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Design with architectural objects in industrialised house-building

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ABSTRACT: This paper introduces a research project with the aim to develop concepts and tools for architectural design, taking the ideas of “behaviour settings” as a starting point, to enable a more relevant holistic view in object oriented design of buildings. In this paper we introduce the concept of “architectural object” as a representation of a real “situation” involving people, behaviour, experience and environment, based on our idea that architectural design results in “situations” similar to but not identical to “behaviour settings”. The purpose is to define a selection of possible configurable architectural objects that reflect the variability of situations possible to achieve using an industrialised building system. As architectural objects they shall be able to manage comprehensive information to be used in process tools for building design, production and facilities management. This paper presents a theoretical foundation for the use of architectural objects in a BIM environment. It also presents an analysis of the object structure that is applied to configure building projects in a company with off site production of volume elements, and proposes how these objects could be developed into architectural objects. The conclusion of the case study is that the company architects’ view of the volume elements and their constituent design modules implicitly includes a conceptual model of user activities and phenomenal properties of the built environment. By formalising these concepts and making them explicit as part of the architectural object, the related information can be accessible to all parties in the processes, design, production and facilities management. The information can be used for gaining experience of the building in use, for simulation, as input to brief development, and other analyses of interest. In an industrialized building process including volume elements, architectural objects could be developed during the product development phase and applied during building project design as configurable design units. Future research will investigate further possible application of the idea of architectural objects, specifically to support the architectural design process in industrialized house-building.

1 INTRODUCTION

1.1 *Demands for industrialized building*

The building industry, in Sweden and internationally, has not shown the same development in productivity and industrialization as the manufacturing industry, much due to its project oriented operation and its favourable economy based on rising land costs (ECTP 2005, Egan 1998). The sector has also been criticized for quality failures and high costs. An industrialization of the industry has been pointed at as a measure of meeting these problems (Bygghuset 2002). A general opinion in the building industry is that a new and sustainable industrialization must avoid social and architectural problems as those apparent in the industrialization efforts of the European Mass-Housing movement after WW II, e.g. the Swedish

‘one million dwelling program’ in the 60’s and 70’s.

1.2 *Conditions for architectural design*

Architectural design has different conditions in different building processes. Traditionally, the building process is project oriented with a unique composition of participants in each project. The architect often has an initial role of defining the physical framework regarding function, materials and aesthetics, also affecting later decisions concerning technical solutions, production and economy. The work is governed by established routines and a clear division of responsibilities. It is characterized by strong time pressure and cost awareness in combination with limited possibilities of cooperation in early stages between design and production (Borgbrant 2003, Winch 2002).

Different strategies have been developed in order to handle problems related to lack of integra-

tion among stake-holders in the construction process. Turn-key contracting aims at facilitating early cooperation between design and production, but criticism has been raised due to its prime focus on production costs, neglecting life-cycle costs as well as architectural design issues (Byggkostnadsdelegationen 2002). Strategic partnering gives opportunities for work in integrated teams promoting reuse of experience and making the processes more effective (Miles 1996 and Kadefors 2002). Lean thinking is characterized by a strong customer focus where every activity that does not contribute to the product's customer value is questioned with the purpose to eliminate these from the process (Womack and Jones 1996, Josephsson and Saukuriipi 2005). Object-oriented ICT makes information management more efficient, promotes integration of design activities and supplier networks, and supports individual customer choice (Olofsson et al 2004, Wikforss 2003, Ekholm et al 2008).

1.3 *The need for a comprehensive architectural view in the design process*

The shift from drafting oriented CAD to object oriented CAD enables new ways of managing and structuring design information (Eastman 1999). To an increasingly larger extent object oriented design tools are used in building design today. The development supports not only the production of drawings and visualisation, but also the development of BIM, Building Information Models. The combined project models are not only intended for use during the design phase, but also during production and facility management. The question of how to organise and exchange design information is a major subject of R&D today (ECTP 2005), exemplified by the IAI activity to develop the IFC standard of how objects and their properties may be exchanged among actors (Kiviniemi et al 2008).

However, not only the organisation of design information and how it is transferred between actors are problems, but also how the process is organised for creating the information. By enabling concurrency of contributions from different actors, the conditions for analyses of interacting factors, including a holistic architectural perspective are at hand (Anumba et al. 2007).

Modelling of buildings based on their constituent technical parts or functional relations among spaces, based on quantifiable specifications in building briefs, is supported today by object oriented design tools. But regrettably there is no software support for managing information about user activities which according to Ekholm (2001) would enable a more complete representation of the information generated and communicated in the design and facilities management processes.

