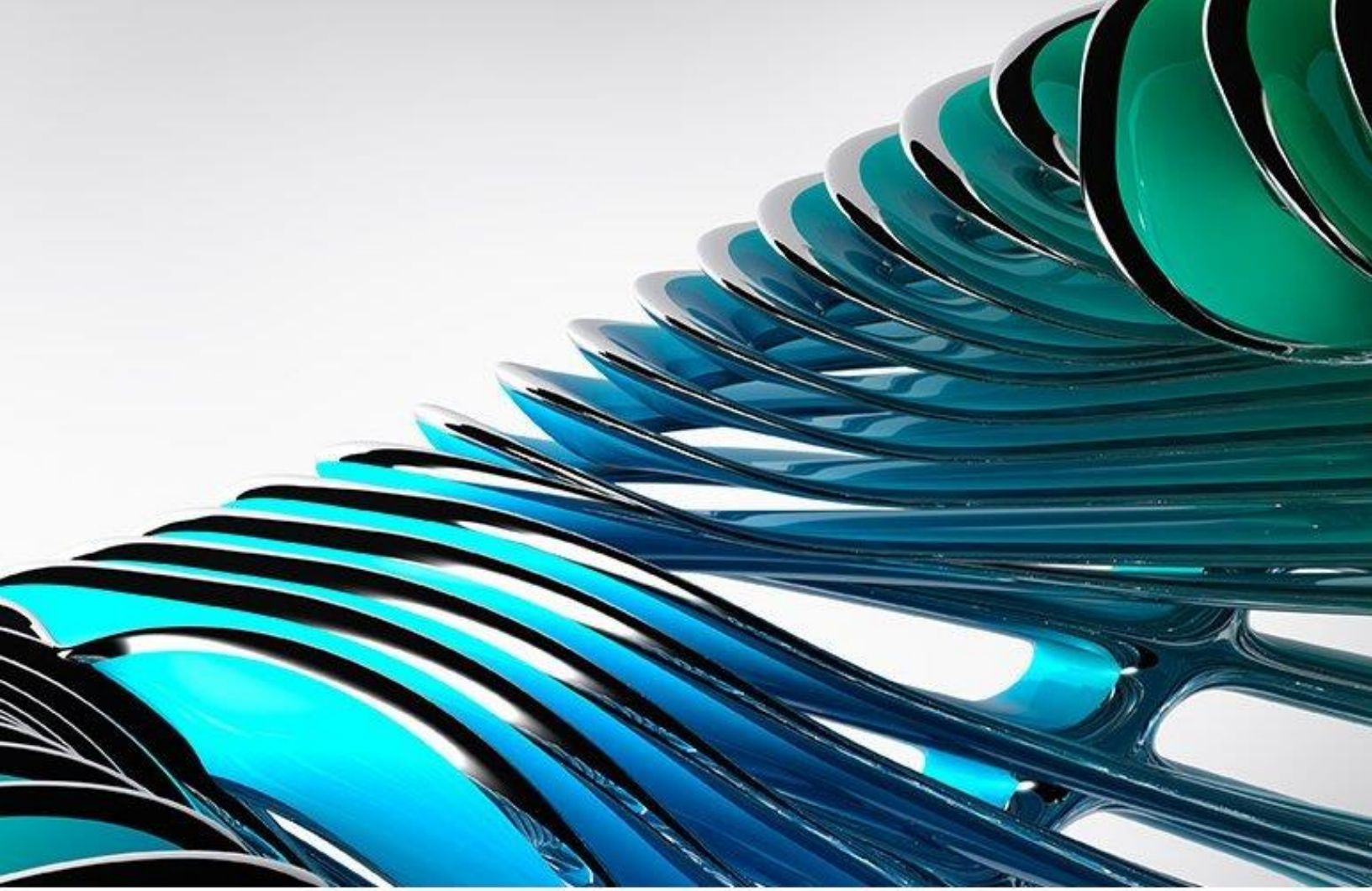

Classification Systems and Their Use in Autodesk Revit®

Managing the “I” in BIM

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ABSTRACT

This white paper, authored by CADD Microsystems in collaboration with Autodesk, was written to identify the purpose and need of classification systems in general, but also specifically the default classification systems supported by the Autodesk Classification Manager for Revit (Uniformat, MasterFormat, OmniClass, Uniclass), including real world examples. This paper will explore how the Autodesk Classification Manager for Revit helps support the use of classification systems during design, construction, and operations.

What is Classification Management?

Classification Management is a strategy to classify the built environment. There are multiple Classification Management systems used all around the world. The most common ones are the following:

1. **MasterFormat** | A master list for organizing construction work results, requirements, products, and activities. Mostly used in bidding and specifications, MasterFormat originated in North America and is produced by the Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC).
2. **UniFormat** | For arranging construction information, organized around the physical parts of a facility known as functional elements, and mainly used for cost estimates. UniFormat originated in North America and is produced by the Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC).
3. **Uniclass** | For all aspects of the design and construction process. In particular, for organizing library materials and structuring product literature and project information. Uniclass originated in the United Kingdom and is produced by the Construction Industry Project Information Committee (CPIC) and the National Building Specification (NBS).
4. **OmniClass** | For organization, sorting, and retrieval of product information for all objects in the built environment in the project lifecycle. OmniClass originated in North America and is produced by the Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC).

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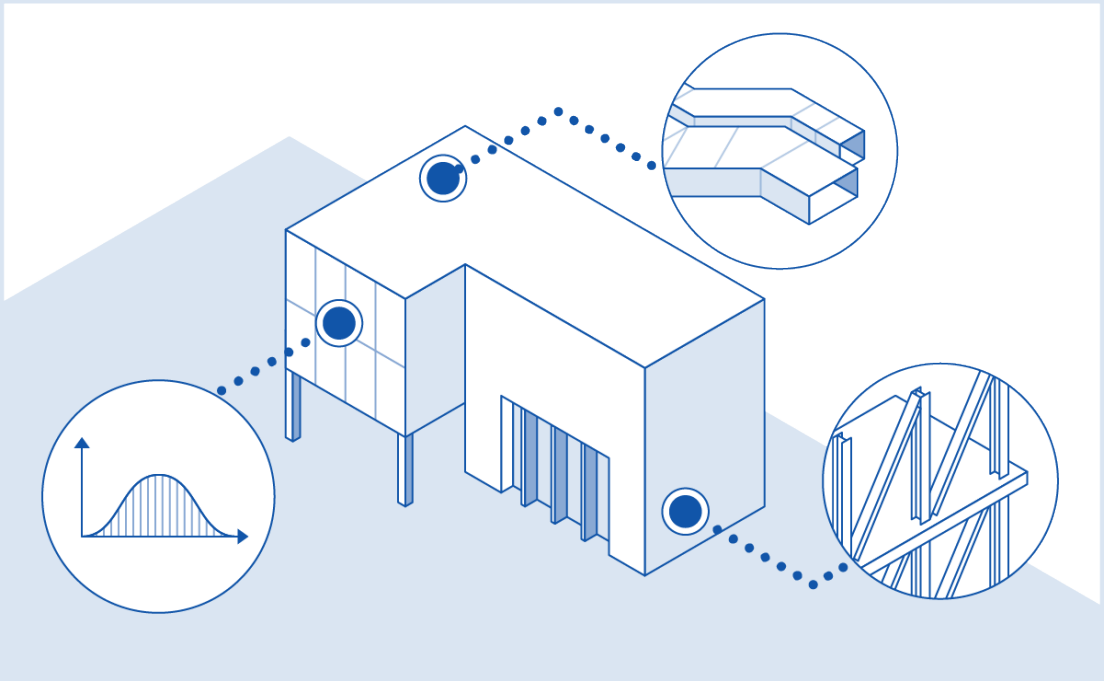
Why Is It Important?

