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ABSTRACT

The purpose of building classification systems is to provide the sector with agreed and standardised terminology and semantics, e.g. in systems for technical specification, cost calculation, and exchange of information. There is a growing need to use classification systems in a BIM context. In international construction projects and international construction product trade there is a need both to translate between national classification systems and to develop common systems.

The idea behind the international framework standard for building classification ISO 12006-2 is that national systems would be easier to compare if they adhere to the class definitions suggested in the standard. A study of two classification systems, the BSAB system in Sweden and the DBK system in Denmark, both within the framework and yet not compatible, has risen the idea of a deeper analysis of the theoretical basis for the ISO 12006-2 classification system to find a solution to this problem.

The project has developed such a theoretical framework in order to clarify the relationship between classes representing parts of buildings in the ISO 12006-2 standard, specifically the Construction entity part, Element and Work result classes. This is specifically needed when the standard is used in the context of BIM, since building models include both specialization and compositional relations among information objects representing parts of buildings.

The proposed theoretical framework is based on a systems view on the built environment that distinguishes constructions in four main compositional levels: construction entities, technical systems, building elements and components. Based on the theoretical framework developed in this project, possible new interpretations of the classification standard ISO 12006-2 are discussed.

Keywords: building classification, ISO 12006-2, BSAB, DBK.

1   INTRODUCTION

1.1   Background

The purpose of building classification systems is to provide the building and facilities management sector with agreed and standardized terminology and semantics to be used in the processes throughout the life-cycle of entities of the built environment. Historically, building classification was developed to serve the information needs in technical specifications and cost calculations (ISO 1994). With the introduction of CAD and BIM, new requirements have emerged, e.g. support for building modelling with compositional relations between building parts, which challenge the established view of building classification systems as only concerned with specialization relations among types of parts.

In international construction projects and international construction product trade there is a need to both translate between national classification systems and develop common systems. The international framework standard for building classification ISO12006-2 defines a framework of generic classes of interest in construction and facilities management. It is intended to be used as a starting point for development of detailed classification tables. The idea is that national systems would be easier to compare if they adhere to the class definitions suggested in the standard (ISO 2002).

ISO 12006-2 has its roots in the Swedish SfB-system (Giertz 1982), and was developed in close relation with the work on the Swedish BSAB 96 and the British Uniclass systems, following the ISO Technical Report that preceded the ISO 12006-2 (ISO 1994). Since its appointment, ISO 12006-2 has been applied in the development of building classification systems like the Swedish BSAB 96 system

(The Swedish Building Centre 1999, Svensk Byggtjänst 2005), the British UNICLASS (RIBA 1997), the North American Omniclass (Omniclass 2011) and recently the Danish DBK-system (bips 2006 a).

However, in spite of principally adhering to the ISO standard, the DBK system diverges from the others in a way that makes it seemingly incompatible. This specifically regards the concept of building parts, and the way classification tables for these are designed (Ekholm 2011, Ekholm and Häggström 2011). DBK also adheres to EN 81346 (DS 2009) which applies an approach that in one table combines classification and compositional structuring. Haug et al. (2010) have described this combination as a "product oriented structure". Thus the table for building parts in DBK has a product oriented structure, where classes similar to Element and Work result traditionally based on separate views are joined in the same table.

The objective of this project is to develop a theoretical framework that may clarify the relationship between classes representing parts of buildings in the ISO 12006-2 standard, specifically the Construction entity part, Element and Work result classes. This is specifically needed when the standard is used in the context of BIM. Applications studied in this context are the Swedish BSAB system and the Danish DBK system. BSAB may be seen as a representative for other systems with a similar view, e.g. Uniclass and Omniclass.

In the following, Chapter 2 introduces some basic concepts used for the analyses; Chapter 3 shortly presents the analysed standards; Chapter 4 presents the theoretical framework for building classification; and finally Chapter 5 summarises and draws some conclusions for further development of ISO 12006-2.

2 SYSTEMS, PARTS AND CLASSIFICATION

2.1 Systems and their parts

A system is an object composed of other, mutually related, objects. It has a composition, environment and structure, the latter referring to all internal and external relations of the system. A system can be either concrete or abstract. A concrete system is a complex thing with bonding relations among its parts and to its environment. Members of the composition of a system, and the system as a whole, have a part-whole relationship. Basic to this relation is that the existence of a part precedes the existence of the whole (Bunge 1977, 1979).