1.4 *"Situations" as the result of architectural design*

Architectural design is since ancient days understood to include aesthetical, functional and technical aspects on buildings and built environment. Design does however not only affect the built environment but also intentionally affects the humans who use and experience it (Steadman 1975, Hillier 1996). The built environment sets conditions and gives possibilities for human activity; therefore it is relevant to conclude that architectural design handles man and building as a system (Ekholm 1987).

The environmental psychologist Roger Barker has introduced the concept "behaviour setting" to refer to a concrete unit of behaviour and milieu, with the milieu circumjacent and synomorphic to the behaviour (Barker 1968:18). According to Amos Rapoport "the environment can be conceptualized as a system of settings within which a system of activities take place" (1997). Christopher Alexander's similar concept "pattern" is described as a design unit with a strong emotional content referring to concrete systems of place and human activities and experience (1979). The inseparable unit of social activity and built environment, is named "fabric" by John Habraken in a similar attempt to capture the essence of the built environment in use, as a living organism (Habraken 2005).

These insights support our hypothesis that architects design with socio-technical systems or "situations" in mind. A situation can be described as human activity carried out in an environment with phenomenal values that support a specific mind-set and experiences during the activity. We call a situation seen as a design unit "architectural object". Architectural objects refer to situations of people, behaviour, experience and environment as a unit.

Even though the architect's work results in "situations", practical methods and tools that take these as a starting point are lacking. To describe activities and their properties as activity objects may be considered a step forward towards such tools. Eastman and Siabiris (1995) have developed a prototype CAD-system which illustrates the possibility to explicitly handle information about activities and their relations to the built environment. Ekholm and Fridqvist (2000) have shown a model schema where building space is defined by building elements, and how user activities can be related. Ekholm has designed a prototype information system for activity modelling as an add-on to ArchiCad (Ekholm 2001). Szuba (2005) presents another system as an add-on to ArchiCad, to be used for defining building spaces from activity spaces and functional requirements on the building. The question whether phenomenal values

could be linked to objects composed of activities and built environment creating architectural objects is however yet unexplored.

Object-oriented CAD-tools available today take as starting point objects representing building elements and spaces. In addition to that, an architectural object needs to include objects representing user activities and phenomenal properties; see Fig. 1.

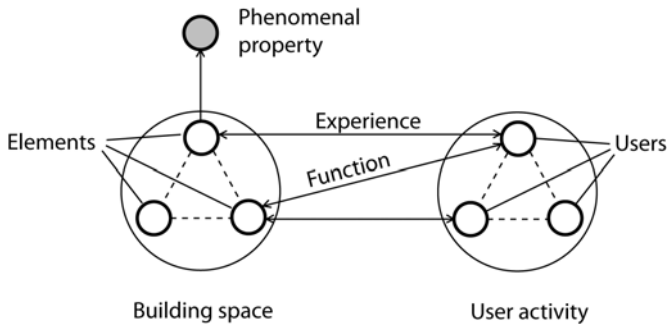


Figure 1: Constituents of an architectural object

1.5 Aim of the research project

This paper introduces a research project with the aim to develop concepts and tools for architectural design in industrialised house-building. The ideas of “behaviour settings” are taken as a starting point to enable a more relevant holistic view in object oriented building design. The purpose is to develop configurable architectural objects that reflect the versatility of an industrialised building system. As architectural objects they shall be able to manage comprehensive information to be used in information systems for building design, production and facilities management.

The research may be understood as a continuation of the group’s earlier work concerning modeling of human activities in building design, e.g. the BAS-CAAD project (Ekholm and Fridqvist 1999), and the definitions of the concept of space, initiated by (Björk 1994), and further developed by Ekholm and Fridqvist (2000) and Ekholm (2001). The context for the project is firstly design of house-building projects for industrialised building, where we think the methodology with architectural objects may have the largest impact in a short time perspective.

1.6 Aim of this paper

This article deals with the theoretical foundations for the use of architectural objects in a BIM environment. It also presents an analysis of the object structure that is applied by a company with off site production of volume elements to configure building projects, and proposes how these could be developed into architectural objects.

1.7 General research questions

Achieving high architectural quality in industrial house-building regarding function, aesthetics and adaptability is a fundamental requirement on industrial house-building. Knowledge of how questions of architectural design could be integrated in process and platform development needs to be developed in order to strengthen customer focus and optimize issues on design with regard to e.g., function, aesthetics, buildability, logistics, environmental consequences and energy consumption.

The research questions in this project relates to process and platform properties and ICT-support, three areas of importance for architectural issues in industrial house-building:

- Could architectural objects serve as a tool in the development of processes for building platform development and building project design to support questions of architectural quality in concurrent engineering?
- Could architectural objects be a foundation for investigating functional and aesthetic versatility of the building platform, considering production engineering consequences, with the objective to enable high architectural design standards and adaptability to various customer preferences over time?
- Could architectural objects in ICT-tools support issues of architectural quality in process and product platform development and in the configuration of a specific building project?

