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Classification Systems for the Built Environment: A Cornerstone for the Long-term Performance Analysis

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Abstract. *In the long-term performance analysis of the built environment, classification systems are seen as a key consideration. When classifying residential building objects, characteristics such as accuracy, exhaustivity, and consistency are required. It is noticeable that while organizations around the world are working to develop an internationally agreed standard classifier, the use of national classification systems remains widespread. Therefore, this paper focuses on reviewing the most popular classification systems such as CoClass, Uniclass 2015 and OmniClass®, among others, and discusses their strengths and weaknesses, in order to be useful both to the research and technical communities. Based on this, two main contributions are derived. On the one hand, the paper points out that there is no international consensus to use a common classification system. On the other hand, some recommendations are given and illustrated to meet the challenges of classifying existing buildings, in particular under a functional assessment approach.*

Keywords: *Classification systems; Built environment; Uniclass; OmniClass; CoClass*

1 Introduction

Over the past decades, construction industry professionals have been striving to better document and organise building project information to facilitate communication and enhance information exchange (White 1966, Down 1976). In this regard, there is widespread agreement that a classification framework is essential for a coherent reference for the description, assessment, analysis and monitoring of buildings during their life cycle (CSI and CSC 2010, Bowen et al. 1992, Charette and Marshall 1999, Svensk Byggtjänst 2005). The historical classification approach focused on the needs of the early stages of the life cycle from primarily an economic assessment of building alternatives viewpoint: (i) concept and definition, and (ii) design and development. Such classification strategy was also identified as being helpful in the subsequent stages and was consequently extended to (iii) construction, installation and commissioning, (iv) operation and maintenance, (v) mid-life upgrading or life extension, and (vi) decommissioning and disposal.

Several national classification systems have been developed for the construction industry worldwide. Given the international attention they have attracted, it is important to point out the following ones: Samarbetskommittén för Byggnadsfrågor (SfB), Byggandets Samordning AB

(BSAB) and CoClass (Svensk Byggtjänst 2016) in Sweden; CI/SfB (RIBA 1969), Uniclass (Crawford et al. 1997), Uniclass 2 and Uniclass 2015 in the United Kingdom (UK); and, UNIFORMAT, MasterFormat®, UNIFORMAT II, UniFormat® and OmniClass® (CSI 2006) in the United States of America (USA)/Canada; all of them are explained in detail in Royano et al. (2023). Figure 1 depicts the periods of use of these classification systems in Sweden, the UK and the USA/Canada. As illustrated therein, the earliest known classification system, SfB, was introduced in 1950, and since then, efforts to update and improve existing systems have not ceased. The lack of a globally recognised system which is internationally used in the construction industry indicates the complexity of designing a suitable building classification system.