A compositional view on a system focuses on the compositional parts of a system. A system may be composed of parts in several levels where systems in lower levels are parts of systems in higher levels. A criterion for a system to belong to a higher level is that new properties have emerged, so that a system in a higher level in some basic respect is different from the systems in lower levels (ibid). For example, in the level order clay→brick→masonry, new properties emerge in each level. Another example would be foundation poles, posts, beams and trusses constituting a carcass.

A functional system is a system that undergoes processes, i.e. the state of a functional system is changing (Bunge 1977:15). A functional view on a system focuses on its functional relations to the environment. The functional parts of a system are those that contribute to functions of the system as a whole. There are functional parts or subsystems in various levels. An example of a functional system is the load-bearing structure, carcass, of a construction entity. Functional parts of a carcass may e.g. be vertically load-bearing parts and horizontally load-bearing parts. A functional system is composed of one or many compositional parts (Ekholm and Fridqvist 2000). Parts identified from different aspects do not always coincide; e.g. the relation between functional and compositional parts in a design situation is many to many.

2.1.1 Classification

A class is a conceptual construct referring to a collection of objects with one or many properties in common. To classify means, for a defined purpose, to divide a collection of objects in mutually separated sets, classes (Hunter 1988). A classification system is a conceptual system of classes with specialization relations designed for classification of objects in a domain. In order to classify a set of objects it is initially necessary to determine both the collection to be classified, and the purpose of the classification (Bunge 1979). The purpose is the main basis for selection of subdivision criteria.

Examples of subdivision criteria in a construction context are compositional properties and functional properties. Examples of compositional properties are geometrical shape, construction material or method of construction and examples of functional properties are load bearing or climate separating.

A classification based on intrinsic properties is more stable than a classification based on external properties. Composition and internal structure, including e.g. form, constituent parts, contained media, is more stable than for example functions in relation to the environment. A certain function can be achieved by different systems, and the external function may change when the environment changes. Accordingly, a classification of things should use intrinsic properties for its primary subdivision criteria, and only secondarily use external functional properties as subdivision criteria.

2.2 Classification and product oriented structuring

Classification systems may, apart from a level order of specialisation, also have a level order of composition, so called "product oriented structuring". Fig. 1 below shows a combination of compositional structure and functional classification on different compositional levels. The classes of a classification system can be organised in composition levels, and each class can be primarily characterised by composition and secondarily by function. On each compositional level there are separate sets of classes for each kind of part.
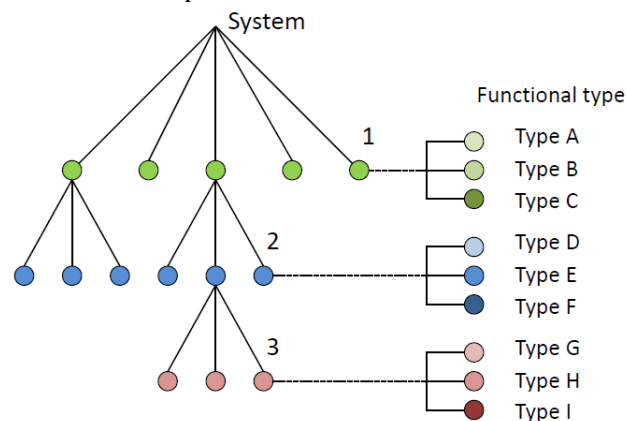

Figure 1. A classificatory structure with compositional parts and their functional types, the numbers 1-3 denotes levels of part-whole relations.

2.3 Classification and BIM

A building information model represents characteristics of a building of interest in the construction and facilities management processes. Among the information needed is the composition and structure of the building (Eastman 1999). Besides its structure, and relations of specialization, a building model consists of classes related by composition, from the building as a whole, through its technical systems and larger elements down to its smallest components (Björk and Penttilä 1989).

Building classification according to ISO 12006-2 does no clarify how the classes may be applied in building information modeling (ISO 2002). There is no theoretical model of the built environment in the standard that describes the relation between classes for BIM. For example, there is no guidance whether it would be possible to introduce a compositional relationship between classes like Element and Work result, although in certain applications like cost calculation the latter are considered parts of the former. On the contrary, it is assumed that Element and Work result are separate views on the same collection of thing, which is questioned in the analysis below.