The activities conducted throughout the lifecycle of any facility generate an enormous quantity of data that needs to be stored, retrieved, communicated, and used by all parties involved. [13]

Continuing advances in "Smart Building Technologies," "Building Information Modeling" (BIM) technologies, and construction practices have not only increased the amount and detail of data generated and exchanged, but have also further raised expectations about its use and value as an asset. This increase in the amount and types of information generated, and the AEC industry's subsequent reliance on it, demands an organizational standard that can address the full scope of this information. This organizational standard will enable and add certainty to information communicated between parties separated by miles, countries, or continents. [13]



Industry organizations have begun to realize that a greater degree of harmonization in classifying information is now necessary and possible. This harmonization and reuse of information for multiple purposes is at the heart of the value and cost savings presented by Building Information Models. [13]

Many facility owners and managers insist on having access to all information generated during a developing project and updated throughout the life of a facility. They want to have access to the data that was used to prompt decisions, the options that were considered, the records of those options and decisions, and the information used to support the decisions made. They need that information to better manage their facilities as the information will likely become an expected or saleable asset that will be transferred to future owners. Coordinating the production, storage, and retrieval of that information is a daunting task. [13]

The increasing international trade in construction products, and the diversification of consultant and contracting services in different places at differing times, makes nationally and internationally accepted principles for information organization and the preparation of construction documentation of vital importance to the continued health of the industry. [13]

Standardizing the presentation of such information improves communication among all parties involved in construction projects. This helps the project team deliver structures to owners according to their requirements, timelines, and budgets. [13]

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How Are Classification Systems Used in the Industry?

Each of the three typical project stakeholders have different goals for classification systems:

Owners | Use classifications to organize data for facility & asset management, development planning, and cost estimates.

Contractors | Use classifications for construction management, scheduling, and cost estimates.

Architects and Engineers | Use classifications to generate project specifications.

Each project is different and has different needs. For one project, multiple classifications may be used and all elements may be classified. More often, only one or two classification systems are used and only some elements are classified, depending on the needs for the project, the data to be collected for the database, and the effort involved.

BIM data can also include non-object attributes which may be added for information at the project or facility level. It can be as simple as a value for an attribute in a database.

How Do Professionals Get Educated on Them?

Most architects, engineers, and contractors learn through professional experience on projects. MasterFormat is often the first exposure to classifications because it is used to write specifications which provide guidelines for a project's construction. Some may also gain experience in UniFormat to produce cost estimates. In the United States, the Construction Specifications Institute (CSI) offers classes and certification exams for formal training.

Most undergraduate architecture programs at universities in the United States are focused on design, history, and presentation, but some do include curriculum on BIM and classifications. Classifications are taught in detail at graduate university programs, especially those related to construction management.

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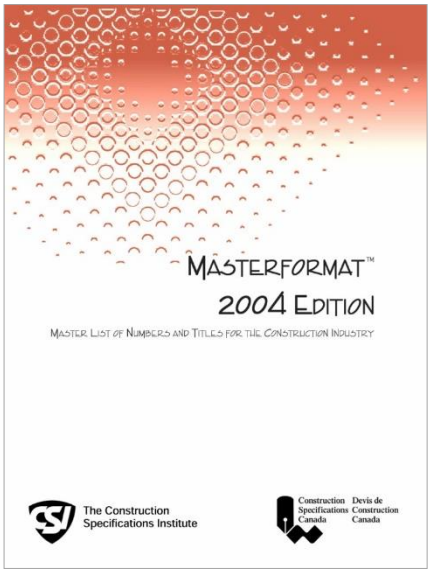
Popular Classification Systems

MasterFormat

MasterFormat is a standard for organizing specifications and other written information for commercial and institutional building projects in the U.S. and Canada. Sometimes referred to as the "Dewey Decimal System" of building construction, MasterFormat is a product of the Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC). It provides a master list of Divisions, and Section numbers with associated titles within each Division, to organize information about a facility's construction requirements and associated activities. [17]

After World War II, building construction specifications began to expand as more advanced materials and choices were made available. The CSI was founded in 1948 and began to address the organization of specifications into a numbering system. In 1963, they published a format for construction specifications with 16 major divisions of work. A 1975 CSI publication used the term MasterFormat. The last CSI MasterFormat publication to use the 16 divisions was in 1995 and this is no longer supported by CSI.

In November 2004, MasterFormat expanded from 16 Divisions to 50 Divisions, reflecting innovations in the construction industry and expanding the coverage to a larger part of the industry. Updates were published in 2010, 2012, 2014, and 2016. [17]



MasterFormat is used throughout the construction industry to format specifications for construction contract documents. The purpose of this format is to assist the user to organize information into distinct groups when creating contract documents, and to assist the user searching for specific information in consistent locations. The information contained in MasterFormat is organized in a standardized outline format within 50 Divisions (16 Divisions pre-2004). Each Division is subdivided into a number of Sections. The divisions of MasterFormat are listed in Appendix A. [17]

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UniFormat

Overview

UniFormat is a standard for classifying building specifications, cost estimating, and cost analysis in the U.S. and Canada. The elements are major components common to most buildings. The system can be used to provide consistency in the economic evaluation of building projects. It was developed through an industry and government consensus and has been widely accepted as an ASTM standard. [17]

Hanscomb Associates, a cost consultant, developed a system called MASTERCOST in 1973 for the American Institute of Architects (AIA). The U.S. General Services Administration (GSA), which is responsible for government buildings, was also developing a system. The AIA and GSA agreed on a system and named it UNIFORMAT. The AIA included it in their practice on construction management, and the GSA included it in their project estimating requirements. In 1989, ASTM International began developing a standard for classifying building elements based on UNIFORMAT. It was renamed to UNIFORMAT II. In 1995, the Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC) began to revise UniFormat. UniFormat is now a trademark of CSI and CSC and was most recently published in 2010. [17]

UniFormat Level 1 Categories

- A Substructure
- B Shell
- C Interiors
- D Services
- E Equipment and Furnishings
- F Special Construction and Demolition
- G Building Sitework

UniFormat Levels 2 and 3 Categories

An example of how the numbering system expands to provide additional detail below level 1 is shown for A Substructure:

A10 Foundations
  A1010 Standard Foundations
  A1020 Special Foundations
  A1030 Slab on Grade

A20 Basement Construction
  A2010 Basement Excavation
  A2020 Basement Walls

Uniclass

Overview

Uniclass 2015 is a unified classification system for all sectors of the UK construction industry. It contains consistent tables classifying items of all scales; from facilities such as a railway, to products like anchor plates, flue liners, or LED lamps. [17]

In the UK, the Construction Industry Project Information Committee (CPIC) created Uniclass as a unified classification system for all sectors of the UK construction industry. Originally released in 1997, Uniclass allows project information to be structured to a recognized standard. This original version has now been heavily revised to make it more suitable for use with modern construction industry practice and to make it compatible with BIM, now and in the future. [17]

Led by the National Building Specification (NBS), experts from across the industry have developed the new system, known as Uniclass 2015. This significantly extends the scope of the previous version and responds to industry feedback on the draft tables known as Uniclass 2, published by CPI in 2013. [17]

Development

Uniclass 2015 was designed to provide a comprehensive system suitable for use by the entire industry, including the infrastructure, landscape, and engineering services, as well as the building sector and for all stages in a project lifecycle. It also provides a means of structuring project information essential for the adoption of BIM Level 2, which is a component of the UK BIM Mandate. Information about a project can be generated, used, and retrieved throughout the lifecycle. [17]

The initial classification work has focused on the seven core tables that describe an asset required to support the Digital Plan of Work. Additional tables covering Form of Information, Project Management, and Construction Aids are also under development. [17]

Uniclass 2015 has been carefully structured to be in accordance with *ISO 12006-2 Building construction – Organization of information about construction works – Part 2: Framework for classification*. This means that Uniclass 2015 is particularly suited to use in an international context, as mapping to other similarly compliant schemes around the world is streamlined. [17]

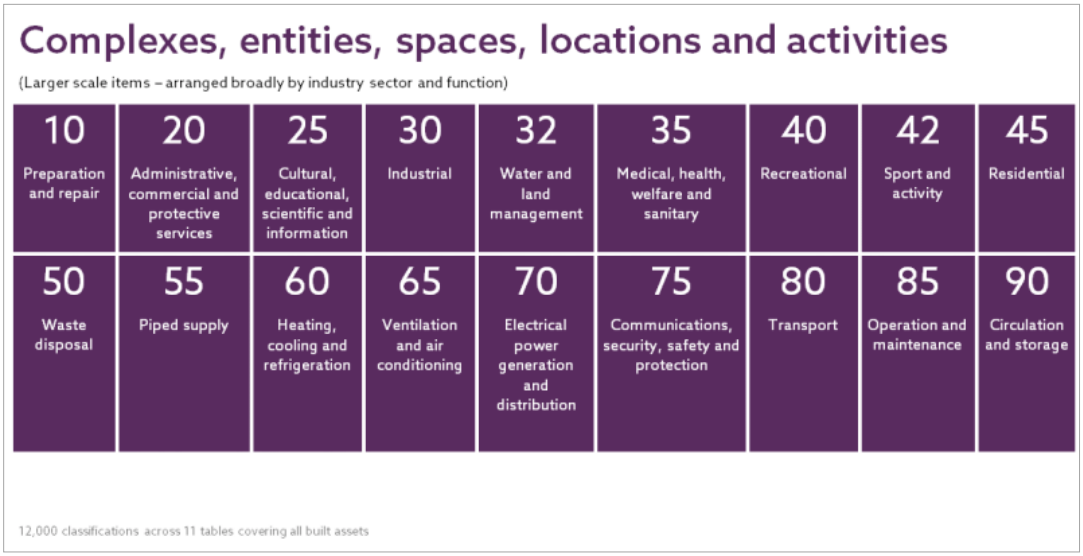
Application

Uniclass 2015 is divided into a set of tables, each accommodating a different ‘class’ of information. These can be used to categorize information for costing, briefing, CAD layering, etc., as well as when preparing specifications or other production documents. [17]

