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# A critical analysis of international standards for construction classification - results from the development of a new Swedish construction classification system

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## **Abstract**

A new Swedish construction classification system, CoClass, is now under development. CoClass has presented two alternative classifications for review, both based on the standard for construction classification ISO 12006-2:2015. One alternative also applies the IEC CD 81346-series for reference designations which includes classification tables for systems and components with function as the basis for subdivision of classes. A critical analysis shows that the 81346 series subdivision by function only is of limited use in the construction sector, and that the ISO-standard is unclear regarding appropriate tables and principles of specialization. It also shows that in a construction classification system, overall compositional structure, form, should be the basis for subdivision of classes, and that two separate construction element tables must be developed, one for construction elements and another for construction element components. The future of the proposed IEC CD 81346-series as international standards for construction classification series is uncertain.

Keywords: Construction classification, standardization, ISO 12006-2, IEC 81346

## **1 Introduction**

A new Swedish construction classification system, called CoClass, is now under development (CoClass 2016). It will be based on the revised framework standard for construction classification ISO 12006-2:2015. The work on CoClass is carried out by a consortium including the Swedish Transport Administration and the Swedish Building Centre, and is chaired by the sector organisation BIM Alliance. The project started in 2014 and will end in October 2016.

The work has included an inventory of built objects at all levels of composition from construction complexes to construction element components. Some 10 specialist groups were engaged in the inventory of technical systems and components, covering every sector of building and civil engineering. The objective of the classification work has been to organise these objects into classes in a comprehensive and logically structured classification system.

This paper discusses some theoretical and practical considerations from the CoClass work, focusing on classification of construction elements. At first, some central concepts in classification theory are introduced. Then the standard for construction classification ISO 12006-2:2015, and the standards for reference designations in the 81346-series which also include tables for construction classification, are analysed and discussed. Results from the Swedish work are presented as part of the analyses and at the end of the paper.

## **2 Classification theory**

### **2.1 Basic concepts**

Common concepts are essential for both human communication and semantic interoperability. Classification systems compile, relate and define concepts of a field of knowledge in a logical way. Construction classification is developed for use in the processes of planning, construction

and management of the built environment, and is a necessary requirement for Building Information Modelling, BIM.

Classification is a method to discriminate among objects in a collection called the “universe or domain of discourse” (Bunge 1998:82). It is fundamental that the discriminating properties are chosen according to the purpose of the classification. The aim of the Linnéan classification was to order plants in kinship categories, therefore Linnéus chose properties related to sexual reproduction that could reveal kinship and common descent. Similarly, the aim of the periodic system of atomic elements is to distinguish between kinds of atoms, by systematizing their internal structure.

A classification that considers such essential and objective properties is called natural (Bunge 1998:91). Classifications that are based on more superficial or subjective properties are called artificial. Examples of the latter are alphabetical ordering, or orderings based on properties like colour, taste, or even function, which treats the object as a black box.

A construction classification system to be used in planning, construction and management of the built environment should consider essential and objective properties. Its classes should be based on similarities in structural, or compositional, properties rather than functions. The internal structure of the entities of the built environment is in focus for those that create technical solutions for the functions required by users of the built environment; it is also a natural basis for distinguishing the different fields of engineering technology involved in planning, construction and maintenance of the built environment.

## **2.2 Function vs functional part**

In connection with classification it is necessary to distinguish between a function and a functional part. A function is a mutual property of two interacting things, but attributed to the agent in that relation. For a further analysis of kinds of properties see (Ekholm 2002). A functional part could be defined as a thing with a function of interest in a certain context. A functional part also has the property of form, i.e. characteristic overall structure, like a wall or a roadway. The concept of functional part is also discussed in (Ekholm and Häggström 2011).

As a property, function itself is not enough to discriminate between things, for example, the functions heating and cooling can be held by different functional parts like fluid systems, ventilation systems or electrical systems. In connection with planning, construction and management of the built environment, the interest is focused on functional parts characterized by both function and form, with form as discriminating property. ISO 12006-2 calls these parts “construction elements”.

## **2.3 Construction elements must support an incremental determination of properties**

A design process starts with requirements on properties of a desired solution. Performance requirements and selection of a technical solution at an overall level leads to new functional requirements and new technical solutions at the underlying levels (Gielsing 1988).

One can e.g. impose requirements on climate and sound level for a workplace. The overall technical solution can be an office building with functional parts like walls, windows and ceilings. The technical solutions for these parts need to fulfil to the functions concerning thermal insulation and sound reduction. Depending on the chosen construction for e.g. the wall, whether it is of solid concrete or a combination of layers, its parts will have different functional requirements, and different technical solutions.