3 THE ISO 12006-2 FRAMEWORK STANDARD, BSAB 96 AND DBK

3.1 Background and scope of ISO 12006-2

The ISO 12006-2 standard for building classification is intended to be used as a framework for developing building classification systems by organisations on a national or regional basis (ISO 2002).

It has been developed as a step in harmonizing different national and regional building classification systems.

ISO 12006-2 identifies the main classes of interest to the construction sector for use in CAD, specification, product information and cost information systems (ISO 2002:4). The scope of the standard is the complete life cycle of construction works within building and civil engineering. It lists recommended tables according to particular views or principles of specialisation and gives examples of entries that may occur in these tables (ibid:6).

3.2 Main classes in ISO 12006-2

ISO 12006-2 uses a basic process model to distinguish main categories of interest, i.e. resources, processes, and results. Four generic classes of results are identified: "Construction Complex", e.g. airport and motorway, which consist of one or more "Construction Entity", e.g. building and bridge, and "Construction Entity Part", e.g. wall and road surface, and "Space", e.g. a room or roadway (ibid:9).

The generic result classes "Construction Complex", "Construction Entity", and "Construction Entity Part" are related by a part-of relationship in a compositional level order as shown in Figure 2 of the standard (ISO 2002:16). A "Construction Complex" is classified by function or user activity. A "Construction Entity" is classified either by form, i.e. compositional type, or by function and user activity. A "Construction Entity Part" defined as "a solid material part of a construction entity, having physically delineated boundaries", is however not represented in a table. Instead two other part concepts "Element" and "Work result" representing views on the construction entity part are represented in tables. An "Element" is a "construction entity part which, in itself, or in combination with other such parts, fulfils a predominating function in the construction entity". A "Work Result" is "a construction result achieved in the production stage or by subsequent alteration, maintenance or demolition processes".

Both Construction entity part and Work result are considered construction results, i.e. they are compositional parts of the construction entity. However there is no mention of a part-of relationship between the two. A Work result is also considered a view on a Construction entity part, which means that they in some instances are identical. However an Element is also considered a view on a Construction entity part. In that case Work result and Construction entity part cannot be identical. Instead this must be interpreted as Work results are part of Elements. This is supported by the definition of the class Designed element, which is defined as an "Element for which the Work result(s) have been defined".

The concept of Element in the standard is ambiguous since its definition only mentions functional characteristics. The interpretation of the Element as a function is emphasized in the description in the BSAB 96 system which states that "Elements sometimes seem to be structured on the basis of the composition of the construction entity instead of expressing the functional specification of the element. However, this is only due to lack of practical wordings for those complex functions" (The Swedish Building Centre 1999:31). However, in different applications Elements are given names that indicate other characteristics as well, e.g. position in the Construction entity, and geometrical shape. The BSAB 96 system has Element classes like "Loadbearing external wall" and "Surface layers on wall".

The idea of a compositional relation between Elements and Work results is not new. For example the latest Finnish building classification system Talo 2000 states that "building elements are divided into structural parts whenever several types of production work are required to produce a single building element" (Talo 2000 2006).

3.3 Implementations of the Element class in BSAB and DBK

3.3.1 Development of the concept of building part in Swedish building classification

The initial 1950 version of the Swedish SfB-system encompassed a relatively small number of building elements or parts (54 classes sorted under 9 headings) and was used in ByggAMA 1950 (ByggAMA 1950). Characteristic features were position in the building and construction type, e.g. "external walls" and "flat roofs". In a later version, the view of what was to be regarded a building part

was considerably changed. Also smaller details of a building were considered building parts since a "construction commodity when assembled or mounted in a building is transformed into a building part" (ByggAMA 1965).

With the abandonment of the SfB-system for the BSAB-system 1972, building parts were divided into two kinds, each represented in separate Product tables. Product table 2 concerned "larger parts", defined as "physically material parts, distinguished by their primary technical properties in the finished product", rather similar to the SfB-parts from 1950, while Product table 1 concerned "assemblies and mounted apparatus", defined as "physical material parts distinguished by similarity in composition or significant effort of resources like commodities or work needed for their creation" (BSAB 1972).