1.8 Methodology

The project will build on the research teams’ experience of how user activity and building could be handled in an integrated way as architectural objects to accentuate a use-centred perspective in the design processes. The aim is to develop prototypes for CAD-tools handling architectural objects in a BIM-environment. The project’s specific focus is on the architectural design requirements on ICT-support in concurrent engineering for industrialised house-building. However this focus will be set against a firm theoretical framework covering also process and product design.

The research project will design a model for process and product development with related criteria for the organisation of object oriented information management for industrial house-building, focusing on its architectural design. The model will be built through literature studies, interviews with key actors, and empirical studies.

The interviews with key actors aim at completing the literature studies and address people involved in architectural design concerning traditional and industrial house-building respectively,

as well as people in other industries with functions involving the gain of information on aesthetical, functional and technical customer requirements. Design support with architectural objects will be tested using object-oriented CAD-tools in a BIM-environment. Specific objects and routines needed in the development may also be created by the researchers using the object language GDL in ArchiCad. We will however cooperate with software developers for supplementary competence.

The work will be organized in two steps. A thorough mapping of the information flow in product development and building design at an industrial house-builder will be conducted. The product portfolio and its modular components will be studied from the point of view of functional grouping and assembly, and how production flow and quality confinements can be organised. Based on this, suggestions will be developed for how architectural objects could be implemented in the routines for product development and configuration in the company.

The second step is a profound study concerning feasible demands on product and process platforms in accordance with architectural design. This step will include development and testing of prototypes in cooperation with software developers and design consultants.

1.9 Organisation

The project is part of the Lean Wood Engineering program initiated by the Swedish Governmental Agency for Innovation Systems, VINNOVA, in collaboration with 12 industrial partners from wood manufacturing industries as well as the building sector. The work will be carried out as a post graduate project at the division of Design Methodology at Lund University, Lund Institute of Technology. Cooperation is intended with companies involved in industrial house-building, e.g. those participating in the LWE-program.

1.10 Expected results

The project will develop a methodology and prototype software for handling object oriented ICT support in industrial house-building with focus on demands set up in the context of architectural design, emphasising customer values as function, aesthetics and adaptability.

The project results should be of significant importance to designers and companies within the field of industrial building, particularly for dwellings, supporting the development of company specific process and product platforms and the realization of actual building projects.

2 THEORETICAL FRAMEWORK FOR ARCHITECTURAL OBJECTS

2.1 Behaviour setting

A behaviour setting, according to Barker, “consists of one or more standing patterns of behaviour-and-milieu, with the milieu circumjacent and synomorphic to the behaviour”; Barker mentions e.g. “a basketball game, a worship service, a piano lesson” (Barker 1998:18). The synomorphic property is explained as “an essential fittingness”, i.e. behaviour and milieu are fundamentally coordinated. Behaviour settings consist of behaviour-milieu parts, i.e. “things and occurrences that have both physical and behavioural attributes” (ibid:19). A behaviour setting has a certain degree of interdependence of its constituent parts, and an independence from other behaviour settings (ibid:23). Attributes of behaviour settings include among others geographic and temporal locus, occurrence and duration, occupancy time, functional position of inhabitants, action patterns, and behaviour mechanisms.

2.2 Architectural object

In section 1.4 an architectural object was described as a “situation” involving people, behaviour, experience and environment. A definition of an architectural object may be developed in relation to Barker’s “behaviour setting” concept and to the “space” and “activity” schemas developed by Ekholm and Fridqvist (2000) and Ekholm (2001) respectively. An architectural object should not be seen as identical with a “behaviour setting”, but as an architectural design unit that may support the design of certain activities and their related built environment.

A tentative conceptual schema for an architectural object has been developed, see Fig. 2 below. In the schema an Architectural object may be functionally composed of other architectural objects, and consists of a human Activity, located in a Natural or built environment, the latter seen as a Construction entity space. The Activity has Duration and Relations to other Activities. It may be functionally composed of Activities, and is carried out by Persons using Equipment. An Architectural object has none or many Phenomenal property experienced by a Person. A piece of Equipment has Duration, it may be used in different Activities, and composed of other Equipment. The Construction entity space is based on a spatial view of a Construction entity, and it is composed of Construction entity parts seen as Enclosing elements.