These tables are also suitable for buildings and other assets in use, as well as maintaining asset management and facilities management information. [17]

Organization

The suite of tables is broadly hierarchical and allows information about a project to be defined from the broadest view of it to the most detailed. For detailed design and construction, the main starting point are Entities, which are composed of Elements; Elements are made up of Systems, which in turn contain Products. [17]



[5]

Entities can also be described using the Spaces and Activities tables, if required, and at the more general level the Complexes table contains terms that can be thought of as groupings of Entities, Activities, and Spaces. [17]

A more detailed description of the tables can be found in Appendix B.

Use

The tables are designed to be flexible and to be able to accommodate sufficient codings to ensure coverage to allow for a multitude of items and circumstances, including new technologies and developments that are yet to emerge.

Each code consists of either four or five pairs of characters. The initial pair identifies which table is being used and employs letters. The four following pairs represent groups, sub-groups, sections, and objects. By selecting pairs of numbers, up to 99 items can be included in each group of codes, allowing plenty of scope for inclusion.

For example, Systems are arranged in groups with subgroups that are subdivided, which leads to the final object code:

SS_30	Roof, floor and paving systems
SS_30_10	Pitched, arched and domed roof structure systems
SS_30_10_30	Framed roof structure systems
SS_30_10_30_25	Heavy steel roof framing systems

Or

SS_50	Disposal systems
SS_50_75	Wastewater storage, treatment and disposal systems
SS_50_75_67	Primary sewage treatment and final settlement systems
SS_50_75_67_46	Lamella tank systems

OmniClass

Overview

The OmniClass Construction Classification System (OCCS), typically referred to as "OmniClass", is useful for many applications from organizing library materials, product literature, and project information, to providing a classification structure for electronic databases. It incorporates other classification systems currently in use as the basis of many of its Tables: MasterFormat for work results, UniFormat for elements, and EPIC (Electronic Product Information Cooperation) for products. [13]

OmniClass is designed to provide a standardized basis for classifying information created and used by the North American architectural, engineering, and construction (AEC) industry, throughout the full facility lifecycle, from conception to demolition or reuse, and encompassing all the different types of construction that make up the built environment. OmniClass is intended to be the means for organizing, sorting, and retrieving information and deriving relational computer applications. [13]

Development

OmniClass follows the international framework set out in the *International Organization for Standardization (ISO) Technical Report 14177 - Classification of information in the construction industry, July 1994*. This document was later established as a standard in *ISO 12006-2: Organization of Information about construction works - Part 2: Framework for classification*. OmniClass has been developed under the auspices of the following guiding principles established by the OCCS Development Committee at their September 29, 2000 inaugural meeting:

- OmniClass is an open and extensible standard available to the AEC industry at large.
- There is a full and open exchange of information between participants in OmniClass development.
- OmniClass is being developed and updated with broad industry participation.
- OmniClass development is open to any individual or organization willing to actively participate.
- The industry as a whole, rather than any one organization, will govern development and dissemination of OmniClass.
- OmniClass is focused on North American terminology and practice.
- OmniClass is compatible with appropriate international classification system standards.
- Applicable efforts in other parts of the world are reviewed and adapted as appropriate.
- Existing legacy classification systems, references, and research materials applicable to OmniClass development are considered in the formulation of the OmniClass. [13]

Organization

OmniClass consists of 15 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 entries can be combined with entries on other tables to classify more complex subjects. [13]

The organization of the OmniClass Tables is based on the segregation of information types to be classified into a set of discrete, coordinated tables. The information contained in each table exists, and is organized, based on a specific facet or view of the total information that exists in the built environment. [13]

> *Classification's value comes from the order it provides to the information – the "human-facing side of BIM."* [9]

Not all the tables are developed to the same degree; some have much more extensive top-level listings and more depth of entries than others, simply due to the depth and complexity of their subject matter. The number of top level classes in any given table is designed to number as few as possible to offer users a manageable number of categories to browse and with which to work. The level of detail in the subclasses of each table can be as extensive as needed. [13]

The OmniClass tables are designed to work together to provide extremely granular, or specific, classification. Depending on the complexity of the object being classified, and the level of detail desired, an object can have occurrences in one, two, or more tables. Occurrences on multiple tables can then be combined using the rules outlined in the OmniClass Application Guide. This classification can then be combined with values drawn from applicable entries on *Table 49 - Properties*, providing a highly granular level of indexing that will be extremely useful to databases and other computer applications. [13]

Although OmniClass is designed so that it can be used for hard copy classification (classic physical storage methods), the real power of OmniClass is dependent upon its implementation in computer technology (primarily relational or object-oriented databases), using that technology's ability to relate information from a variety of perspectives and to produce reports from all perspectives. The result is an information management tool that is more flexible and powerful than any simple flat-file storage system. [13]

Both Uniclass and OmniClass draw their table definitions and table concepts from *ISO 12006-2*. The following chart shows how these are all related: [14]

ISO 12006-2: 2015	Uniclass 2015	OmniClass 2006-2013
A.2 - Construction Information	**FI** - Form of Information (Beta)	**Table 36** - Information
A.3 - Construction Products	**Pr** - Products	**Table 23** - Products
-	-	**Table 41** - Materials
A.4 - Construction Agents	-	**Table 33** - Disciplines
-	-	**Table 34** - Organizational Roles
A.5 - Construction Aids	**TE** - Tools and Equipment	**Table 35** - Tools
A.6 - Management	**Pm** - Project Management	**Table 32** - Services
A.7 - Construction Process	-	**Table 31** - Phases
A.8 - Construction Complexes	**Co** - Complexes	-
A.9 - Construction Entities	**En** - Entities	**Table 11** - Construction Entities by Function
-	-	**Table 12** - Construction Entities by Form
-	**Ac** - Activities	-
A.10 - Built Spaces	**SL** - Spaces/Locations	**Table 13** - Spaces by Function
-	-	**Table 14** - Spaces by Form
A.11 - Construction Elements	**EF** - Elements/ Functions	**Table 21** - Elements (Includes Designed Elements) (Uniformat)
-	**Ss** - Systems	-
A.12 - Work Results	-	**Table 22** - Work Results (MasterFormat)
A.13 - Construction Properties	-	**Table 49** - Properties
-	**Zz** - CAD	-

More information about each of the OmniClass tables can be found in Appendix C.