The building parts in BSAB 72 were seen as "technical product parts" of the building. In the next version, BSAB 83, building parts were defined as "planned or real result of construction activities at the building site". The parts in Product table 2 were subdivided using "the technical function as main subdivision criteria". But there was no principal difference between the two versions concerning the nature of building parts (BSAB 1983).

Later, the BSAB 96 version marked a definite change with respect to the view on building parts. They were now seen as identified from two different views on the building's composition, both views giving a complete account of parts. On the one hand there were the "Elements" (Byggdelar) defined by function, as a "part of a building that fulfils a main function in the building", and on the other hand the "Work results" (Produktionsresultat) defined by compositional properties, e.g. resources like material and labour (Svensk Byggtjänst 1998, The Swedish Building Centre 1999).

3.3.2   Implementation by BSAB 96

BSAB 96 is a Swedish classification system that in most respects is in accordance with ISO 12006-2. It has the same extension concerning basic process model, classification tables and application domain as ISO 12006-2 (Svensk Byggtjänst 2005). Experiences from the development of BSAB 96 have strongly influenced the development of the ISO standard.

The class Byggnadsverk in BSAB has the same definition as Construction entity by function and user activity, however with "form" as the primary subdivision criteria, which is not a functional but a compositional property. Thus, the table for Byggnadsverk in BSAB is a combination of the table for Construction entity by form and the table for Construction entity by function and user activity.

The class Byggdel in BSAB adheres to the definition of Element in the ISO standard. Byggdel has function as a primary subdivision criterion, e.g. "Loadbearing external walls" or "Outdoor climate envelope in external walls". However, as mentioned above, the class names indicate geometrical form and position in the building as subdivision criteria as well. In principle BSAB 96 does not allow compositional relationships in the table for elements, only specialization relations are considered appropriate.

The BSAB table for Work result is called "Produktionsresultat", and that table is also in accordance with ISO 12006-2 but the definition is simplified. "Produktionsresultat" are primarily used for specifying material and works requirements in procurements, e.g. "Walls of brick" or "Layers of plasterboards indoors". "Byggdelar" and "Produktionsresultat" are represented in separate tables. In cost calculations, they are used with the interpretation that members of "Produktionsresultat" are parts of members of "Byggdelar".

3.3.3   Implementation by DBK

The DBK system is developed to cover the information needs for the entire "life-cycle of construction works". In DBK this is interpreted as "the total process concerning the built environment and the elements hereof" (bips 2006c). Out of scope are "large infrastructure facilities" but they are planned to be included in later versions. DBK is based on both ISO 12006-2 and DS/EN 81346. The reference systematic in the latter is used as the basis for coding principles in DBK and the choice of the "produktaspektet" (product aspect) to define parts of the built environment. The functional aspect and the product aspect are used in DS/EN 81346 to define parts from these aspects in a system, the method

used is called "structuring" (DS 2009). The concept "product aspect" is here interpreted as identical with the concept compositional aspect used in this text.

"Bygninger" in DBK adheres to the definition of Construction entity by function and user activity in ISO 12006-2 and "Bygningsdel" adheres to the definition of Element. DBK specifically uses the opportunity given by the definition to introduce compositional relationships among Elements, which BSAB does not allow. Table 25 "bygningsdele i produktaspektet" is subdivided by compositional criteria in several levels and use function as criteria for further subdivision on each level (bips 2006 b).

On the top level, there are 22 different Systems, e.g. Wall system, and Ventilation system. In the next lower level parts of Systems are identified; e.g. the Wall system consists of 19 main parts e.g. Wall construction, Window section and Door section. These parts are also composed of parts in yet another lower level e.g. Vertical stud, Horizontal stud, Sheet, Framework, Joint, Membrane, Isolation, Cladding and Covering.

The Element table in DBK is structured as a compositional hierarchy of parts in several levels. In each level specific kinds are identified and listed in a separate Table 25 a, e.g. External walls and Internal walls. DBK does not implement the Work result as a separate table, but considers the "assemblies and mounted apparatus" as Elements in the lowest composition level. In the table, these lower level Elements are repeated multiple times, in relevant selection depending on the characteristics of the higher level Element.

The DBK systematics for Element is organized as a facetted classification system. The classes are created by the user when there is a need. The system is thus different from enumerative systems where all classes are listed in tables. The ISO standard is presuming that each table is enumerative in itself, in e.g. the Elements table in BSAB all elements are listed.