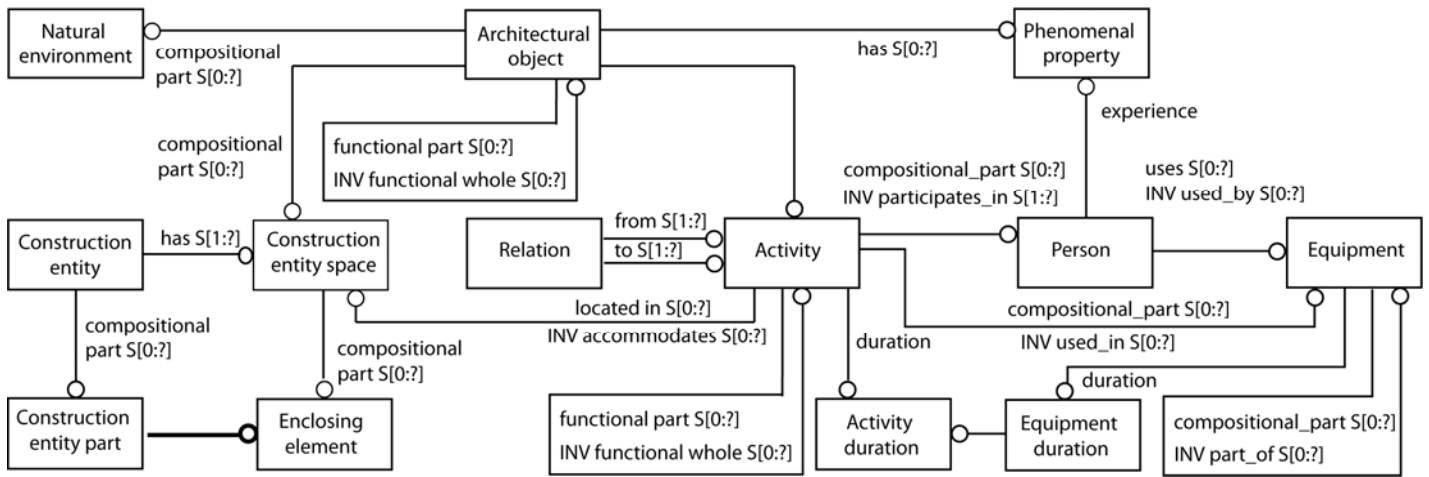


Figure 2: A tentative conceptual schema for an Architectural object

The phenomenal property represented in the schema is intended to allow documentation of the intended phenomenal values of people active in the real situation. Such intended properties are e.g. feelings of comfort, beauty, and safety. These in turn are used as the basis for determining requirements on material properties of the built environment that may result in such feelings. This procedure is well known in design theory, see for example, *The House of Quality Methodology* (Cross 2000:120).

Documents resulting from a traditional architectural design process naturally display the built environment, while information about its use has to be interpreted by the receivers of the documentation. Thus “one complete half of the ‘ensemble’ is completely missing” (Steadman 1979). By ‘ensemble’ Steadman refers to the composite system of man and building in use. Through object oriented information management, it is now possible to represent also those concepts that in a paper based process traditionally are left to the reader’s own interpretation. The concept of architectural object tries to capture the whole ‘ensemble’ seen as situations composed of both user and environment including its desired phenomenal properties.

3 CASE STUDY

3.1 General

The possibilities for rationalizing product design process and information management are considerable within industrialised house-building. Object oriented configuration and BIM-models could show noticeable synergy effects even in production and facility management. This case-study aims at studying modularisation in a company working with volume elements. These include spaces and could in a traditional design process by an architect

be interpreted as “situations”. The aim of the case is to explore whether a modularisation process could be based on architectural objects as well as on technical-functional objects.

3.2 The company

The studied company Open House Production AB is part of the Norwegian OBOS-group. The company is specialised in industrialised house-building, producing apartment buildings based on volume elements. During its 5 year operation about 1500 apartments have been finished in Oslo Norway and the Swedish Malmo region. Client has been another affiliate to the OBOS group, which has benefited the exploration of the concept.

3.3 The concept

3.3.1 Modules and composed elements

The Open House concept is based on lightweight steel and factory outfitted volume elements, inserted in a prefab steel frame on site. Other prefabricated parts are e.g. balconies, stairs, and installation shafts mounted on site. Long-time relations with sub-contractors and suppliers are contracted for parts not produced in-house. On-site production is limited, including foundation, finishing, service fittings and particular façade systems, reducing on-site activity to 2-3 months for a block of 40 apartments.

The system volume elements are named modules both as design objects and in its physical form. The system modularity is cc 3900 mm, leaving 3600 mm maximum room width. Length of modules is limited to house type or transport restrictions. Room height is set to 2600 mm. Prefab units, e.g. balconies, are handled as modular objects in the design process even if they are not volume elements. All modular units follow detailed type drawings of their compositional parts, e.g. wall elements with windows, doors and installations. These could also include prefabricated bathroom

units or whole kitchen outfits from sub-contractors, with possible customer choice on a component level.