Other Classification Systems

In addition to the application of *ISO 12006-2* in Uniclass, the object-oriented framework standardized by *ISO/PAS 12006-3* has been adopted by ICIS members in their Lexicon program, and both standards are followed by groups in several other countries that are developing similar classification standards. They include Norway, the Netherlands, the UK, and others in Europe in concert with the Nordic chapter of the International Alliance for Interoperability (IAI) and the Japan Construction Information Center (JACIC), which is currently working to develop the Japanese Construction Classification System (JCCS), modeled in part on OmniClass. [13]

BIM in the AEC Industry

The construction industry is exhibiting signs of a historic shift in its fundamental methods due to the BIM movement. This new methodology combines information needed for a project's design, construction, and operation into a digital form. BIM is importantly defined as the development and use of a technology to simulate the construction and operation of a facility from which views and data appropriate to various users' needs can be extracted and analyzed. BIM also enables better collaboration between design information and the fabrication processes of construction, resulting in newly emerging processes that replace traditionally separated design, construction, and facilities management. [8]

The term BIM is used both as a noun and as a verb, but the industry is moving towards the 'verb' definition of BIM:

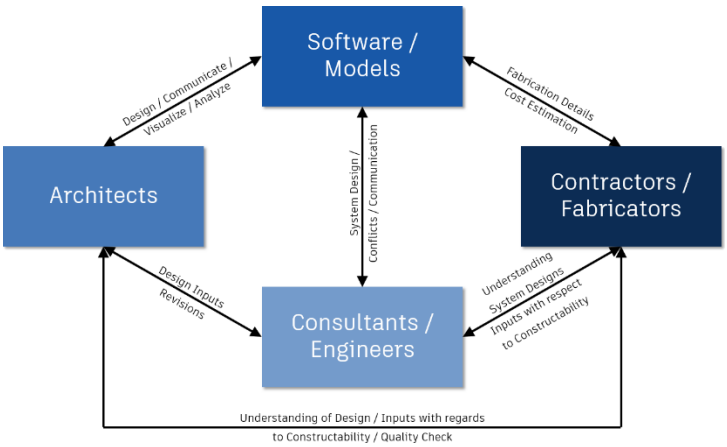
> ***Building Information Modeling*** *is a process whereby a building is modeled virtually, with its associated information, to be used to help design, construct, and maintain a building.*

BIM as a noun (a digital / virtual model of a building used in the BIM process), is typically referred to as a 'model' or 'BIM model".

BIM originated in the late 1990s when improvements in hardware speed and performance allowed for the development of intelligent 3D design software. These developments meant that CAD software was now capable of storing related data of the building elements rather than simple graphic representation of those elements. [8]

Various Stakeholders for BIM Adoption

BIM has been suggested as a solution to the fragmented nature of the AEC industry. The use of BIM for architects and engineers facilitates communication of design intent to contractors, fabricators, and subcontractors. BIM use by contractors, fabricators, and subcontractors facilitates successful implementation of the design intent. Owners, although not directly involved in the creation of BIM models, are the most important driver and the biggest beneficiary of BIM. BIM reduces risks to the owner as well through effective delivery of design intent and implementation, thus reducing legal exposures. BIM further provides a tool for the owners of the facility to manage the project over its complete lifecycle. Many see BIM as a methodology for better serving owners in the AEC industry. [8]



BIM Stakeholder Relationships

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Autodesk Classification Manager for Revit

Background

Classification systems and processes need to evolve for the new BIM world. After all, the promise of BIM is more data reuse and less data re-entry. We need to reuse the intelligence in our models and minimize manual tasks.

Currently, Autodesk Revit – the AEC industry's premier BIM model authoring tool - utilizes classification systems in three ways by having built-in parameters (data fields) for the following purposes:

OmniClass Number + OmniClass Title | These parameters are set at the Revit family level and represent *OmniClass Table 23 – Products*. Most of the families that come with Revit have these assigned, but you can add this information to any family by editing the family's properties. For Revit 2018, it is reading the database file at the following location by default:

C:\ Users \ <USERNAME> \ AppData \ Roaming \ Autodesk \ Revit \ Autodesk Revit 2018 \ OmniClassTaxonomy.txt

Assembly Code + Assembly Description | These parameters are used to assign the UniFormat number. Some families that come with Revit may already have these assigned, but many do not. For Revit 2018, it is reading the database file at the following location by default:

C:\ ProgramData \ Autodesk \ RVT 2018 \ Libraries \ <LIBRARY SUBFOLDER> \ UniformatClassification.txt

Keynote | This parameter is set up by default to assign the MasterFormat number, but it is somewhat impractical to note drawings with MasterFormat. Most people use this Keynote parameter for adding their own custom sheet notes.

There are some inherent challenges with the way classifications are assigned to out-of-the-box Revit content. Most notably, that they are, in general, assigned one level above where they need to be. For example, assigning an *OmniClass Table 23* value at the family definition level means that all types in that family have the same OmniClass number, but changing the size or other type values can cause the OmniClass number to be different. In addition, the databases that ship with Revit are often out of date or missing key values.

These issues created a need for a better way to assign and manage classification values in Revit.

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A Better Tool

The **Autodesk Classification Manager for Revit** is a user-friendly add-in for Revit that allows people to easily organize and manage classification data across multiple Revit models, no matter which system is used. The classification data can be applied to Revit elements from systems such as UniFormat, MasterFormat, OmniClass, Uniclass, or even a custom database. In addition, all the classification data used in this process is accessed from an included Excel spreadsheet that is fully editable. The Autodesk Classification Manager for Revit is being used by more than 5,000 Revit users around the globe.

This tool can be downloaded for free from www.biminteroperabilitytools.com. This website always has the latest build as well as all the resources (sample files, videos, help pages, etc.).

A custom database with the Classification Manager allows a person to build a list of standard values that can be accessed within Revit, applied to any parameter (custom, shared, or even standard), and can be applied to more than one family category. For example, you could have a custom Classification Manager database for fire ratings. Often, Revit users do not know if they should type in “1 HOUR”, “1 HR.”, “1-hour rating”, etc. You can create a standardized list of fire rating values and users can select both the door and the wall that hosts that door at the same time and apply the standard value to the default “Fire Rating” parameter on both elements.

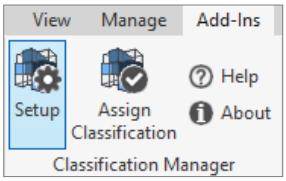
Key Features

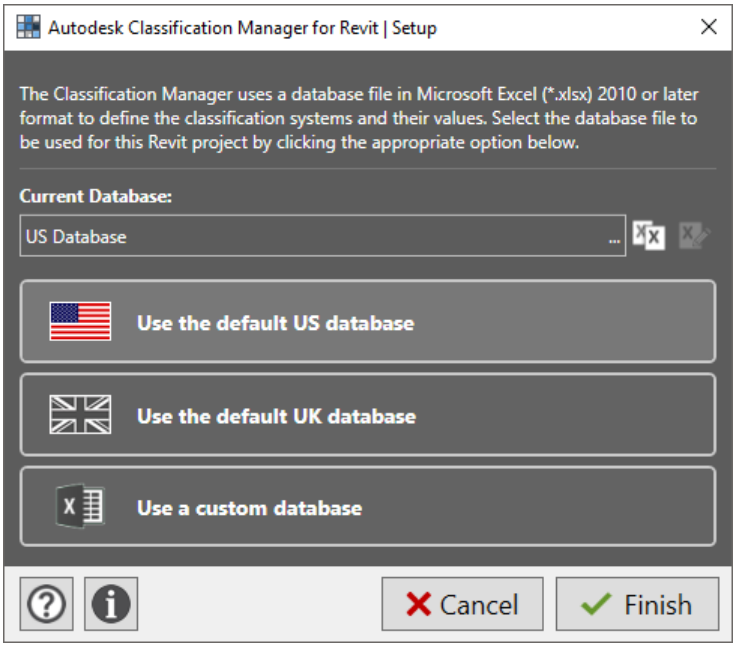
- The Autodesk Classification Manager for Revit is an add-in for Autodesk Revit.
- It runs on Revit 2013, 2014, 2015, 2016, 2017, and 2018.
- It allows a Revit user to assign multiple classification system values to elements and types with one click.
- It references fully configurable Microsoft Excel files for its classification system database files.
- It integrates with the Autodesk COBie Extension for Revit by providing “category” data for Contact, Facility, Space, and Type worksheets.
- The naming of the parameters it uses can be controlled by editing the database file.

How to Use

Setup

The first step in using the Classification Manager is to select a classification database. Clicking “Setup” from the Classification Manager Panel located on the Add-Ins tab allows a default dataset to be selected. A new dataset can be created from the default Excel file, or the current dataset can be opened for editing. The user needs to select one of the database options to use for their Revit project:

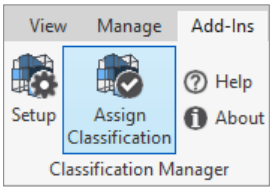




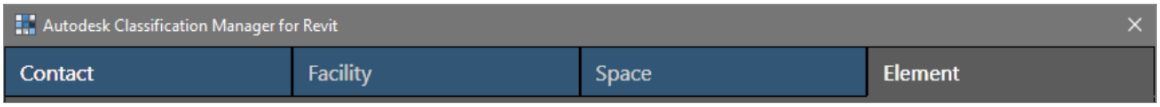
The user can return to this screen to change the selection at any point during the project lifecycle, if necessary. The name of the database chosen is saved in the extensible storage of the RVT file. Instructions on creating a custom classification database can be found in the Excel file, "Classification Manager Database Custom.xlsx" located in the Classification Manager installation folder.