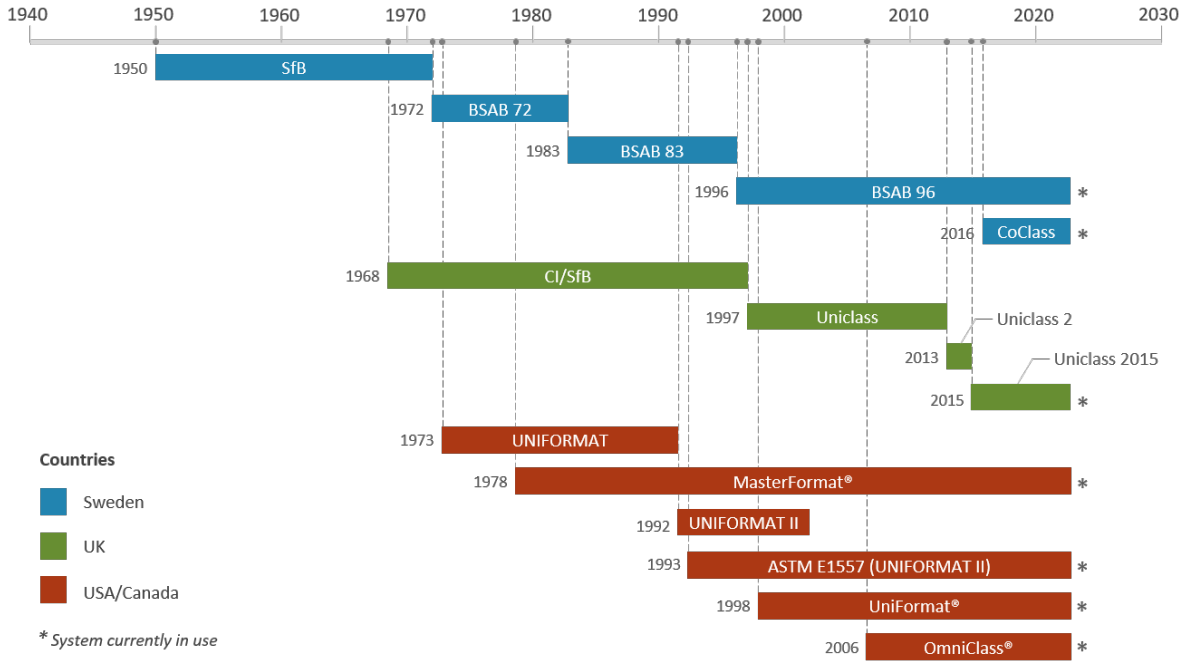

Figure 1. Timeline of the classification systems analysed from Sweden, the UK and the USA/Canada.

Due to the urge for guidance on how to use standards in the field of information classification in the construction industry, since 1988, the International Organization for Standardization (ISO), through its ISO/TC 59/SC 13 Technical Committee on "Organization of information in the processes of design, manufacture and construction", has been working on the development of a prospective standard for provisional application. As a result, ISO/TR 14177 was published in 1994 as a technical report prepared to provide (ISO 1994):

- The basis for a better flow of information during the creation and use of the facilities,
- Guidelines for the organisation of industry information.

Its provisional application made it possible to gather information and experience on its use in practice in the years following its publication. Based on this preliminary experience, the Technical Committee referred to above and now focused on the "Organization and digitization of information about buildings and civil engineering works, including building information

modelling (BIM)", developed the International Standard ISO 12006-2. This part of ISO 12006 was first published in 2001 (ISO 2015) when there was still little international standardisation of classification systems for the construction industry. This first edition is currently withdrawn and has been replaced by the second edition published in 2015. The purpose of ISO 12006-2 is twofold: (i) facilitate the exchange of information between applications throughout the life cycle of construction works (building and civil engineering), and (ii) define a framework for the development of built environment classification systems. ISO 12006-2 identifies a set of recommended classification table headers for a variety of information object classes, and it is intended to be utilised by organisations developing these systems and tables. However, it does not provide a complete operational classification system nor the contents of the tables (it only provides examples). The application of this second part of ISO 12006 for the development of local classification tables will facilitate the harmonisation between them, even though there may be variations in some particular items/contents to meet local needs. Therefore, the emergence of this international standard plays a crucial role in the development of future classification systems, providing a common framework for classification.

Although classification systems can be applied to general scenarios in the construction industry, this work is primarily concerned with their suitability for residential buildings.

There is very limited published literature that delves into the origin, evolution, current situation and specific usability/applicability of the classification systems most commonly used at the international level. The vast majority of existing works focus on describing the features of a particular system or comparing the structure and content of a set of classification systems, but without providing an overall assessment of the differences and similarities between them, and their potential applicability to specific stages of the life cycle of the built environment. Moreover, the lack of accurate historical traceability in the literature makes it difficult to understand the need for its creation, the main changes that have marked its evolution and the relation/dependence between the available classification systems. To address the above-mentioned deficiencies, this paper aims to (i) analyse the strengths and weaknesses of the three classification systems most widely used at present (CoClass, Uniclass 2015 and OmniClass®), and (ii) identify potential knowledge gaps to facilitate the design of suitable classification systems for residential buildings during the operation and maintenance stage.

2 Comparative Analysis

As a result of the comprehensive review of the literature on selected classification systems for the built environment, this section will highlight the convergences and coincidences between the most widely used systems today. Because of their long track record, CoClass (Sweden), Uniclass 2015 (UK) and OmniClass® (USA/Canada) are the best-known classification systems in the construction industry. Comparison will be in terms of their general characteristics, the tables that compose them, and their design and structure.

2.1 General Description of the Analyzed Classification Systems

While CoClass and Uniclass 2015 are the fruit of a complete overhaul of their predecessor systems, OmniClass® seems to have remained anchored in the past; it retains practically intact its initial structure, and two of its tables still come from previous systems (MasterFormat® and UniFormat®). As can be seen in Table 1, the three systems analysed are designed to classify

the entire built environment over the life cycle and comply with the general classification framework recommended by ISO 12006-2:2015. However, CoClass differs from the rest in complying with the ISO/IEC 81346 series, which implies that the description of objects is constructed in a composition structure according to the recommended rules for reference designations.