3.3.2 Technical interface

System details comprise the standardized interfaces between system modules and frame, its compositional parts, installations etc. as well as the interface to sub-contractors prefabricated completions. These predefined interfaces and limitations on system modules are considered being the system platform, still offering extensive freedom for architectural design in each system module as well as prefabricated unit.

3.3.3 Product development

Product development has mainly involved continuous multi-disciplinary system development with additional system details. Due to openness to customer requirements and architectural design the scope of the system platform has gradually been widened. A number of projects have also resulted in an extensive library with preferred design solutions for system modules, compositional parts and prefabricated units. These have been stored as reference files and objects in the evolved BIM environment, and are forming a product portfolio of configurable objects.

3.4 Building project design

3.4.1 CAD-organisation

The company's architects and engineers have a design and CAD coordinating role in a project and are responsible for the project's BIM model (see Fig. 3) developed in ArchiCad. The BIM-model is part of a project network, but information exchange is still based on dwg or pdf-format to external consultants through a common project server.

The BIM model acts as object database in the project, however also linking non-object oriented drawing files. From the model object, information for e.g. drawings, calculations, and 3D-visualisation is presented. The model object's role for supporting configuration and coordination of the different project parts is vital for the design and production preparation process, even though the company does not use a PDM-system.

The BIM information is based on a number of objects represented in different product library and object reference files. In the project BIM model, these objects and additional drawing data are represented through hierarchically linked files corresponding to parts, assembly units, factory or prefabricated modules, and finally the project level.