"Bygningsdelstype" (Designed element) in DBK is defined as "the material content of a part of the building or the way it is put together". "Bygningsdelstype" does not fully adhere to the concept Designed element in the ISO-standard due to lack of Work result in DBK. "Bygningsdelstype" in the product aspect are listed alphabetically in Table 25a. "Bygningsdelstype" are described as "specific solutions to be used in a concrete construction". The table shall be used in combination with Table 25 as a guidance to specify constructions and their parts depending on their technical solutions.

4 A CLASSIFICATION FRAMEWORK FOR BIM

4.1 Artefact and built environment

The natural and built environment is selected and designed to accommodate and enable human activities. From a compositional view, the built environment consists of manufactured and assembled products, here called constructions. A construction is designed for one or many purposes i.e. its properties are basic for at least one function.

The relation between functions and constructions in a design process are many to many, see Figure 2. A specific function can be realized by one or many constructions and a specific construction has one or many functions.
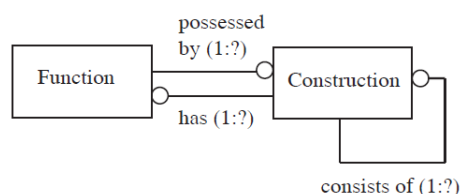

Figure 2. In a design process, the relations between constructions and functions are many to many.

4.2 The built environment as a system

4.2.1 Components

The constructions in the lowest level of the built environment are the components, i.e. processed and assembled construction material. Examples of components are mounted wall studs, gypsum board,

countertops, bathroom fixtures, diffusers, electrical cables, etc. Components each have a characteristic function in the construction entity. They are possible to use as they are, or as further assembled in different combinations to make up more complex constructions.

Components are often not specialized for the constructions of which they are part, but if so they also have an extended definition, which includes form or position relative to the construction of which they are part. They have similarities to Work results in the ISO 12006-2 standard. Components are often characterized by their dominant materials such as wood, concrete, steel etc. in different variations and combinations. Components make up the basic constituents of Building elements.

4.2.2 Building elements

Building elements are the immediate parts of technical systems. Compared to Components, Building elements are larger or more complex constructions, they are often specialized for the technical system of which they are part and also often characterize the building as a whole. Building elements have similarities to Elements in ISO 12006-2, but their definition includes, besides characteristic function, form or position relative to the technical system of which they are part.

Building elements each have their compositional structure such as beam structures, floor structures, land surfaces and vegetation beds. The primary subdivision criterion is compositional rather than functional. It could be hypothesized that this is also tacitly recognized for Elements of the ISO-standard. As noted above concerning the BSAB 96 system, the Elements "Loadbearing external walls" or "Outdoor climate envelope in external walls" are obviously defined by form and position in the building and the referents to those classes would here be classified as Building elements. The difference in the classification methodology is that Building elements are considered to be composed of parts which the Elements are not.

4.2.3 Technical systems

A technical system is a construction with a characteristic technical function in the construction entity. It is composed of building elements and components. Many Technical systems have a characteristic form, and may be classified accordingly as, e.g., House construction, Road construction, Mast construction, Quay construction, Bridge construction, and Railway construction. Also other compositional characteristics may be used as criteria, e.g. constituent building elements, construction material or contained media, e.g. water systems, electrical systems, air duct systems. Technical systems in buildings can also be characterized secondarily by functional properties as load-bearing, space enclosing and media supplying as well as furnishing and equipping (SIS 2002).

4.2.4 Construction entity

In ISO 12006-2 a Construction entity is defined as "an independent material construction result of significant scale serving at least one user activity or function". Here, a Construction entity is defined as a complex of technical systems that together have the functions needed to enable desired user activities or functions, see Figure 3. A basic criterion is that at least one of these technical systems is a permanent ground construction, to separate Construction entities from e.g. vehicles, boats and aircrafts. Construction entities are often named according to the technical system generally considered the most characteristic, such as house (construction), road (construction), mast (construction), quay (construction), and bridge (construction).

