A Comparison of Construction Classification Systems Used for Classifying Building Product Models

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Building classification systems have established standard terminology and semantics for the construction sector. It is critical to use classification systems when dealing with specifications, structuring of documents and cost estimation. Classifying building product models in a standard way is a major step in organizing building product libraries. By giving the proper classification code to the product models, they can be arranged for different purposes such as cost estimation. However, several classification systems have been developed across the globe such as Uniclass in the UK and OmniClass in North America. Each system has been developed for a different purpose since the same collection of objects can be classified with different criteria. This paper studies four classification systems that are being used for classifying building product models. We structured four specific criteria to study these classification systems. We first argue that each criterion has a major role in defining different classification systems. These four criteria are: purpose and properties of the classification system, framework of the system, grouping principle within the system, organization and taxonomies of tables. Then considering these criteria, a comparison among the selected classification systems is presented.

Key Words: Classification systems, BIM, OmniClass, MasterFormat, UniFormat, Uniclass

Introduction

Building classification systems have established standard terminology and semantics for construction sector that can be used in different aspects (Ekholm & Haggstrom, 2011). This helps to summarize and organize available knowledge in a structured way. In the construction industry, using classification systems is critical when dealing with specifications, structuring of documents, calculation of costs, exchanging information, etc. (Ekholm, 1996). More importantly, in BIM (Building Information Modeling) paradigm, classifying building product models in a standard way is one of the major steps in organizing the product models (Eastman et al., 2011). By giving the proper classification code to product models, they can be arranged for construction information or cost estimation within the building model and also they can be sorted within product databases. In this context, one point of importance must be highlighted. The term “Building Product Modeling” (Eastman, 1999) was initially used to describe what is currently known as “Building Information Modeling”. The term “Building Product Model” was also used when referring to the project’s model describing a particular building. But in this paper, we use the term “Building Model” which is also known as Building Information Model to refer to the project’s model that represents the building. By “Building Product Models” or “Product Models” we mean objects that are the components of the building model.

With the growing adoption of Building Information Modeling (BIM), architects and contractors often require organized collection of product models for different purposes such as cost estimation. Moreover, the need for exchanging the information of building product models with project partners and product suppliers, through the lifecycle of a building, both nationally and internationally is growing. This emphasizes that organizing such information in a systematic way is critical to better understand and affectively use the data (Howard, 2001; Keijer, 1993). However, there has been various classification systems developed by several countries and institutions over fifty years such as BSAB in Sweden, Uniclass in the UK, DBK in Denmark and OmniClass in North America (Ekholm A., 1996; Jorgensen, 2011). Despite the fact that these classification systems have been all developed with the purpose of classifying building artifacts, there are major differences among them. In fact, each system has its own way of classifying the construction artifacts. The same collection of objects as Ekholm describes, can be classified differently in each classification system (Ekholm A., 1996). The problem is that although there have been some studies on different classification systems such as the work of Howard (2001) and Ekholm & Haggstrom

(2011), there is not a clear idea of the features that distinguish these systems from each other. We start by reviewing the area, then outline a general structure that all classification systems need to provide. This structure provides a framework for comparisons of the classification systems. Using this structure, we then review four main classification efforts carried out in North America and in the UK. Last, we summarize the comparison of these systems and identify areas where additional research is needed.

Construction Classification Systems

Classification is a means to describe construction entities in a standardized way. A classification system sorts a series of objects into different classes consists of members with specific properties (Ekholm, 1996). "A class is a conceptual construct referring to a collection of information objects with one or many properties in common. To classify means to divide a collection of objects in mutually separated sets or classes" (Ekholm & Haggstrom, 2011). Classification organizes the most general classes at the higher levels which are also known as root levels. Then, accordingly the most special classes are arranged at the lower levels. In any node of this hierarchy, the subclasses are in fact specializations of their superclass and any superclass is a generalization of its subclasses (Jorgensen, 2011). In other words, properties of a super-class are general and properties of subclasses are specific to the members in that collection (Ekholm A., 1996). Various construction classification systems have been developed by different countries and institutions such as SfB and BSAB in Sweden, Uniclass in the UK, Building 90 in Finland and MasterFormat or OmniClass in North America (Jørgensen, 2011a). Howard (2001) believes that while conforming internationally will improve collaboration among countries, a well-defined national system is required for local needs (Howard, 2001). Ekholm and Haggstrom (2011) discuss that in international construction projects and product trade there is a need to translate between national classification systems as well as the need for developing a common system (Ekholm & Haggstrom, 2011). In order to translate and map between these systems we first need to be able to compare them based on a common structure. What generic features each classification systems should provide and how these systems should be compared with each other is unclear.