Assign Classification

For elements in the Revit model, select the elements, and then click the "Assign Classification" icon. One can also select Family Types from the Project Browser.

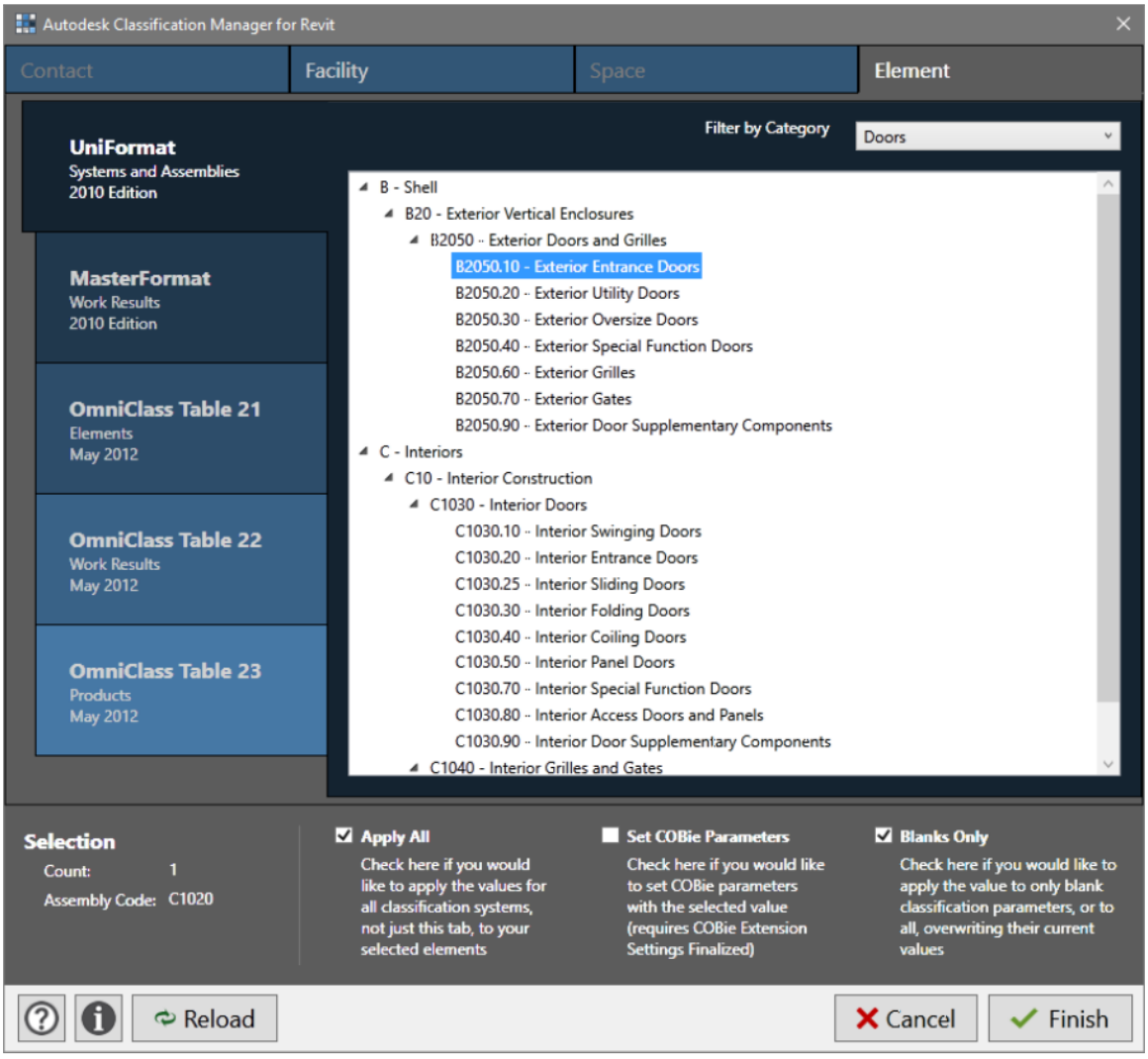


Depending on what type of element is selected, the appropriate tab and filter will be applied to limit the classifications shown to those related to the selection.



If no element is selected, the option will be given to assign “Facility” classifications, which get assigned to the Project Information.

The “Contact” tab is used as integration with the Autodesk COBie Extension for Revit.



The user can simply navigate through the tree in the right-hand window, select the wanted classification, and click the “Finish” button. One can easily toggle between classification systems on the left if the database supports multiple systems. If the chosen database has been set up to support cross classifying, the "Apply All" checkbox

will attempt to assign classifications across the systems available in the database. "Set COBie Parameters" will assign the classification to the appropriate default parameter used by the Autodesk COBie Extension for Revit, if those parameters exist in the model. The "Blanks Only" checkbox can keep from overwriting any existing data already in the parameters used by the Classification Manager.

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Conclusion

Comparing Classification Systems

Kereshmeh Afsari and Charles M. Eastman, from The Georgia Institute of Technology, wrote a paper in 2016 that compared the four major classification systems based on the following specific criteria:

- **Purpose and Properties of the Classification System** | The purpose defines the properties of interest to the classification that configures how the objects should be sorted into classes. [1]
- **Framework of the System** | Framework provides a conceptual basis for the construction industry. The idea is that national systems can be compared more easily if they follow the same class definitions in the standard. This provides a basic structure of information about construction and its main categories. [1]
- **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. 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. [1]
- **Organization and Taxonomies of Tables** | 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. 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. [1]

Comparison between four classification systems based on the established criteria: [1]

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 lifecycle.	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 and 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, and 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.

Future of Classification Systems and BIM Integration

With an increase in international projects, where multiple teams from all over the world must collaborate on a single project, there is a growing need to have a structured guideline for combining classification systems at an international scale. As per Roger J. Grant, Program Director for the National Institute of Building Sciences (NIBS):

> *"Having one overarching International Classification Management System is not a good option. What we need is to map various National Classification Management Systems."*

Grant believes that the rapid development of information technology within the construction sector, and the globalization of construction material and products, requires coordination of standards and systems. [10]

Grant also stresses the importance of tying classification management systems with Industry Foundation Class (IFC). IFC is an object-based file format with a data model developed by the buildingSMART alliance® (bSa) to facilitate interoperability in the AEC industry, and is commonly used as a collaboration format in BIM-based projects. There are inherent benefits using IFC since it is a platform neutral, open file format specification that is not controlled by a single vendor or group of vendors. However, IFC poses its own challenges during implementation when intelligent information is lost as data moves from one software to another. Countries like Denmark, Norway, and Finland are taking a lead in adoption of IFC. IFC adoption is still not very popular in the US. [10]

One of the organizations that studies the adoption of Classification Management Systems internationally and their integration with BIM is the International Construction Information Society (ICIS). ICIS includes representatives from 13 countries and five continents. [6]

> *"Apart from the technological challenges of information mapping, there are perception barriers for adoption of Classification Management Systems, since users presume these are difficult to implement."*

This quote is by Greg Ceton, Director of Strategic Initiatives and Special Projects, CSI. Greg also suggests that, regardless of the barriers, *"CSI will keep maintaining MasterFormat, UniFormat, and OmniClass in the future."* [9]

Graham H. Stewart, founder of the Digital Guerilla Consultancy, Ltd., is taking classification systems to the next level by utilizing the Autodesk Classification Manager for Revit to automatically assign classification values across multiple systems such as Uniclass, NRM, NBS, and IFC. [11]

Future studies need to investigate ways to provide capabilities for comparing and mapping between classification systems and their integration with BIM.

Closing

Building classification systems have established standard terminology and semantics for the AEC industry. 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.

In this paper, we studied four of the most popular classification systems developed across the globe. Each system has been developed for a different purpose, but all of these systems and the tools like the Autodesk Classification Manager for Revit that simplify their use, provide purpose and will continue to help the industry drive adoption of BIM principles and workflows.