Table 1. Description of currently most widespread classification systems.

	CoClass	Uniclass 2015	OmniClass®
Organisation	Svensk Byggtjänst	NBS Enterprises Ltd.	The Construction Specifications Institute, Inc. (CSI)
Country of origin	Sweden	UK	USA/Canada
Language	Swedish and English (partially)	English	English
First publication	2016	2015	2006
Last revision	2022	2022	2013 (partially)
Predecessor systems (year of the first publication)	SfB (1950) BSAB 72 (1972) BSAB 83 (1983) BSAB 96 (1996)	CI/SfB (1968) Uniclass (1997) Uniclass 2 (2013)	UNIFORMAT (1973) MasterFormat® (1978) UNIFORMAT II (1992) ASTM E1557 (1993) UniFormat® (1998)
Compliant with	ISO 12006-2:2015 IEC 81346-1:2022 IEC 81346-2:2019 ISO 81346-12:2018	ISO 12006-2:2015	ISO 12006-2:2015
Scope	Built environment	Built environment	Built environment
Coverage	Complete life cycle	Complete life cycle	Complete life cycle
Document/file format	Web service	Spreadsheet (.xlsx)	Spreadsheet (.xls) Portable (.pdf)
Open access	Partially (free version only gives access to the basic table view, and personal information is required)	Fully (personal information is required)	Non-open access (licence payment is required)
Source	byggtjanst.se/tjanster/coclass	uniclass.thenbs.com/	csiresources.org/standards/omniclass
Update frequency	Monthly	Quarterly	Unscheduled

Software	CoClass API	NBS BIM Toolkit	Crosswalk®

2.2 Tables of the Analyzed Classification Systems with Reference to ISO 120006-2

This part of the comparative analysis aims to evaluate the concordance between the tables of the three classifiers. The comparison compiled in Table 2 is organised by reference to those recommended by ISO 12006-2:2015, grouped into four categories: Construction resource, Construction process, Construction result and Construction property.

Table 2. Tables of currently most widespread classification systems with reference to ISO 12006-2.

ISO 12006-2:2015		CoClass (Sweden)		Uniclass 2015 (UK)		OmniClass® (USA/Canada)	
Construction resource							
A.2	Construction information	–	–	FI	Form of information	36	Information
A.3	Construction products	–	–	Pr	Products	23	Products
				--	*Materials*	41	Materials
A.4	Construction agents	–	–	Ro	Roles	33	Disciplines
						34	Organisational roles
A.5	Construction aids	–	–	TE	Tools and Equipment	35	Tools
Construction process							
A.6	Management	–	–	PM	Project management (in part)	32	Services
A.7	Construction process	–	–	–	*Process activities*	31	Phases
Construction result							
A.8	Construction complexes	BX	Construction complex	Co	Complexes	–	–
A.9	Construction entities	BV	Construction entity	En	Entities	11	Construction entities by Function
						12	Construction entities by Form
A.10	Built spaces	UT	Space	SL	Spaces/locations	13	Spaces by Function
						14	Spaces by Form
A.11	Construction elements	FS	Functional systems	EF	Elements/functions	21	Elements (Uniformat®)
		KS	Constructive systems	Ss	Systems		

		KO	Components				
A.12	Work results	PR	Work result	Ss	Systems (in part)	22	Work Results (MasterFormat®)
				Pr	Products (in part)		
Construction property							
A.13	Construction properties	–	Properties	–	*Properties and characteristics*	49	Properties
(Other tables not included in ISO 12006-2:2015)							
		AK	Activities	Ac	Activities		
		FA	Maintenance activities	Zz	CAD		

2.3 Structure of the Analyzed Classification Systems

According to ISO 22274:2013 on "Systems to manage terminology, knowledge and content — Concept-related aspects for developing and internationalizing classification systems" [8], a classification system is considered as a systematic collection of classes (or sets of objects sharing the same characteristics) organised under a set of known rules, and in which objects can be grouped in conformity with the purpose of the classification. Classification systems should be carefully designed to avoid structures that do not provide the necessary information or that are too complicated and confusing for users, as this would make it difficult to unequivocally characterise objects. Taking this premise into account, Table 3 evaluates the classification systems studied based on selected factors to better understand how they have been designed and how their content is expressed.

Table 3. Design and structure of currently most widespread classification systems.