Structural Features of Construction Classification Systems

In this paper the main objective is to come up with a structure that provides fundamental features of each classification system for comparison purposes. Therefore, through literature, first the structural features of a classification system are organized into four criteria as: purpose and properties of the classification system, framework of the system, grouping principles within the system, and organization and taxonomies of tables. These criteria establish the methodology to study different classification systems and to distinguish these systems. The study then investigates major classification systems in North America and in the UK that are used for classifying building product models. Rather than describing each system in turn, this paper considers each one under four headings based on four above mentioned criteria to enable more detailed comparisons. Classification systems that are studied here are CSI classifications i.e. OmniClass, MasterFormat and UniFormat from North America and Uniclass from the UK.

Purpose and Properties of the Classification System

First critical step in classifying a collection of information objects is to define the purpose of the classification (Ekholm A., 1996; Ekholm & Haggstrom, 2011; Jorgensen, 2011). The purpose defines the properties of interest to the classification that configures how the objects should be sorted into classes (Ekholm A., 1996). Therefore, purpose and properties is a fundamental feature of a classification system.

Framework of the System

Framework provides a conceptual basis for the construction industry. If this conceptual representation is required to be accepted across the construction sector, it must have a meaningful and strong theoretical foundation and it also needs to be relevant to different contexts (Ekholm A., 1996). In addition to being a source of classifying industry levels, a well-established construction classification system plays a significant role as an information center through the life cycle of a project. Therefore, it is important to use a proper framework for managing construction information (Kang & Paulson, 2000). The idea is that national systems can be compared more easily if they follow the same class definitions in the standard (Ekholm and Haggstrom, 2011; ISO, 2001). This provides a basic structure of information about construction and its main categories. Some examples of major frameworks are as follows:

1. Among the earlier classification systems, one of the systems that has been used in several countries is Construction Index/Samarbetskommitten for Byggnadsfragor (CI/SfB). But CI/SfB cannot represent many new construction technologies (Kang & Paulson, 2000).
2. Because of the shortcomings of CI/SfB, International Organization for Standardization (ISO) developed a new classification system framework (Kang & Paulson, 2000; Omniclass Secretariat, 2006). In 1994, an ISO technical committee (TC59/SC13 WG2) developed a new international framework (ISO 1994) for construction classification system (Ekholm & Haggstrom, 2011; ISO, 2001; Kang & Paulson, 2000).
3. ISO technical report in 1994 was established as a standard in ISO 12006-2 (Omniclass Secretariat, 2006). The ISO 12006-2 standard for building classification is a framework for developing building classification systems that can be used by organizations on either a national or regional basis (Ekholm and Haggstrom, 2011). ISO classification scope was expanded into lifecycle information that includes construction management and products (Kang & Paulson, 2000) and describes a framework of generic classes of interest in construction and facilities management. ISO 12006-2 is developed to be the basis for the development of detailed classification tables (Ekholm and Haggstrom, 2011; ISO, 2001) and has been used in the many building classification systems (Ekholm and Haggstrom, 2011; Howard, 2001; Jorgensen, 2011) such as BSAB, UniClass and OmniClass (Gelder, 2011a).

Other established frameworks are ISO 12006-3:2007 also known as buildingSMART Data Dictionary (buildingSMART, 2016) and DS/EN 81346 (Ekholm and Haggstrom, 2011).

Grouping Principles within the System

Construction classification systems have two different principles of grouping objects. These grouping strategies are direct grouping (also known as enumerated or hierarchical) and combinatory or faceted grouping. In a direct grouping the classes are identified through a combination of properties. The properties are based on the purpose of the classification (Ekholm A., 1996). In this grouping, new objects cannot be accommodated and it would be required to have regular revision (Cann, 1997). An example of direct grouping of the parts of a building is wall, floor, foundation, roof, window (Ekholm A., 1996). In a combinatory grouping or faceted classification on the other hand, one or multiple sets of attributes can be combined. A facet performs as a set of similar properties such as functions that provides the capability to categorize all members in a collection (Ekholm A., 1996). In a faceted classification only simple subclasses that are based on a single principle of division are listed and are then grouped into facets. Compound subclasses can be generated by combining these simple subclasses (Cann, 1997). In a faceted classification, new objects can be classified by combination of existing concepts (Ekholm A., 1996; Cann, 1997).