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APPENDIX A: MasterFormat Divisions

MasterFormat 2016 Edition

The current MasterFormat (April 2016) divisions include:

PROCUREMENT AND CONTRACTING REQUIREMENTS GROUP	
Division 00	Procurement and Contracting Requirements
SPECIFICATIONS GROUP	
General Requirements Subgroup	
Division 01	General Requirements
Facility Construction Subgroup	
Division 02	Existing Conditions (Ex. Alterations to existing natural conditions)
Division 03	Concrete (Ex. Footings)
Division 04	Masonry (Ex. Concrete block and brick work)
Division 05	Metals (Ex. Steel framing)
Division 06	Wood, Plastics, and Composites (Ex. House framing)
Division 07	Thermal and Moisture Protection (Ex. Insulation and water barriers)
Division 08	Openings (Ex. Doors, windows, and louvers)
Division 09	Finishes
Division 10	Specialties
Division 11	Equipment
Division 12	Furnishings
Division 13	Special Construction
Division 14	Conveying Equipment
Division 15	*RESERVED FOR FUTURE EXPANSION*
Division 16	*RESERVED FOR FUTURE EXPANSION*
Division 17	*RESERVED FOR FUTURE EXPANSION*

Division 18	*RESERVED FOR FUTURE EXPANSION*
Division 19	*RESERVED FOR FUTURE EXPANSION*
Facility Services Subgroup	
Division 20	*RESERVED FOR FUTURE EXPANSION*
Division 21	Fire Suppression
Division 22	Plumbing
Division 23	Heating, Ventilating, and Air Conditioning (HVAC)
Division 24	*RESERVED FOR FUTURE EXPANSION*
Division 25	Integrated Automation
Division 26	Electrical
Division 27	Communications
Division 28	Electronic Safety and Security
Division 29	*RESERVED FOR FUTURE EXPANSION*
Site and Infrastructure Subgroup	
Division 30	*RESERVED FOR FUTURE EXPANSION*
Division 31	Earthwork
Division 32	Exterior Improvements
Division 33	Utilities
Division 34	Transportation
Division 35	Waterway and Marine Construction
Division 36	*RESERVED FOR FUTURE EXPANSION*
Division 37	*RESERVED FOR FUTURE EXPANSION*
Division 38	*RESERVED FOR FUTURE EXPANSION*
Division 39	*RESERVED FOR FUTURE EXPANSION*
Process Equipment Subgroup	
Division 40	Process Interconnections

Division 41	Material Processing and Handling Equipment
Division 42	Process Heating, Cooling, and Drying Equipment
Division 43	Process Gas and Liquid Handling, Purification and Storage Equipment
Division 44	Pollution and Waste Control Equipment
Division 45	Industry-Specific Manufacturing Equipment
Division 46	Water and Wastewater Equipment
Division 47	*RESERVED FOR FUTURE EXPANSION*
Division 48	Electrical Power Generation
Division 49	*RESERVED FOR FUTURE EXPANSION*

MasterFormat 2004 Edition

Same as MasterFormat 2016, except without the following divisions:

- Division 40 - Process Integration
- Division 46 - Water and Wastewater Equipment

MasterFormat 1995 Edition

Before November 2004, MasterFormat was composed of 16 divisions:

- Division 1 - General Requirements
- Division 2 - Site Construction
- Division 3 - Concrete
- Division 4 - Masonry (Ex. Concrete block)
- Division 5 - Metals (Ex. Beams)
- Division 6 - Wood and Plastics
- Division 7 - Thermal and Moisture Protection
- Division 8 - Doors and Windows
- Division 9 - Finishes
- Division 10 - Specialties
- Division 11 - Equipment
- Division 12 - Furnishings
- Division 13 - Special Construction
- Division 14 - Conveying Systems
- Division 15 - Mechanical (Ex. Plumbing and HVAC)
- Division 16 - Electrical

MasterFormat 1988 Edition

Same as MasterFormat 1995 except the following:

- Division 2 - Site Construction

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APPENDIX B: Uniclass Tables Description

The Uniclass tables comprise:

- **Complexes** | A complex describes a project in overall terms. It can be a private house with garden, drive, garage, and tool shed, or it can be a University campus with buildings for lecturing, administration, sport, halls of residence, etc. Rail networks and airports are also examples of complexes.
- **Entities** | Entities are discrete things like buildings, bridges, tunnels, etc. They provide the areas where different activities occur.
- **Activities** | This defines the activities to be carried out in the complex, entity, or space. For example, a prison complex provides a detention activity at a high level, but can also be broken down into individual activities like exercise, sleeping, eating, working, etc. The activities table also includes surveys, operation and maintenance, and services.
- **Spaces/Locations** | In buildings, spaces are provided for various activities to take place. In some cases, a space is only suitable for one activity, for example a kitchen, but a school hall may be used for assemblies, lunches, sports, concerts, and dramas. Also classed as spaces are transport corridors that run between two locations, such as the railway between London Kings Cross to Newcastle, or the M1 from London to Leeds.
- **Elements and Functions** | Elements are the main components of a structure like a bridge (foundations, piers, and decks) or a building (floors, walls, and roofs). Functions cover things like lighting, heating, and water; general requirements that are not yet designed.
- **Systems** | Systems are the collection of components that go together to make an element or to carry out a function. For a pitched roof, the rafters, lining, tiles, ceiling boards, insulation, and ceiling finish comprise a system, or a low temperature hot water heating system is formed from a boiler, pipework, tank, radiators, etc.
- **Products** | Finally, the individual products used to construct a system can be specified, e.g. joist hangers, terrazzo tiles, and gas fired boilers.

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APPENDIX C: OmniClass Tables

Below is a full list of the OmniClass tables with a brief description of their key features. Definitions of the terms used and examples are given in the introductions to each of the tables.

Table 11 | Construction Entities by Function	
Definition	Construction Entities by Function are significant, definable units of the built environment comprised of elements and interrelated spaces and characterized by function.
Examples	Single Family Residences, Mining Facility, Local Transit Bus Station, Interstate Highway, Waste Water Treatment Facility, Freezer Storage Facility, Department Store, Courthouse, Hotels, Convention Center
Discussion	A construction entity is complete and can be viewed separately rather than merely as a constituent part of a larger built unit. An office building is a construction entity, but a conference room within the building is a space. Function is the purpose or use of a construction entity. It is defined by primary occupancy and not necessarily by all activities that can be accommodated by the construction entity. Construction entities usually also have physical form and location. This table is not concerned with physical form; that is the basis of Table 12 - Construction Entities by Form. There is a correlation between form and function; function may dictate form, as illustrated by a baseball park. Other construction entities can accommodate several functions throughout their useful life; for instance, a mid-rise building can have residential, educational, or business functions.
Legacy Sources	▪ IBC, BOCA, UBC, and other building code occupancy classifications ▪ ISO 12006-2 Table 4.2 - Construction Entities (by function or user activity) ▪ ISO 12006-2 Table 4.6 - Facilities ▪ *Uniclass* Table D - Facilities ▪ Appraisal Institute Commercial Data Standards

Table 12 | Construction Entities by Form	
Definition	Construction Entities by Form are significant, definable units of the built environment comprised of elements and interrelated spaces and characterized by form.
Examples	High-Rise Buildings, Suspension Bridge, Platform, Space Station
Discussion	A construction entity is complete and can be viewed separately rather than as a constituent part of a larger built unit. A skyscraper is a construction entity, but a shaft that extends the height of the skyscraper is classified as a space. Construction entities classified by this table have a site and physical form. This table is not concerned with function; that is the basis of Table 11 - Construction Entities by Function. Tables 11 and 12 can be used together to classify both form and function of construction entities. For instance, a high-rise building form can be combined with a residential function to classify a high-rise apartment building. Note that in common usage many terms used to describe form-driven construction entities are also used to describe spaces and/or functions.
Legacy Sources	▪ ISO 12006-2 Table 4.1 - Construction Entities (by form) ▪ *Uniclass* Table E - Construction Entities

Table 13 | Spaces by Function	
Definition	Spaces by Function are basic units of the built environment delineated by physical or abstract boundaries and characterized by function.
Examples	Kitchen, Mechanical Shaft, Office, Highway
Discussion	A space is a part of the built environment that is marked off in some way. It is usually a component forming a larger, more significant construction entity. A space can be delineated by either physical or abstract boundaries. Often these are environmental parameters such as walls and roofs which separate the interior “space" from that which bounds it (other spaces, elements). Other spaces, like an airport approach zone, are delineated by non-corporeal, abstract boundaries. Spaces have a purpose or use. This is their function and forms the basis of this table. Spaces can be occupied by people, things, and substances and serve as mediums for activities and movement. Spaces also have physical form and this is the concern of Table 14 - Spaces by Form. There may or may not be a correlation between the form of a space and its function. Most spaces can accommodate many different functions throughout their useful life.