To conclude, a technical solution to a functional part also consists of functional parts whose technical solution must be determined. This design process, called product determination, continues until the constituent parts are sufficiently determined for the construction process to be carried out.

# **3 Analysis of the standard for construction classification ISO 12006-2**

## **3.1 Revision of the standard**

The ISO standard 12006-2 provides a framework for construction classification. The objective of the standard is to facilitate the development of classification systems to support the

exchange of information between stakeholders and applications throughout the life-cycle of the built environment. Applications include systems for modelling, specification, product information and costing. The standard does not contain complete classification tables, but provides examples of tables and classes. The first edition was published in 2001 (ISO 12006-2:2001). When it was drafted there were no international guidelines for construction classification. With the standard as a starting point, several national systems were developed, in North America, Scandinavia and the UK.

A revised second edition was published in 2015 (ISO 12006-2:2015), intended to better support building information modelling, BIM, and with improved concept definitions. In the new version construction elements may have part-of relations, which allows a better support for building modelling, while work results are changed from being construction results to being property sets representing specific views on construction results.

The standard recommends tables with classes defined on the basis of different views, such as *form*, i.e. overall compositional structure, and *function* of the built environment. The standard shows a process model with the main classes: resources, processes, results and characteristics. Each main class has been divided into specialized classes. An object can be seen both as a whole and as a system of parts. The concept schema shows examples that construction entities can be part of larger construction complexes and that they can be made up of construction elements. Also spaces can be seen as systems, they can be part of larger spaces and divided into smaller. See Figure 1.

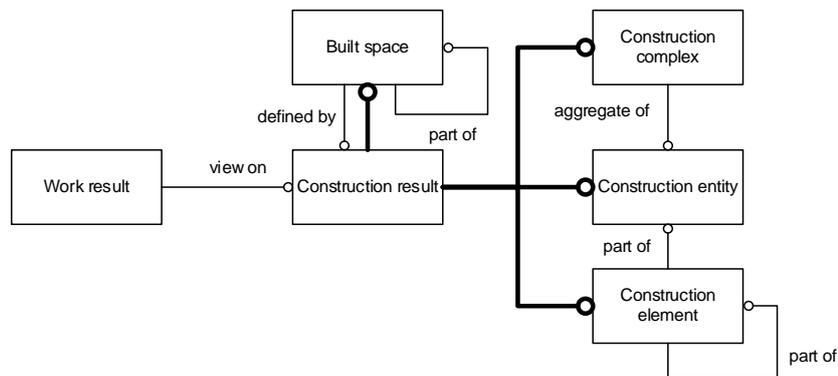


Figure 1. Extract from the concept schema in ISO 12006-2:2015.

In the previous version of 2001, function was the only discriminating characteristic mentioned for construction elements, which if applied, meant that one could not distinguish between different compositional structures, e.g. climate separating wall structure or roof structure.

In the new version from 2015 it is now, beyond function, also possible to have form and position as discriminating properties, e.g. the class "external wall" which besides function (space separating) also expresses form (vertical plate) and position (part of the construction entity's outer shell). In connection with BIM it is essential that all objects of interest to represent visually have form, from the smallest construction products like screws and nails, through construction elements like beam and bridge deck, to whole construction entities like house and bridge.

### 3.2 Weakness in ISO 12006-2:2015

In the development of CoClass, a number of questions have emerged that concern difficulties and lack of guidance in the application of ISO 12006-2:2015. The two main difficulties concern, firstly, principles for specialization of construction entities and construction elements, and secondly, tables for construction elements in different composition levels.

#### 3.2.1 Principle of specialization

The ISO 12006-2:2015 standard specifies in Section 5, Table 1, that the principle for subdivision of classes of construction elements can be function, form or position, or any combination of these. In the application instructions described in Appendix A.11 there are

examples of classes divided into those alleged to be based on function only, e.g. "floor construction system", "water supply system", "cooling supply system", and "fire protection system" and those alleged to be based on a combination of position and form, e.g. "slab", "railway tracks", and "window". Definitions are not provided and it is impossible to determine if the examples respect the alleged principle of subdivision. However, the class names, i.e. floor, suggest that also form is taken into consideration.

The same criticism can be directed towards the standard's ambiguity in classification of construction entities. The basis for subdivision is stated to be "form or function or user activity or any combination of these" (ISO 12006-2:2015 Table 1). Practical application in the Swedish BSAB 96 shows that a first partition based on form is needed to clearly distinguish between construction entities, such as houses, bridges, railways and power lines. In the next partition, the use activity can be discriminating, e.g. residential building, footbridge, passenger traffic, and high voltage (BSAB 96 1999:45).