Organization and Taxonomies of Tables

For defining subdivision criteria, the purpose of the classification has the main impact (Ekholm and Haggstrom, 2011). Since a classification purpose determines the properties and the nodes of the taxonomy, different classification purposes may result in different taxonomies of the same objects (Jorgensen, 2011). Examples of subdivision criteria in a construction context are compositional properties and functional properties. Examples of compositional properties are geometrical shape or construction material and examples of functional properties are load bearing or climate separating (Ekholm & Haggstrom, 2011). Moreover, if each node in the hierarchy defines a class according to only one criterion, the classification is known as clean and if multiple criteria are used for this, the classification is mixed. Jorgensen says ideally, objects belong to only one node in taxonomy, but sometimes these can be characterized by multiple nodes. In this case, one of the nodes is the primary class and the other classes are secondary (Jorgensen, 2011). But Ekholm (1995) argues that in this case the classes are not properly defined. He believes the purpose of a classification is to distinguish between the objects in a collection. So, a classification should be “exhaustive and definite”. Exhaustive means every object in the collection must belong to a class, and definite means each object may only belong to one class (Ekholm A., 1996).

Survey of Construction Classification Schemes

In this section, four classification systems that are developed in North America and in the UK and are being used for classifying building product models are summarized and reviewed. The study is structured based on four major criteria presented earlier as main features of the classification systems.

OmniClass

The OmniClass Construction Classification System (OCCS) is established for organizing all construction information (OmniClass Secretariat, 2006). OmniClass is supported by CSI (Construction Specifications Institute) and CSC (Construction Specifications Canada). Various editions of OmniClass, and its predecessor tables such as MasterFormat and UniFormat, have been widely used across North America for many years (Gelder, 2013). Its significance is in its use within the National BIM Standard in the United States (Brodt, 2011).

Purpose and Properties

The OmniClass is designed to assist in the organization, sorting and retrieving information for use in preparing project information, cost and specification information and other information generated throughout the full facility life cycle. It is useful for many applications such as organizing library materials (OmniClass Secretariat, 2006). Its purpose is to provide classification for all products and procedures through the project life cycle (Ceton, 2011).

Framework

OmniClass follows the framework set out in ISO Technical Report 14177 that was later established as a standard in ISO 12006-2 (Ceton, 2011). It incorporates other systems currently in use as the basis of many of its tables such as MasterFormat for work results table , UniFormat for elements table, and EPIC (Electronic Product Information Cooperation) for structuring products. Of all frameworks, ISO 12006-2 and ISO12006-3 have more immediate impact on OmniClass (OmniClass Secretariat, 2006).

Grouping Principle

OmniClass is a faceted classification that has the ability to classify from multiple points of view and to structure data (Grant & Ceton, 2008; Ceton, 2011; Johnson, 2008). This has made OmniClass useful in managing project information. OmniClass uses 15 different ISO tables, each of which represents a different facet of construction information. Each table can be used independently to classify a particular type of information, or it can be combined with in other tables to classify an entity that is not included (Grant & Ceton, 2008; Ceton, 2011; Johnson, 2008).

Organization and Taxonomies

OmniClass has fifteen tables. These tables correspond to ISO 12006-2 arrangement of information. Among fifteen tables, table 21, 22 and 23 specifically address the classification of building products. Table 21 (Elements) is based on UniFormat, Table 22 (Work Results) is based on MasterFormat. Table 23 (Products) is based on EPIC. These tables enable classification of products as a pure product in the Products table, by their functional purpose in the Elements table, and by work results or construction practice in the Work Results table. A combination of these tables in a faceted approach provides the capability of classifying a product and its function precisely (Johnson, 2008). Aligning tables with similar terminology, sequencing, grouping and coding for elements, work results and products would help elements and services be mapped but these three tables don't fully align (Gelder, 2013).

MasterFormat

MasterFormat is produced by CSI and CSC (MeLampy, 2007; CSI and CSC, 2004). It is used for most building design and construction projects in North America (CSI and CSC, 2004) and has been a standard for organizing construction information since 1960s. The 2004 edition was modified with OmniClass in mind so that it can be used as one of the OmniClass tables and be coordinated with other related tables (OmniClass Secretariat, 2006).