Table 13 | Spaces by Function	
Legacy Sources	▪ Reference to made to 'basic human functions and activities' as might be found in anthropology texts ▪ ISO 12006-2 Table 4.5 Spaces (by function or user activity) ▪ *Uniclass* Table F, Spaces ▪ U.S. General Services Administration (GSA) space definitions ▪ International Code Council (ICC) space definitions ▪ Appraisal Institute Commercial Data Standards

Table 14 | Spaces by Form	
Definition	Spaces by Form are basic units of the built environment delineated by physical or abstract boundaries and characterized by physical form.
Examples	Room, Alcove, Cavity, Courtyard, Easement, City Block
Discussion	A space is a segment of the built environment that is marked off from other spaces and elements in some way. It is usually a component part of a larger, more significant construction entity. A space can be delineated by either physical or abstract boundaries. These boundaries determine the form of the space which can be three-dimensional such as a room, or a mere surface such as a walkway. The form of the space can create a medium for action or movement, which is related to the function of the space. Many spaces are also largely unoccupied, but serve a function within the facility. This table is only concerned with form; Table 13 - Spaces by Function is concerned with the purpose or uses of a space.
Legacy Sources	▪ ISO 12006-2 Table 4.4 Spaces (by degree of enclosure) ▪ *Uniclass* Table F - Spaces

Table 21 | Elements (Including Designed Elements)	
Definition	An Element is a major component, assembly, or "construction entity part which, in itself or in combination with other parts, fulfills a predominating function of the construction entity" (ISO 12006-2). Predominating functions include, but are not limited to, supporting, enclosing, servicing, and equipping a facility. Functional descriptions can also include a process or an activity. A Designed Element is an "*Element for which the work result(s) have been defined*" (ISO 12006-2).
Examples	Structural Floors, Exterior Walls, Storm Sewer Utility, Stairs, Roof Framing, Furniture and Fittings, HVAC Distribution

Table 21 | Elements (Including Designed Elements)	
Discussion	An element fulfils a characteristic predominant function, either by itself, or in combination with other elements; Table 21 is organized by elements' implied functions. Major elements may be composed of several sub-elements. For example, a shell enclosure might be composed of superstructure, exterior closure, and roofing. Currently, elements are most often used during early project phases for identifying a project's physical, operational, or aesthetic characteristics. Elements are considered without regard to a material or technical solution of the function. For each element, there may be several technical solutions capable of accomplishing the element function, and more than one may be selected for a project. These solutions are the designed elements. Many applications exist for element-based classification. OmniClass Table 21 - Elements can provide a useful way to organize and classify elements at the early stages of a project, before particular or specific materials and methods (designed elements) have been determined, and help to conceptualize the project without the restrictions imposed by any particular design solution. The Elements Table can be used to organize information such that it can be used to stimulate project decisions, record those decisions (and subsequent changes), and can also be used as a basis for organizing documents to form a contractual commitment between two or more parties on a project. These usually take place at an early design development stage, but may occur at any project stage or phase.
Legacy Sources	▪ *UniFormat* (CS1/CSC 1992, 1998) ▪ ISO 12006-2 Table 4.7 Elements (by characteristic predominating function of the construction entity) ▪ ISO 12006-2 Table 4.8 - Designed Elements (element by type of work) ▪ *Uniclass* Table G - Elements for Buildings ▪ *Uniclass* Table H - Elements for Civil Engineering Works ▪ ASTM E1557 *UNIFORMAT II*, A variety of ASTM "format" documents addressing specific classification of subjects associated with these element tables

Table 22 | Work Results	
Definition	Work Results are construction results achieved in the production stage or phase or by subsequent alteration, maintenance, or demolition processes and identified by one or more of the following: the particular skill or trade involved; the construction resources used; the part of the construction entity which results; the temporary work, or other preparatory or completion of work which is the result.
Examples	Cast-in-Place Concrete, Structural Steel Framing, Finish Carpentry, Built- Up Bituminous Waterproofing, Glazed Aluminum Curtain Walls, Ceramic Tiling, Hydraulic Freight Elevators, Water-Tube Boilers, Interior Lighting, Railways

Table 22 | Work Results	
Discussion	A work result represents a completed entity that exists after all required raw materials, human or machine effort, and processes have been provided to achieve a completed condition. Since facility owners ultimately desire a completed entity, specifiers routinely specify contractual requirements by work result, and minimize the specifying of details about how to achieve that result to contractors. Table 22 provides a classification arrangement that organizes information most appropriately from the viewpoint of identifying the "results of work" required to provide all or part of a facility. Table 22 - Work Results is based almost entirely on an existing publication called *MasterFormat*, which has been a standard means of organizing construction information in North America since the 1960s. The 2004 edition of *MasterFormat* is also the only legacy document that was modified with *OmniClass* in mind, to eventually serve as one of the *OmniClass* tables and be coordinated with other related tables. A work result may pertain to several manufactured products (an assembly) such as exterior insulation and finish system, or to a single product such as a framed marker board. A work result could also involve only labor and equipment which are utilized to achieve the desired result, such as trenching.
Legacy Sources	▪ *MasterFormat* 2004 Edition, ISO 12006-2 Table 4.9 - Work Results (by Type of Work) ▪ *Uniclass* Table J - Work Sections for Buildings ▪ *Uniclass* Table K - Work Sections for Civil Engineering Works

Table 23 | Products	
Definition	Products are components or assemblies of components for permanent incorporation into construction entities.
Examples	Concrete, Common Brick, Door, Metal Window, Junction Boxes, Pipe Culverts, Cast-Iron Boiler, Curtain Walls, Textured Paints, Vinyl-Coated Fabric Wall Covering, Demountable Partitions, Pre-Engineered Manufactured Structures

Table 23 | Products	
Discussion	Products are basic building blocks used for construction. A product may be a single manufactured item, a manufactured assembly of many parts, or a manufactured operational stand-alone system. This table provides a basis for identifying products categorized by number and name in a unique location. Table 22 - Work Results on the other hand, provides multiple classifications for any given product dependent upon the application (or work result) the product is employed in. An example is a panel of glass, which can have many work result locations, such as in a window, as cabinet shelving, or in an interior sidelight to a door opening. Basic materials are also considered to be products when they are used in their original form as a component to achieve a construction work result. An example is sand used as a subbase cushion for brick paving. Sand is also a constituent material of other products such as items made from precast concrete. Hence base materials like sand occur both in this table and in Table 41 - Materials. The focus of Table 41 - Materials is the basic composition and physical properties of materials without regard to composition or use.
Legacy Sources	▪ *Uniclass* Table L - Products ▪ EPIC (Electronic Product Information Cooperation) ▪ *MasterFormat*, ISO 12006-2 Table 4.13 - Construction Products (by function)

Table 31 | Phases	
Definition	Lifecycle phases are often represented by two terms used somewhat interchangeably in our industry. For the purposes of clarity and standardization, OmniClass offers two specific definitions for their usage in OmniClass Tables: **Stage** | A categorization of the principal segments of a project. Stages usually are: Conception, Project Delivery Selection, Design, Construction Documents, Procurement, Execution, Utilization, and Closure. **Phase** | A portion of work that arises from sequencing work in accordance with a predetermined portion of a Stage. For purposes of usage in *OmniClass* classifications, a Stage is a higher-level of categorization and a Phase is a subordinate level of titling within a Stage
Examples	Conception Stage, Schematic Design Phase, Bidding Phase, Construction Phase, Occupancy Phase, Decommissioning Phase

Table 31 | Phases	
Discussion	This table provides the time and activity dimension for the process of creating and sustaining the built environment. A "project" can be defined as a planned undertaking consisting of a process or set of procedures to accomplish a task. In a projects early context, Stages are identified and defined relative to a specific project and its tasks. Phases are portions of time and activity efforts within any Stage that are usually defined later. The scope of a construction project can vary from tiny - for instance changing a filter on a mechanical unit - to gargantuan - like designing and constructing a below grade expressway through a dense urban environment. Projects take place over time and are composed of one or more Stages with their subordinate activities - Phases. These occupy segments of time and represent specific activities that occur between changes in substance or process. These Stages or Phases do not endure forever; they are transitory. A Stage is often marked by one or more accomplishments or deliverables. Generating a deliverable constitutes the end of a Stage or Phase. Transition from one Stage or Phase to the next is an indication of accomplishment, progress, or advancement.
Legacy Sources	▪ CSI Project Resource Manual (PRM) ▪ CSC Manual of Practice ▪ Total Cost Management Framework AACE International ▪ ISO 12006-2 Table 4.11 Construction entity lifecycle stages (by overall character of processes during the stage) ▪ ISO 12006-2 Table 4.12 Project stages (by overall character of processes during the stage)