Construction entities are different depending on their functions for the users, and one or several functional types can be specified in addition to the compositional types. House constructions specialized for the function domestic living are called house-buildings, and other specializations can be named museums, gymnasiums and schools. In the same manner, civil engineering works can be specialized as roads or railways. Within each category, one can further distinguish between more specialized functional types.
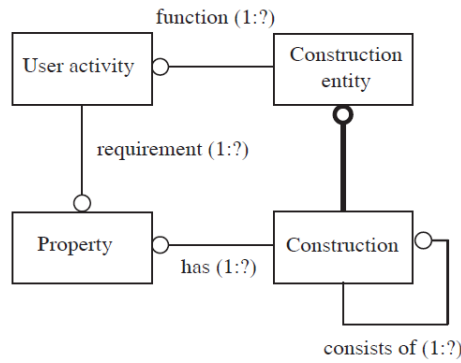
Figure 3. A construction entity is a system of constructions and has one or several functional relations to user activities that put requirements on properties of those constructions.

4.3 A compositional conceptual model of the built environment

4.3.1 A compositional view

Based on the concepts defined above, it is possible to build a compositional model of the built environment relating the basic classes defined here. A specific model that represents the composition of artifacts has no definite number of levels, the purpose of the model will determine its extent. However, four composition levels of special interest to BIM-applications for cost calculation and specification are identified here. These are Construction entities, Technical systems, Building elements and Components. All these are constructions with properties, including technical functions. User activities put requirements on the properties of constructions in order that a desired function may be obtained. The construction is the result of processes that use resources. All these have properties. See Figure 4.

Spatial relations are essential for desired function to emerge. Spaces are made up of different constructions, e.g. building elements like wall, floor and roof make up a room in a house construction, or buildings that make up a street space or a square in a city. See Figure 4.
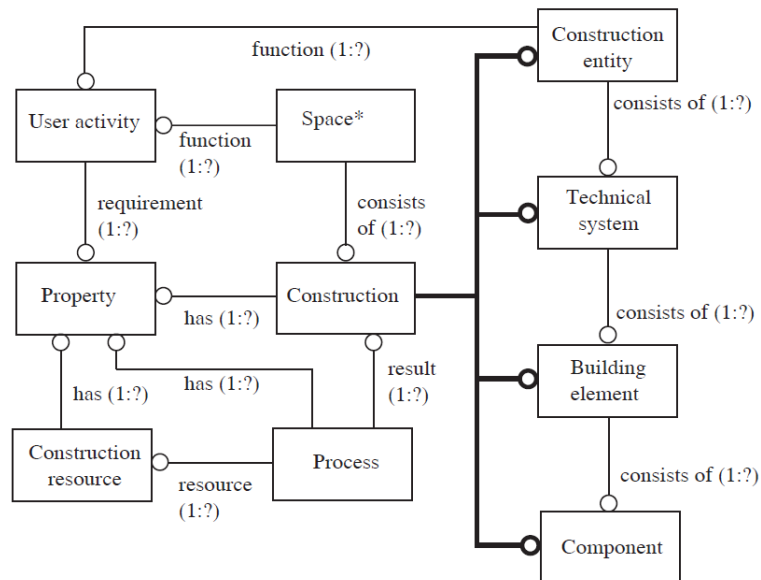

Figure 4. A conceptual model of the built environment reflecting certain information described in ISO 12006-2. The asterisk marks that Space is defined by spatial relations.

5 DISCUSSION

5.1 New classes and their relations to ISO 12006-2

The ISO 12006-2 framework standard for building classification has a process model relating resources, processes and results. The results make up the built environment. However, the standard is lacking a theoretical foundation in the form of a compositional model of the built environment seen as a system composed of parts in different levels. The analysis here suggests a solution to this problem.

Today the ISO 12006-2 standard allows an interpretation of the concept Construction entity part both as Element and as Work result, but it does not specify the relation between these classes. However, in specific applications, e.g. cost calculations, Work result are seen as part of Element. The BSAB system adheres to this interpretation of the ISO standard. DBK on the other hand, interprets the concept of Element as composed of larger and smaller parts, where the smaller parts are intended to cover the needs catered for by the Work result class. DBK also introduces the concept of technical system as the highest compositional level of building parts.

The proposal put forward here has been to define three classes representing building parts of different complexity in a construction entity. A Technical system is a major part of a construction entity with a characteristic technical function in the construction entity, it is composed of Building elements and Components. The proposed class Building element is similar to the Element class in ISO 12006-2, but has a slightly different definition and includes not only function, but also characteristic form and position in the building. The proposed class Component is similar to the Work result class in ISO 12006-2, but includes functional properties among those already mentioned in the definition of Work result.