Purpose and Properties

MasterFormat is a master list of numbers and titles classified by work results (MeLampy, 2007) for organizing information about construction work results, requirements, products, and activities (CSI and CSC, 2004). Its primary uses have been in organizing bidding and contract requirements, specifications, and product information (MeLampy, 2007). Its original purpose was for organizing project manual (Johnson, 2008). Then, it started to be used for classification of product models and other technical information.

Framework

MasterFormat is developed based on the recognition of data filing problem started in 1972 (Johnson, 2008) and its frameworks were established before ISO 12006. The framework of MasterFormat relies on publishing index, industry practice and gradual development (CSI and CSC, 2004).

Grouping Principle

MasterFormat is a hierarchical classification system (Kang & Paulson, 2000). It is organized in an enumerative manner. MasterFormat was heavily updated and new sections were added to the latest version.

Organization and Taxonomies

Each MasterFormat number and title defines a "section" arranged in "levels". The main collections of related construction products and activities are level one titles or "divisions". Each division is made up of level two, level three, and often level four numbers and titles gradually specifies more detailed areas (CSI and CSC, 2004). These numbers and titles are intentionally structured for anticipated growth and expansion in the future by CSI organized in fifty (2004 version) divisions.

UniFormat

In 1973 Hanscomb Associates, a cost consultant, developed a system called Mastercost for the American Institute of Architects (AIA) while U.S. General Services Administration (GSA) was also developing a system. The AIA and GSA agreed on a system and named it UniFormat. Then in 1989, ASTM International began developing a standard for classifying building elements, based on UniFormat. It was renamed to UniFormat II. In 1995, CSI and CSC revised UniFormat (Charette & Marshall, 1999) and latest version was published in 2010.

Purpose and Properties

UniFormat organizes construction information around the physical parts of a facility called systems and assemblies known as functional elements. These systems and assemblies are characterized by their function without identifying the work result (CSI, 2012; OmniClass Secretariat, 2006; CSI and CSC, 2010). Since UniFormat organizes items by their component elements, a modified version of it was used in developing table 21 of OmniClass (OmniClass Secretariat, 2006). Its main use is as a format for estimators to present cost estimates in schematic design phase.

Framework

The framework for UniFormat II classification is suitable for applications including cost control and schematic phase preliminary project descriptions. It accommodates items based on the judgment of building professionals (Charette & Marshall, 1999). It refers to physical parts of buildings with a particular design, construction or technical solution which is in accordance with ISO 12006-2 (CSI and CSC, 2010).

Grouping Principle

UniFormat framework is a hierarchical system and allows aggregation and summarization at different levels (Charette & Marshall, 1999).

Organization and Taxonomies

UniFormat accommodates major categories of construction information separated by their special function. These functions include nine categories (CSI and CSC, 2010) in five hierarchical levels (Charette & Marshall, 1999). It accommodates nine categories in level 1 as (CSI and CSC, 2010): A: substructure, B: shell, C: interiors, D: services, E: equipment & furnishings, F: special construction & demolition, G: building site work and Z: general.

Uniclass

Uniclass is intended to substitute for the CI/SfB standard (Kang & Paulson, 2000; Howard, 2001) that was being used as representative work breakdown structure (WBS) in Europe. Uniclass first published in 1997 in the UK is supported by Construction Project Information (CPI). In 2011, the CPI Committee (CPIc) endorsed NBS (National Building Specification) proposal to unify Uniclass (Gelder, 2011b).

Purpose and Properties

Uniclass is developed with the purpose to be a classification system for all aspects of the design and construction process. It is intended for organizing library materials and for structuring product models and project information (Kang & Paulson, 2000).

Framework

Uniclass was published in accordance with ISO 12006-2 and it was supposed to integrate a number of existing tables including SfB Table 1 and the CAWS (Common Arrangement of Work Sections for building works) (Howard, 2001; Kang & Paulson, 2000). Uniclass includes facets to cover CAWS for architectural works, EPIC and Civil Engineering Standard Method of Measurement (CESMM) in quantity surveying. It was initially based on ISO TR 14177:1994 but then it was coordinated with ISO 12006-2 (Gelder, 2011c).

Grouping Principle

Uniclass is in a series of faceted tables and it consists of separate facets (Howard, 2001; Kang & Paulson, 2000).