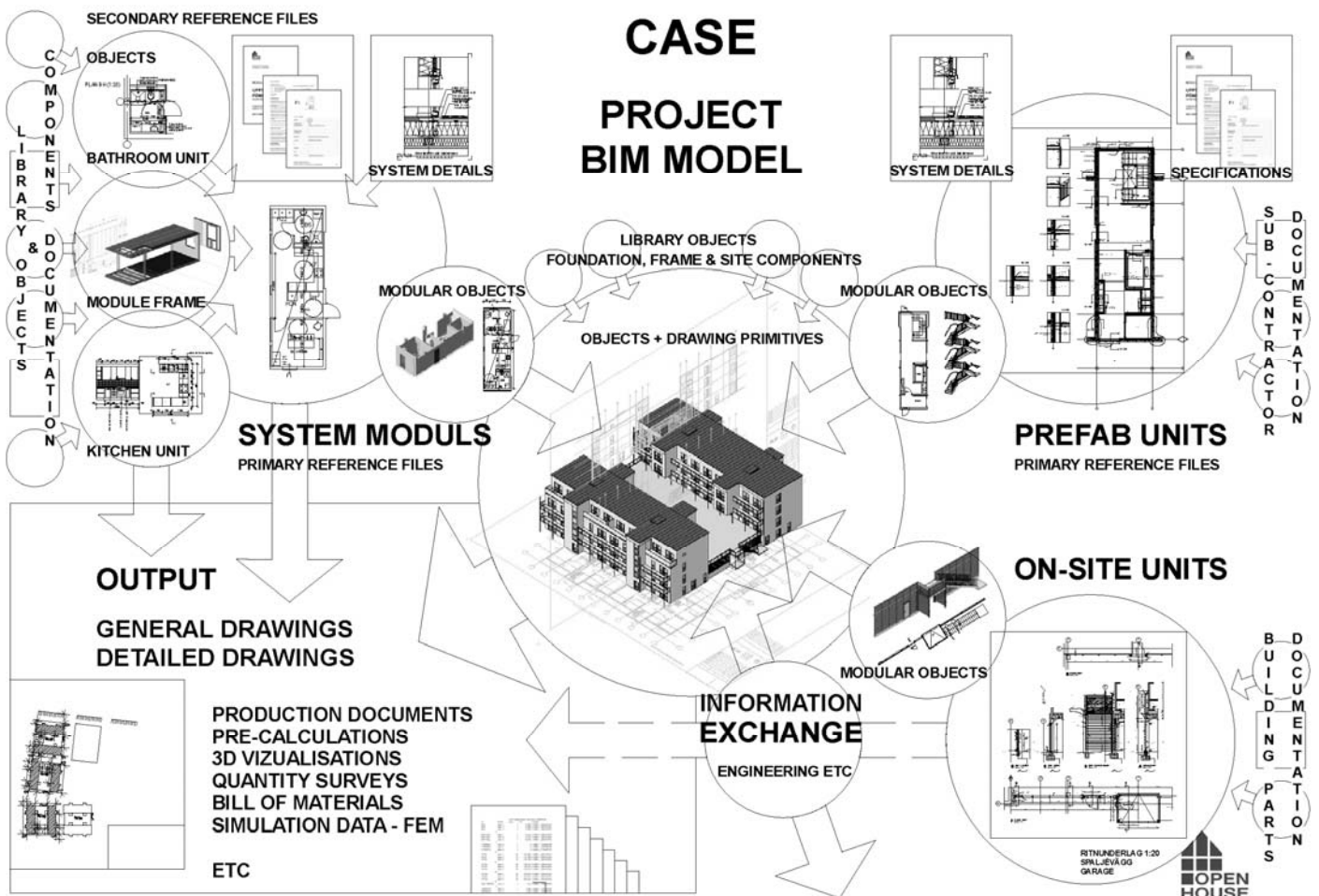


Figure 3. The company's project specific BIM model.

General project information is received from the project model acting as the main BIM model, while factory drawings for volume elements are based on the project module files. Use of layers may collaterally limit the information carried on to superior levels and reduce file sizes.

3.4.2 *Brief development and customization*

In the building brief development phase the architect works with the client on a traditional building program, supplemented by 3D-sketches with objects in a preliminary project model. This pre-configuration in 3D is mostly using modular reference objects or mixing other reference objects, supporting the project modularisation as well as visualising the architecture to the customer. Customized design is this way offered to meet specific customer requirements, even though the compliance with the platform may sometimes be hard to predict for the architect and others.

3.4.3 *Project configuration*

In the systems design phase a more precise modularisation of the project model is done, turning it into a BIM model through configuration with reference objects, compiling it into a file structure and defining areas of responsibility. In general, existing reference objects, as general and high level as possible in the reference object file hierarchy should be preferred, reassuring that also structure, HVAC etc. will fit the general design and have proper system documentation. This also limits the need for external consultants in the particular project. By using predefined modular reference objects the architect can focus on the functional and spatial user perspective. But while the configuration methodology is not yet fully formalized the risk for sub-optimized design is obvious, as changes are called for in a non supported way. This often requires a third production document stage.

3.4.4 *Detailed design and production preparation*

All reference objects in the BIM model should have back-up information in its associated reference files. This, in order to support generation of production drawings and other documents. If new reference objects or combinations have been included this may however call for detailed interdisciplinary design work, often affecting system details as well. These drawings are mostly made in 2D. This could be if a façade material is altered or if new prefab balconies are introduced in the particular project. If this hasn't been called for long in advance such additions to the system platform may cause coordination problems between disciplines, resulting in increased costs and time delays.

4 ANALYSES

4.1 *Building design*

4.1.1 *Platform development vs building design*

The manufacturing industry distinguishes between product development and product styling through individual customer choice, so called configuration (Hvam 1999). Industrialised house-building has a clear process focus and applies the same strategy (Lessing 2006). Industrialisation still requires a reduced variation which is difficult for the building industry, since customer demands for flexibility has a strong tradition. The possibility for design versatility in a project is limited by the degrees of freedom inherent in its configurable parts.

4.1.2 *Building design and adaptability*

During the design phase both user activities and their relations to the building must be taken into account from a typological perspective. In apartment housing it is possible to identify building types according to the supporting structure and its floor plan versatility (Wallinder et al 1976, Wallinder1982). The relation between user and building must also be determined in a long term perspective. This was the aim of the Structuralism theories developed by the Swedish National Board of Public Building defining the concepts of Building related and Activity related building elements (Ahrbom 1983), and the concepts Support and Infill developed by the Dutch SAR (Habraken et al 1974). This structural thinking corresponds to the idea of architectural objects, where user activities are central and should be enabled by the technical platform.

4.1.3 *The role of Cad-programs*

The development of object-oriented design with information stored in object models, has shown to be of importance not only to the design process and its production of drawings. The BIM model can also act as a project data-base and the object information handled according to needs formulated by the process stake-holders is of importance in the whole live-cycle of the building. Research and development in this area mainly concern standards for information processing and exchange between stake-holders in the process. However, only minor efforts have been made to understand the conceptual phase and how a BIM model originally is initiated and organized. In the design proposal stage, an object oriented systematic based on building elements demands a more detailed knowledge of the project than generally is at hand before a more detailed design is effectuated. As these initial steps

address customer requirements and spatial-functional aspects, e.g. activities and aesthetics, they are furthermore hard to combine with the technical building element perspective.