	CoClass (Sweden)	Uniclass 2015 (UK)	OmniClass® (USA/Canada)
Structure of classification system	Enumerative (higher levels) and faceted (lower levels)	Faceted	Faceted
Structure of individual tables	Hierarchical, with a "top-down" approach	Hierarchical, with a "top-down" approach	Hierarchical, with a "top-down" approach
Number of tables	10	12	15
Maximum level of hierarchical nesting	3	4	7
Classification scheme (higher to the lower level)	Level 1 (class) Level 2 (sub-class) Level 3 (sub-sub class)	Level 1 (group) Level 2 (subgroup) Level 3 (section)	Level 1 Level 2 Level 3

		Level 4 (object)	Level 4 Level 5 *(some of them)* Level 6 *(some of them)* Level 7 *(some of them)*
Expandable structure	Not necessary. If the object of interest is not located, it shall be classified at a higher level.	Extra room is provided between existing codes to accommodate future additions.	Extra room is provided between existing codes to accommodate future additions.
Notation	Alphanumeric characters	Alphanumeric characters	Numeric characters
Coding example	B.AD.QQA030%F5	Ss_25_30_95_95	21-02 20 20 10

Possibly one of the most important distinctions regarding the degree of maturity and determination of classification systems is the fact that CoClass, in compliance with IEC 81346-2, considers its tables to be complete. This implies that non-specific identifications such as "others", "general", or "miscellaneous" do not appear in their tables as occurs in OmniClass® and, to a much lesser extent, in Uniclass 2015.

2.4 Illustrative Example

After requiring for the classification of the construction element “aluminium sliding exterior windows” we can state what follows. On the one hand, Uniclass 2015 and OmniClass® list many types of windows (75 and 215, respectively) in different tables. In terms of consistency, it can be ambiguous and confusing that "window" can be classified with a different notation depending on whether it is considered a system, product, element or work result. On the other hand, CoClass identifies 57 items and has a very different encoding structure. In the main part of the code, the "window" component is explicitly and unequivocally classified. This classification scheme ensures a stable class code throughout the life cycle of the building, as the object is classified by its inherent function. Other characteristics of windows (such as material or opening type) could be added according to the rules for the construction of reference designations defined in the ISO/IEC 81346 series.

3 Conclusions

The findings of this study will contribute to the benefits of designing standardised classification systems to describe the entire built environment. Based on the literature reviewed, the most important remarks, potential knowledge gaps and future research directions are summarised as follows:

- The emergence of the ISO 12006-2 standard, first published in 2001, was the first step toward the international standardisation of classification systems for the construction industry. For the first time, a framework was defined to facilitate harmonisation between systems and tables developed by the organisations concerned. The ISO/IEC 81346 series lays down rules for the construction of reference designations and classification schemes to provide stable class codes for objects.

- Significant differences have been detected between the structuring principles of CoClass and Uniclass 2015/OmniClass®. All three comply with ISO 12006-2:2015 and are based on long-standing national experiences. However, CoClass also complies with the ISO/IEC 81346 series, so its coding structure provides a consistent and unambiguous system for classifying building elements. Users can build the description of an object from the selection and assembly of appropriate facet codes, following a set of established rules. The Uniclass 2015 and OmniClass® tables also can be used independently or in combination. Nonetheless, rules to form unique codes for classifying object types are not explicitly specified.
- CCS (Denmark) and CCI (international approach) classification systems are very close to the CoClass structure, as they have been developed according to the guidelines of the same aforementioned international standards.
- It has been noted that there is still no international consensus on using a common built environment classification system. The international non-profit organisation CCIC is actively working on the development of a unified and understandable language for building information management. The CCI system, first published in 2020, is intended to be used simultaneously by different countries in all technical fields and industries. As to its potential adoption, we believe that further work is needed to (i) complete the core tables (common to all participating countries), (ii) validate the suitability of the content of core tables in local applications, and (iii) develop national component tables.
- There is no established method for classifying objects in residential buildings in a consistent, unambiguous and standardised manner. Some classification systems duplicate classes in several tables, whereas others do not specify how to define some properties (e.g. material or type). Further efforts are needed to implement the structuring principles and designation rules defined in the ISO/IEC 81346 series.
- While the use of classification systems throughout the asset life cycle is increasingly encouraged, they are primarily conceived to classify information acquired at the design and construction stages. However, this data will not always be available in existing buildings and should be collected on-site as part of technical inspections, with all the difficulties and constraints involved. It is therefore necessary to open up a new line of research to explore the challenges of identifying and classifying such information at the operation and maintenance stage. This particular approach opens up endless opportunities in existing building management (e.g. it could be implemented in a new functionality-oriented classification system).

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