To conclude, the ISO standard should have stated that in order to be relevant to the intended applications, classification of construction entities and construction elements must have form as the discriminating property in the first partition.

### 3.2.2 Levels of construction elements

In the original version of ISO 12006-2:2001 it was not possible to consider construction elements to be composed of other construction elements, which the revised version permits. But a classification table shall not have part-of relationships, only type-of relationships. This means that when drafting tables for construction elements one should distinguish between different tables, the number depends on how many sub-levels of construction elements that are of interest. The standard does not provide any guidance on which these levels or tables can be.

Based on the revised version, the British Uniclass has three levels under the level of construction entity: Elements, Systems and Products (Uniclass 2016). The number of Elements, the highest level in Uniclass, are relatively few. Systems are constructions of products and can be seen as parts of Elements. Products in Uniclass include both components, used in CCS and CoClass, and construction products.

The Danish CCS, also based on the revised version, has three levels of construction elements, Functional systems, Technical systems, and Components (CCS 2016). CCS also adheres to ISO/DIS 81346-12, which is further analysed in section 4.6. In the Swedish CoClass development, one alternative applied the same tables for construction elements as CCS, while the other alternative proposed two tables, one for construction elements and another for construction element components.

The question of the number of levels of interest for construction elements is essential to discuss. A construction element has one or more functions of interest and is distinguished by its specific form, but its technical solution, may not yet be determined. Also the lowest level of construction elements should concern parts that may have *different* technical solutions. For example, a wall or a roadway often consists of cladding and wall frame with different technical solutions, and similarly, a roadway can have different paving and course layer solutions. Generally, construction elements consist of smaller construction elements as far as you find it of interest to leave the question of detailed technical solution open.

One must distinguish between construction elements and construction products. Construction elements on all levels consist of assembled and processed construction products. Construction products have determined technical solutions. They can be both simple and complex, examples of the former are gypsum boards, wooden studs, copper wires or metal ducts, and of the latter assembly elements like floor or wall elements, or even more complex volume elements; all are parts of construction entities or construction elements. The identification of construction elements and construction products are based on different views on construction entity parts and do not belong to the same hierarchy. Construction products are assembly units, and are according to ISO 12006-2 classified independently of construction elements in a separate table. The lowest level in the table for construction elements should therefore *not* consist of construction products.

The question of the highest level of construction elements is linked to the classification of construction entities. The major building construction elements of a bridge can be bridge deck and bridge columns. Together they make up the bridge construction as a whole, i.e. they constitute the bridge construction entity. The installation construction elements of a bridge could be e.g. electric lighting system, traffic control system and drainage system.

To conclude, the main ground and building construction elements and installation systems, are at the highest level of construction elements and make up the immediate parts of the construction entity as a whole. Their constituent construction element components can be placed together in a common table for construction element components. The tables are independent; a construction element component can be classified independently of the construction element it is part of, an air filter, for example, may be part of a sewer system if one would want to make such a construction.

## 4 Analyses of classification in IEC 81346

### 4.1 Part 1

The IEC standard 81346:2009 specifies principles for structuring information about systems to support the development of reference designations for objects in a description or model. A reference designation is a project unique object ID and consists of a combination of classification and identification. The standard is to be applied in information about industrial products in various technology areas including construction, e.g. in a BIM. Part 1 of the standard contains rules and guidelines for the formulation of reference designations, while Part 2 contains a system for classification.

In the standard's Part 1, section 1 "Scope", is said that "The reference designation identifies objects for the purpose of creation and retrieval of information about an object, and where realized about its corresponding component". The text mentions two different "objects": The first refers to an information item, a concept, that is used to describe another object. The second, that can be called "thing object", is the component that the information objects describe from different aspects.

It is the information object that has a reference designation. In Section 1 is noted that a reference designation can be entered on a label located on the component, and that it is the key to finding information about the component in various documents. The reference designation is independent of the actual installed component and must not be confused with the component model designation or serial number.

The standard shows in detail how one can describe a system and its parts from different aspects. The functional aspect means that the system is regarded as consisting of functionally specified parts independently of how the function is realized. The product aspect describes how the system is built up of parts as results of manufacturing and assembly processes, regardless of the product's functioning. The position aspect means that the system can be considered to be made up of places.

It must be noted that a subdivision of a system into a hierarchy of parts from different aspects cannot be done without knowledge of the overall compositional structure of the system. Different designs have different functional and compositional parts, a massive concrete wall has other parts and functional relationships between its parts than a wall with stud frame and drywall. Similarly, the determination of the position of system parts depends on knowledge of the compositional structure of the system.

