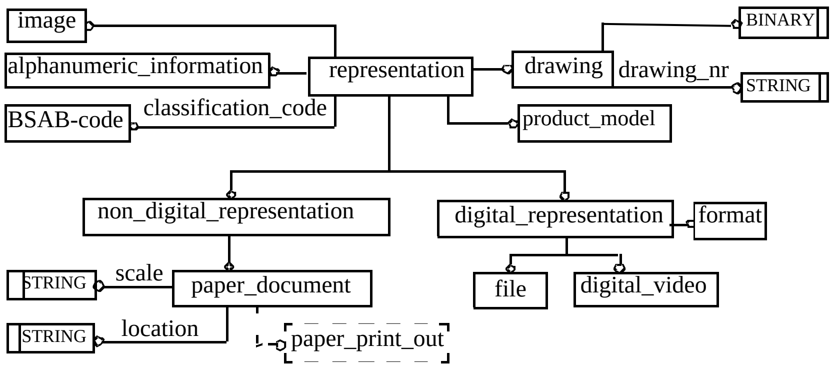

Figure 3. Basic structure of the representation object.

Regarding the kinds of data that we are using, the system is best described as a multimedia information repository. The system can have a browser-based interface. One of the most essential requirements for such a system is that it should support an adequate communication of design representations.

3. Discussion

Our initial idea has gradually evolved into a concept of an object-oriented database having the capacity to store all relevant information a design team reuses. When considering the implementation of this concept, we could define two types of problems: technical and human. At present, some technical obstacles are: the security issues, the lack of standard data models, and the lack of a standard query language for objects. On the other hand, the absence of specific technical solutions at the moment should not be a hindrance for further work on the concept. Today, new technologies are being developed so fast that a concrete solution may be available in few months. The more challenging topic here is the human factor since it involves radical changes in the work methods of the construction industry. The design team has to develop and follow routines for evaluation, storage, and retrieval of information. All actors: architects, structural engineers, HVAC engineers, manufacturers etc., shall have to adapt to the changes in the design and construction process. Professionals are usually motivated to accept a change when they are convinced that it will lead to better results or that their work/firm will benefit from this.

If an architects' office can manage the information generated in a design and construction process, it will not only heighten the productivity of the team but also strengthen the quality of the artefacts (Wikforss, 1994). The transformation in construction involves even a deep understanding and a cultural acceptance of digital information on a broad scale. In the light of all said here, we can conclude that the building industry as whole and design teams in particular are facing a very exciting but also a very demanding future.

The model-oriented approach is not new but it has attracted increasing attention from the research community, the industry, and software producers (Augenbroe, 1995). A common representation of the artefact can be equally interpreted and shared by all collaborators in a project. Research results have shown that a team increases the efficiency of work by using a common model to communicate and test design concepts (Fruchter and Krawinkler, 1993). A model comprising all different kinds of information and representations - the design parts - becomes an efficient tool and a valuable information carrier in an integrated process. Information organized in a model which is sharable and independent of operative system can easily be reused by other professionals in the later stages of an artefact's relatively long life cycle (Tarandi, 1995). The model of design parts, which can be used by all actors in the construction sector, provides the team with entirely new options to reuse professional knowledge and even to broaden the architects' role in fields such as facilities management and recycling.

4. Further Research

At present, we are trying to define a project frame for research in the field of collaborative design. Architects from the Department of Building Design and civil engineers from the Department for Structural Design at Chalmers University of Technology will participate.

One of the objectives will be to implement our concept of a model of design parts as well as a case-based reasoning system for structural design as described by Johansson (1996). This will involve a commercial object-oriented database management system (OODBMS), a CAD-programme as a design tool, and a case-based system. Besides sharing a common data model, we will focus on the issues of a collaborative design process. Another objective is to study a design process where the client/owner, the architect, and the engineer meet at the start of a project in order to formulate the design concept(s). Other researchers (Kalay, 1997) have already focused the attention on the issue:

> "...the engineers cannot begin to design the structure of the building before the architect has specified its shape. Yet, the architect cannot specify the shape of the building without considerable specialized information that is rightly the province of the engineer."

Our intention is to let the architect, the engineer, and the client/owner to communicate on regular basis throughout the project in order to discuss and evaluate design solutions, which will enable us to study the collaborative design process.

References

Augenbroe, G. (ed.): 1995, *COMBINE 2 - Computer Models for the Building Industry in Europe* Delft University of Technology, Delft

Björk, B.-C.: 1993, *Byggproduktmodeller - Nuläge* Statens råd för byggnadsforskning, R27:1993, Stockholm

Carrara, G., Kalay, Y. E., et al.: 1992, Multi-Modal Representation of Design Knowledge, in *Computer Supported Design in Architecture. Mission. Method. Madness,* ACADIA, University of Southern California

Fruchter, R. And Krawinkler, H.: 1995, A/E/C Teamwork in *The Second ASCE Congress of "Computing in Civil Engineering*", Atlanta

Haas, W. and Burkett, W. C., (eds): 1995, *Product Data Representation and Exchange. Part: 225 Building Elements Using Explicit Shape Representation* ISO TC184/ SC4/WG3, Project Draft

Johansson, P.: 1996, *Case-based Structural Design - Reusing Design Calculation Document Information* Division of Steel and Timber Structures, Chalmers University of Technology, Publ. S 96:3, Gothenburg

Kalay, Y. E.: 1997, P3: An Integrated Environment to Support Design Collaboration, in *Representation and Design*, ACADIA, Cincinnati, Ohio

Kirkeby, O. F.: 1990, The MODEL Concept in *NBS-DATA Seminar*. *Byggnadsmodell-produktmodell*, Esbo, pp.14-23.

Landsdown, J. & Maver, T. W.: 1984, CAD in architecture and building, *Computer-Aided Design* **16** (3)

Lindgren, H.: 1992, A Framework for Computer-aided Reuse of Architectural Desing Solutions in *CIB W78 workshop on Computer-Integrated Construction*, Montreal

Popova, M.: 1997, *IT and the Architect's Role* Division of Design Computing, Chalmers University of Technology, CTH-A CADLAB 1997:1, Gothenburg

Schenck, D. A. & Wilson P. R.: 1994, *Information Modeling: The EXPRESS Way* New York, Oxford University Press

Svensson, K. (ed.): 1994, *Neutral byggproduktmodell för integrerad projektering, produktion och förvaltning – systembeskriving* Byggnadsstyrelsens informationer T:123, Huddinge

Tarandi, V. (ed.): 1995, *NICK II - vidareutveckling av format för neutral intelligent CAD-kommunikation* AB Svensk Byggtjänst, Rapport 19, Stockholm

Wikforss, Ö.: 1994, *Information Technology Straight Across Swedish Architecture and Construction* Division of Computer Aided Design and Visualisation, Chalmers University of Technology, CHT-A CADLAB 1994:3,Gothenburg