In industrialised house-building where the technical systems are well defined a methodology with architectural objects would however be supportive not only in the brief development and conceptual design phase, but also for configuration in the proposal design phase, and also for handling user activity related information in the facility management phase. This could however invoke demands for specific software functionality in order to support the object systematic along with existing BIM object systematic. It may e.g. concern the representation of the BIM objects and their properties, and consequently how objects and files can be associated. Of certain interest are topics of object systematic as architectural objects relate to or include other objects and their properties, and may have user-defined parametric properties.

4.2 *Building design using architectural objects*

4.2.1 *Organisation*

A building, as designed, could be seen as composed of architectural objects, even an industrialised house-building platform could be formulated in terms of predefined architectural objects. These would serve as a basis for design configuration in the specific project. Architectural objects could be organised in reference library files according to situation categories or level of detail. These situation levels might represent the block, the building, the apartment or room.

Except for the structuring principle with architectural objects, a similar file structure as in the case study would be aimed at in a design project. Repeated architectural objects within the same project should be using common reference files. This also applies to the hierarchies of linked project files. The matter of handling included objects and object properties in order to constitute the architectural objects will however need further investigation as to the mentioned software functionality.

4.2.2 *Properties of architectural objects*

The properties of activities and related spaces are fundamental to the properties of architectural objects. Space related entities include construction entity parts, these may however be included in different spaces. This means that a wall between two rooms or common service installations may appear in more than one architectural object.

Architectural objects may be joined or included in others; allowing mixed-use activities or hierarchies with situations on different levels. At least one activity object is present in an architectural ob-

ject. This means for example that two architectural objects with the adjacent activities cooking and relaxing in an open floor plan joining kitchen-living room may form a new situation saving space, as such constituting a combined architectural object with its own properties.

Architectural objects may also in a systems view be excluding. In a hierarchy some construction entity objects might not affect the situations on that level and therefore be left out from the architectural object entities. As an example, the façade elements are of no interest for a cooking and dining experience but are relevant for the apartment living situation as such. This suggests that the designer should handle these issues in different contexts of architectural objects.

4.2.3 *Product development*

In a product development scenario, architectural objects would be related to the technical platform along with being flexible in ways meeting customer requirements. Properties linked to user activities and design experiences are central. Nevertheless the building is a combined system where architectural objects could be regarded as cornerstones for concurrent engineering. This, as most situations also involve serving systems and construction parts.

Independent architectural objects don't have to be static, but likely holds limited choice due to the industrialised context and the intended design. They could however be designed to allow optional choice in order to change the phenomenal properties or allow complementary activities. This could allow alternative placement of openings or doors in an inner wall. It could also mean styling, as materials and equipment offered in a kitchen. On the other hand architectural objects in a traditional building context could be the more flexible and allow parameterization.

4.2.4 *Programming and customization*

Relating to the case study, configuration with architectural objects could prove to be a similar but more organised way of handling customer requirements in relation to the platform. In a conceptual or programming phase architectural type objects for building types or apartment types as well as other preferred general architectural objects could be configured to form a preliminary project model and meet the general demands set out in the building program. The objects should all be a result of previous product development. The architectural apartment type objects would in that case hold some general activity properties as well as construction entity properties relevant to the type situation. These might serve as presumptions for later on included objects, e.g. space allowances for different activities in the apartment, or basic