5.2 Limitations

The model presented here is not a complete account of all the classes represented in the ISO 12006-2 standard. It is limited to the compositional relations between different building parts. A further study could e.g. include the concepts of construction resource and construction result. The same thing may be seen as either resource or result depending on which process that is in focus. Another possibility would be to consider resource and result as different views on a construction, and represent these as attributes instead of as class objects.

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REFERENCES

bips (2006 a) *DBK 2006 vejledning*. bips, Lautrupvang 1 B, 2750 Ballerup.

bips (2006 b). *DBK 2006 resultatdomænet 2 Struktur og klassifikationstabeller for bygningsdele*. Rev A 2006-12-01. bips, Lautrupvang 1 B, 2750 Ballerup.

bips (2006c) *DBK 2006 vejledning*. bips, Lautrupvang 1 B, 2750 Ballerup. ISBN 87-91340-62-4

Björk B.-C., Penttilä H. (1989). A scenario for the development and implementation of a building product model standard. *Advances in Engineering Software* 1989 vol. 11, no. 4 pp 176-187.

BSAB 1983 (1983). *BSAB-systemet. Tabeller och tillämpningar*. SB-rekommendationer 6. Stockholm: Svensk Byggtjänst AB.

BSAB 1972 (1972). *BSAB systemet*. Stockholm: Byggandets Samordning.

Bunge M. (1979). *Ontology II: A World of Systems, Vol. 4 of Treatise on Basic Philosophy*. Reidel.

Bunge M. (1977). *Ontology I: The Furniture of the World, Vol. 3 of Treatise on Basic Philosophy*. Reidel.

ByggAMA (1965). *Råd och anvisningar till ByggAMA 1965*. Stockholm: ByggAMA AB.

Bygg AMA (1950). *Allmän material- och arbetsbeskrivning för husbyggnadsarbeten. ByggAMA 1950*. Samarbetskommitten för byggnadsfrågor. Stockholm: AVCarlsons Bokförlags AB.

DS/EN (2009). *Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 1: Basic rules*. CENELEC, Brussels and Köbenhavn.

Eastman C. (1999). *Building product models: computer environments supporting design and construction*. CRC Press LLC.

Ekholm A., Häggström L. (2011). *Mappning mellan systemen för byggklassifikation BSAB 96 och DBK. Version 2011-03-07*. Avd. för Projekteringsmetodik, LTH, Lunds Universitet.

Ekholm A. (2011). *Referencesystematik og Dansk Byggeklassifikation - analyse og anbefalinger incl. Höringsrapport*. Erhvervs- og byggestyrelsen, Köbenhavn.

Ekholm A. och S. Fridqvist (2000). A concept of space for building classification, product modelling, and design. *Automation in Construction,* 9(3), p. 315-328.

Ekholm A. (1996) A Conceptual Framework for Classification of Construction Works. *ITcon* Vol. 1, pg. 25-50.

Giertz, L.-M. (1982). *SfB and its development 1950-1980*. An Anas Forbartha, Dublin.

Haug A., Hvam L., Mortensen, L.H. (2010). A layout technique for class diagrams to be used in product configuration projects. *Computers in Industry* 61 (2010) pg. 409–418.

Hunter J. E. (1988). *Classification made simple*. Aldershot, Gower.

ISO (2002). *SS ISO 12006-2 Building construction – Organization of information about construction works – Part 2: Framework for classification of information*. ISO, SIS Stockholm.

ISO (1994). *Classification of information in the construction industry*. ISO Technical Report 14177. Geneva: International Standardization Organisation.

OCCS (2003). *Overall construction classsification system*. Accessed 2004-04-01 at http://www.occsnet.org/.

Omniclass (2011). *Omniclass*. Accessed 2011-04-25 at http://www.omniclass.org/index.asp.

RIBA (1997). *Uniclass. Construction Project Information Committee*. London: RIBA Publications.

Svensk Byggtjänst (2005). *BSAB 96 System och tillämpningar*. SB-Rekommendationer nr 10. Svensk Byggtjänst AB, Stockholm.

The Swedish Building Centre (1999). *BSAB 96. The Swedish construction industry classification system*. Stockholm: The Swedish Building Centre.

Talo 2000 (2006). *Talo 2000. Construction 2000 classification*. Helsinki: Rakennustieto Publishing.