Table 32 | Services	
Definition	Services are the activities, processes and procedures relating to the construction, design, maintenance, renovation, demolition, commissioning, decommissioning, and all other functions occurring in relation to the lifecycle of a construction entity.
Examples	Designing, Bidding, Estimating, Constructing, Surveying, Maintaining, Inspecting
Discussion	The Services Table is based around actions, which includes any service exercised or provided that influences the built environment. Services are all the actions that are performed by the various participants in creating and sustaining the built environment, throughout the full lifespan of any construction entity.
Legacy Sources	▪ *Uniclass* Table B - Subject Disciplines ▪ ISO 12006-2 Table 4.10 Management processes (by type of process) ▪ AIA Information Classification System Part 2 Hierarchical Listing (May 1989)

Table 33 | Disciplines	
Definition	Disciplines are the practice areas and specialties of the actors (participants) that carry out the processes and procedures that occur during the lifecycle of a construction entity.
Examples	Architecture, Interior Design, Mechanical Engineering, General Contracting, Electrical Subcontracting, Legal, Finance, Real Estate Sales
Discussion	Disciplines are the practice areas and specialties of the participants who are performing services during the lifecycle of a construction entity, considered without regard to the actual job functions of individuals or teams, which is covered by Table 34 - Organizational Roles. Disciplines from Table 33 can be combined with entries from Table 34 - Organizational Roles to provide a full classification such as an electrical subcontracting (discipline) supervisor (organizational role).
Legacy Sources	▪ *Uniclass* Table B - Subject Disciplines ▪ ISO 12006-2 Table 4.15 - Construction Agents (by discipline) ▪ AIA Information Classification System, Part 2 - Hierarchical Listing (May 1989)

Table 34 | Organizational Roles	
Definition	Organizational Roles are the functional positions occupied by the participants, both individuals and groups, that carry out the processes and procedures which occur during the lifecycle of a construction entity. Table 34 can be combined with Table 33 - Disciplines to provide a full classification of each participant in the creation and support of a facility.
Examples	Chief Executive, Supervisor, Owner, Architect, Cost Estimator, Facility Manager, Specifier, Contractor, Administrative Assistant, Equipment Operator, Apprentice, Team, Committee, Association
Discussion	The key concepts underlying Table 34 are the scope of responsibility given to a participant within a given context and the participant's job function, largely without regard to areas of expertise, education, or training. Some organizational roles imply specific areas of expertise, but in general, those subjects are addressed more fully by Table 33 - Disciplines. A participant can be an individual, a group or team of individuals, a company, an association, an agency, an institute, or other similar organization. Organizational roles, when combined with entries from Table 33 - Disciplines, can further define a participant in the process of creating and sustaining the built environment. An example would be an electrical subcontracting (discipline) supervisor (organizational role).
Legacy Sources	▪ *Uniclass* Table B - Subject Disciplines ▪ ISO 1200006-2 Table 4.10 - Management Processes (by type of process) ▪ AIA Information Classification System, Part 2 - Hierarchical Listing (May 1989)

Table 35 | Tools	
Definition	Tools are the resources used to develop the design and construction of a project that do not become a permanent part of the facility, including computer systems, vehicles, scaffolding, and all other items needed to execute the processes and procedures relating to the lifecycle of a construction entity.
Examples	Computer Hardware, CAD Software, Temporary Fencing, Backhoe, Tower Crane, Site Drainage Equipment, Formwork, Hammer, Light Truck, Site Hut
Discussion	Tools are equipment, implements, supplies, software, and other items necessary for creating and sustaining the built environment, but which do not become parts of the final construction entity. They are used by the many participants to perform various services.
Legacy Sources	▪ *Uniclass* Table M - Construction Aids ▪ AIA Information Classification System, Part 2 - Hierarchical Listing (May 1989) ▪ ISO 12006-2 Table 4.14 Construction aids (by function)

Table 36 | Information	
Definition	Information is data referenced and utilized during the process of creating and sustaining the built environment.
Examples	Reference Standards, Periodicals, CAD Files, Specifications, Regulations, Construction Contracts, Lease Documents, Title Deeds, Catalogs, Operation and Maintenance Manuals
Discussion	Entries on the Information table refer to information resources that can be referenced or created in the creation and support of the built environment. Information can exist in various media including both printed and digital forms. Information can include general reference and regulatory data such as a manufacturing standard, or it can be project specific, such as a project manual. Information is the principle tool for communication during the process of creating and sustaining the built environment. Typically, information needs to be filed, stored, and retrieved.
Legacy Sources	▪ *Uniclass* Table A - Forms of Information ▪ AIA Information Classification System, Part 2 - Hierarchical Listing (May 1989) ▪ ISO 12006-2 Table 4.16 Construction information (by type of medium)

Table 41 | Materials	
Definition	Materials are substances used in construction or to manufacture products and other items used in construction. These substances may be raw materials or refined compounds, and are considered subjects of this table irrespective of form.
Examples	Metallic Compounds, Rocks, Soils, Timber, Glass, Plastics, Rubbers
Discussion	This table classifies the basic resources that construction products and tools from which are made. The entries describe the basic composition of these substances without regard to the form the material takes. Because many material names commonly imply a certain form, any apparent overlap between this table and Table 23 - Products is exactly that, an apparent but not an actual overlap. The entries on this table are names that can be applied to the Property “material,” and do not have expressed forms because they are not intended to represent the actual items used in the creating and sustaining the built environment. This table is not intended to be an exhaustive list of possible material names. Any composition that can be described without implicitly or explicitly defining the form would be included in this table. Forms are characteristics like "board," "bar," "sheet," "block," etc. An example of this is "aluminum" – aluminum is a chemical composition. Although aluminum products come in bars, sheets, and other forms, the term aluminum describes the "material" each of those products is made of. Other types of materials included in this table are raw material names that usually encompass both chemical composition and form, because they are found in nature in certain forms. For example, the chemical composition of "sand" is silicon dioxide, but because sand is a naturally occurring form of silicon dioxide and because we use sand as a constituent material of other products, we include it in this table. The fact that sand is also a product used in its own right, in its original form, it will also show up in Table 23 – Products.
Legacy Sources	▪ *Uniclass* Table P - Materials ▪ ISO 12006-2 Table 4.17 Properties and characteristics (by type) ▪ EPIC (Electronic Product Information Cooperation) "Constituent Materials" table ▪ CI/SfB Construction Indexing Manual

Table 49 | Properties	
Definition	Properties are characteristics of construction entities. Property definitions do not have any real meaning out of context -- without reference to one or more construction entities.
Examples	Common properties include Color, Width, Length, Thickness, Depth, Diameter, Area, Fire Resistance, Weight, Strength, Moisture Resistance
Discussion	The members of many of the other OmniClass tables are construction entities (objects), expressed as nouns (for things) or verbs (for activities). Properties serve as modifiers of these objects -- adjectives and other modifiers. This table is limited to properties that are common to, or shared by, two or more construction entities. The names of properties that are unique or specific to a certain construction object do not currently appear in this table except as examples. Factors are things or characteristics of things that influence the nature of a property and are expressed as nouns. Many factors have a direct relationship to a single property that they influence, which is indicated by the terminology used. Other factors influence many different properties, which together represent the effect the factor has on the object. A factor may influence a property during its design or selection or after construction, as stresses or degrading influences. Because there is not necessarily a one-to-one relationship between factors and properties, this table also includes a classification scheme for factors that influence properties of construction entities.
Legacy Sources	▪ *Uniclass* Table N - Properties and Characteristics ▪ ISO 12006-2 Table 4.17 - Properties and Characteristics (by type) ▪ ISO 31-0 - Quantities and Units ▪ BS 6100 Glossary of Building and Engineering Terms ▪ EPIC (Electronic Product Information Cooperation) ▪ IEEE/ASTM SI 10-1997, Standard for Use of the International System of Units (SI): The Modern Metric System ▪ CI/SfB Construction Indexing Manual ▪ IAI-NA Project Management Domain Specification project