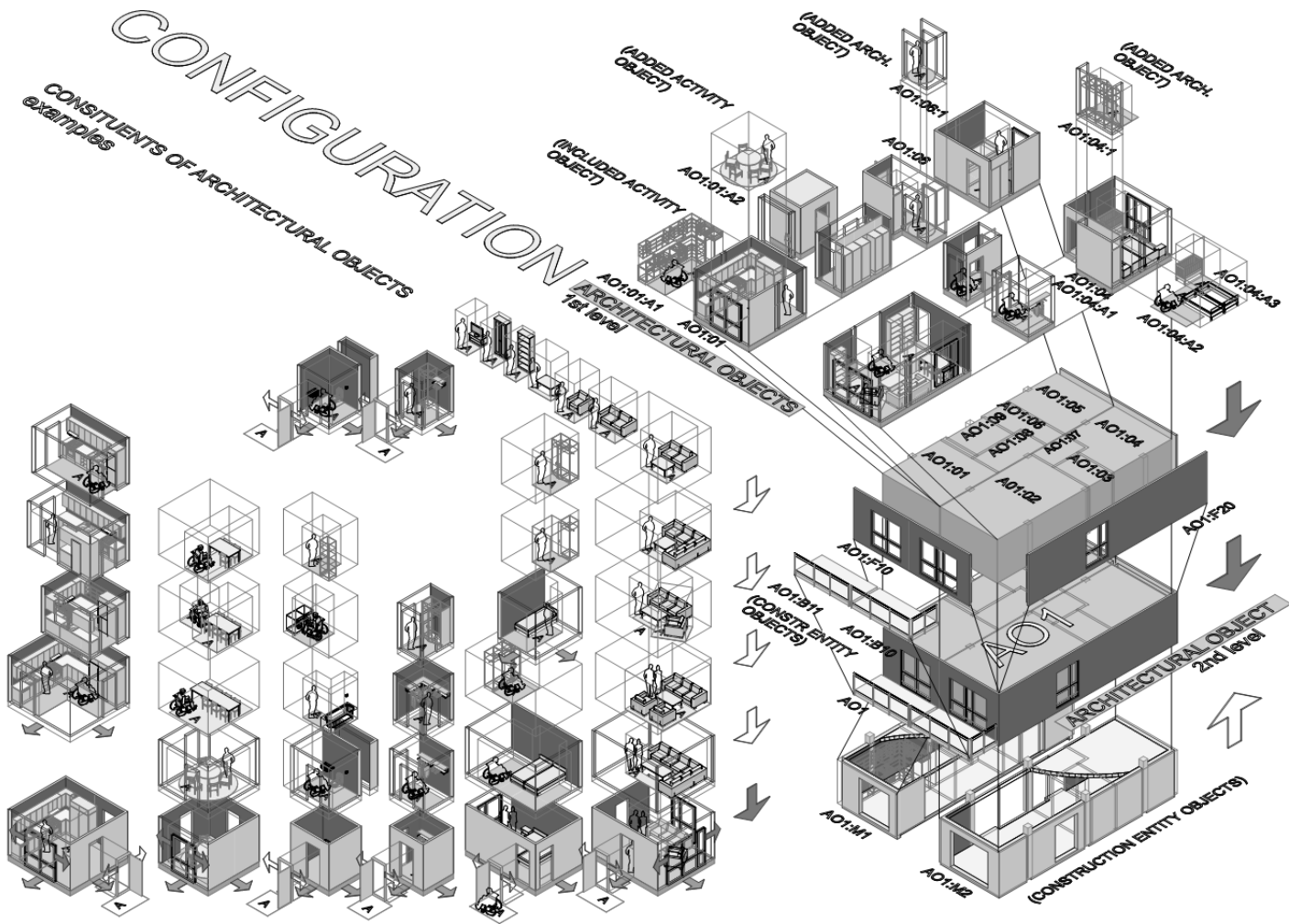


Figure 4. Product configuration

demands on materials that should affect the included detailed architectural objects. Preliminary BIM model data could at this stage be used for pre-calculations and be a result of experiential values set to the type objects.

4.2.5 Project configuration

In a detailed design phase a more firm configuration of the project BIM model would take place. Architectural objects are then successively arranged in the project hierarchy and “styled” according to the flexibility offered on a detailed architectural object level, see Fig. 4. For platforms describing standard type house solutions the flexibility might be more or less limited already on an apartment level, with only minor options concerning finishes etc. The Open House case with a more flexible platform would in this respect benefit more from the methodology, offering options for configuration on room level in situations as cooking, dining or sleeping constituting an apartment. Additional objects may be included but the scheme of architectural object should include most BIM-model objects, as parts of different situations.

5 CONCLUSIONS AND FUTURE DEVELOPMENT POSSIBILITIES

This study has introduced the concept of situation, described as a composite unit of human activity and environment having phenomenal values that support specific mind-sets and experiences during the activity. A situation seen as a design unit is called “architectural object”.

In a case study, we have analysed the design information structure of a company engaged in industrialised production of volume elements for house-building. The experience of the case project shows that configuration of volume elements need not take the technical system as a starting point. The volume elements are implicitly treated as architectural objects by the company architects during project design.

By formalising the concept architectural object and making it explicit, the related information concerning user activities and phenomenal properties, as required and designed, can be made accessible to all parties in the design, production and facilities management processes. The information can be used to gain experience of the building in use, for

simulation, as input to brief development, and other analyses of interest.

In an industrialized building process including volume elements, architectural objects could be developed during the product development phase and applied during building project design as configurable design units.

If the project model and the volume type modules could be preconfigured as architectural objects, then deviations from the platform could be avoided already in the conceptual design stage. Choice options or parametric functions of the volume modules could limit the need for new and separate design solutions. However this requires that desired properties are formulated within a framework of architectural objects.

Design using architectural objects presupposes well defined activities and a technical platform with well defined building elements and resources. Concept development design however, puts other requirements on the Cad-software, including a high degree of flexibility with objects that manage geometry rather than building elements or activities.

Future research will investigate further possible application of the idea of architectural objects, specifically to support the architectural design process in industrialized house-building.

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