Organization and Taxonomies

Uniclass used to have fifteen tables (Kang & Paulson, 2000) but Uniclass2 released eleven tables (CPIC, 2013) representing separate facets. While each table groups similar entities, its hierarchy expands from a two digit code to six digits (Chapman, 2013). Uniclass2 work results tables such as table J "work sections for buildings" (Gelder, 2011b), table K "civil engineering work", table G "elements for building" and table L "construction products" can be used for classifying product models but there is not a simple link between these tables.

Discussion and Conclusion

Based on the criteria established in this paper, the study of four major construction classification systems for building product models is summarized in table 1. These four criteria, facilitate comparison between systems to examine and point out similarities and differences of construction classification systems. By using this structure, fundamental features of each system can be distinguished and analyzed in relation to other systems. For instance, Uniclass and MasterFormat have different purpose and different grouping principles. So, in order to compare them, only the corresponding table in Uniclass that is related to work results can be compared with MasterFormat table. Also, this structure points out the challenging areas that require more attention when mapping between classification systems. For instance, in mapping between Uniclass and OmniClass, while both have similar purpose and similar grouping principles in classifying product models, differences in frameworks should be carefully considered. As table 1 indicates, fundamental differences in object classes within OmniClass and Uniclass is because each system is following different sets of frameworks. So, despite adhering to some common frameworks such as ISO 12006-2, each classification system has its own interpretation of the framework classes while combined with other frameworks. Also, these systems have different strategies for their internal organization and taxonomies. Although within each faceted classifications the tables can be used in combination with each other, the differences in organization strategies of each system makes it challenging to cross reference tables among different classification systems. The challenge is to find logic between tables with similar terminology, sequencing, grouping and coding. If tables for elements, work sections and products align, work sections can be used to map designed elements to their component products. But even within one classification system e.g. within OmniClass or Uniclass, tables do not align (Gelder, 2011c). Future work should further this comparison analysis for other national product classification systems such as BSBA from Sweden and DBK from Denmark.

Table 1

Comparison between four classification systems based on the established criteria

Classification systems	OmniClass	MasterFormat	UniFormat	Uniclass
Country of origin	North America	North America	North America	UK
Produced by	CSI and CSC	CSI and CSC	CSI and CSC	CPIc and NBS
Language	English	English	English	English
Purpose and properties	Organization, sorting and retrieval of product information for all objects in the built environment in the project life cycle.	A master list for organizing construction work results, requirements, products and activities. Mostly used in bidding and specifications.	For arranging construction information, organized around the physical parts of a facility known as functional elements mainly used for cost estimates.	For all aspects of the design and construction process. For organizing library materials and structuring product literature and project information
Framework	ISO 12006-2, ISO 12006-3, MasterFormat, UniFormat, EPIC	Industry practice and gradual development	ISO 12006-2 , Professional judgment	ISO 12006-2 , SfB, CAWS, EPIC, CESMM
Grouping principle	faceted	hierarchical	hierarchical	faceted
Organization and taxonomies	15 inter-related tables categorized by number and name. A combination of Table 21, Table 22 & Table 23 allows for classifying a product precisely.	One table with a series of six numbers and name: Level one with 50 divisions (2004 version) each is made up of level two, level three, and sometimes level four numbers and titles for more detailed areas of work results.	One table with alphanumeric designations and titles in five levels: level one is in nine categories separated by their special function. Level 2 separates them into constituent parts, level 3, 4 and 5 further subdivide them.	The division among facets is based on the alphabet in 11 tables and within each facet by decimal scale up to 6 digits. Table G, J, K and L can be used for classifying product models.

Moreover, there is a need to have a structured guideline for combining classification systems in international scale. In fact, mapping information between major product classification systems would benefit the industry. The rapid development of information technology within the construction sector and globalization of construction material and products, requires international coordination of standards and classification systems. There has been some studies in Sweden to map BSAB with IFC (Ekholm, 1999). Future study needs to clarify how the classification structure of IFC (Industry Foundation Classes) as a neutral international open standard can be coordinated with established industry standards and classification systems. The buildingSMART Data Dictionary (bSDD) which is an ISO based ontology for the building and construction industry (buildingSMART, 2016) can act as an international standardization of ontology to enable coordinating classification systems. So, future study needs to investigate the ways of adding this ontology level to the current classification systems so that this layer can provide capabilities for comparing and mapping between classification systems. Besides, another issue is that there are particular types of building elements that could be hard to classify. For instance sometimes it is difficult to separate walls from roofs or to describe a typical wall section. There are new products being introduced to the market by the manufacturers such as emerging health care equipment. Classification systems should be versatile in a way that can locate new products.

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