Therefore, it is not possible in a design situation to make a functional specification in several levels without considering technical solutions. A technical solution of a function of a part will determine the possible functions of the parts of the technical solution. Design means to iteratively test various solutions in several levels in order to find out the consequences before a decision on a final design can be taken. The functional aspect and location aspect can be applied only when you have knowledge of the system's functional parts, i.e. its construction elements, see Section 2.2 above. The product aspect cannot be used until a decision is taken on assembly units. These important facts are not observed or analysed in the standard's examples of how it is supposed to be applied.

## 4.2 Part 2

The standard's Part 2 contains a classification system which is intended to be used in connection with reference designations. The principle of classification is to "consider every object as a means to perform a task, often with input and output". In this context, "the internal structure of an object is not important" (see 81346-2:2009, Sec. 4.1). Focus is on the object's role or function. In the explanation of the standard is shown that the classes are defined on the basis of a general process model which is assumed to be common to all technologies and disciplines. The functions can be held by physical products but the standard does not purport to be a classification of the products that have the features. Rule 2, Sec. 4.2, says it is the functional object to be classified, not the product that implements it. Since the classes does not consider form, the standard is a classification of functions, not of physical components.

Classification according to the standard is made in two levels, both have function only as principle of subdivision. But contrary to the stated rules, some classes in the second level are grouped with respect to structural properties required to handle different media, i.e. in electric energy, information and signalling, or technical area, i.e. process and mechanical engineering, and building construction. An example is the class "E Providing radiant or thermal energy" with a subclass like "EB generation of heat by conversion of electrical energy". For each class in the second level is also stated examples of components (products) that may have the specified function.

It is subdivision based on function only that is the background to why the classification is considered to be applicable in various technology areas, i.e. objects in various technology areas can belong to the same class. But it is also a limitation that makes classification according 81346-2:2009 not enough precise to be of interest in connection with construction classification, where difference in form is fundamental to specifying, costing and further detailing.

## 4.3 The proposed standard IEC CD 81346-2:2016

The draft standard IEC CD 81346-2:2016 is an adaptation and extension of the existing IEC 81346-2:2009. The new version makes significant principal changes to the systematics, the classes refer no longer to functions but to components (products). The earlier text saying that "the internal structure of an object is not important" has been deleted (81346-2: 2009, 4.1 sec). The news in the standard is that it can be used "stand alone" for the classification of components, e.g. in a description. Some adjustments of the classes in the two upper levels have been made, and a third level has been added. It has, as before, a grouping in functions for different media such as electricity, electromagnetic waves, sound waves, etc. The functions are more detailed and it is possible to distinguish between additional classes.

But function as the only basis for subdivision leads to major difficulties in the classification of components. One difficulty is to find the right class for an object of interest. For example, should a clock be classified as "BKA Counting time sensing object", a subclass of "B Sensing object: BK Time sensing object", or should it belong to the class "PGL Clock", a subclass of "P Presentation: PG Scalar display"? It is not easy to unambiguously determine functions; you need in this case to decide whether the object of interest is "time sensing" or a "scalar display object". Another example of the difficulty to specify a function is "PLF carpet", a subclass of "P Presenting object: PL Ornamental object". An independent assessor may select other functions or combinations of functions e.g. "N covering object" or "F Protecting object".

Another difficulty is that components of the same construction type are scattered among very different functions. For example components in a road construction are found under "N Covering object" and "U Holding object". The "NCA Paving" belongs to the function "N Covering: NC Finishing object", while binder course and base course layers probably belong to the class "ULJ Floor slab" which is a type of "Holding object: Building construction". The underlying subbase course probably belongs to "UMC Reinforcing mass layer" which is a "Holding object: Reinforcement".

A third major difficulty is that the structure with two to three levels of functional partition each using a capital letter code leads to difficulties in making the classification sufficiently atomized. For example, the class "ULJ Floor slab" mentioned above has "base grade" (similar

to base course above, a loadbearing layer in a road construction), “bridge deck”, “building foundation” and “deck”, as alternative terms, which means that these classes don’t have their own codes in the standard. There is an abundance of similar examples.

The first and second partition levels does not guide the user in finding classes based on differences in form, totally different constructions are placed under the same function. Only the third level in certain instances introduces form to distinguish between components.

#### **4.4 A tree of functions or forms**

The structure of a classification system has been compared to a tree with limbs, branches and twigs representing species in different levels of specialisation (Darwin 1872:104). In a classification system with function as principle for subdivision, all limbs, branches and twigs are functions. Such a classification system is not a classification of objects themselves, but of their functions.

In a classification system that classifies objects based on form, the trunk, common to all limbs, would represent e.g. construction elements. Each limb is a major technical field, e.g. electrical systems, liquid systems, gas systems, building construction systems etc. The branches are specialised fields within these systems and the twigs the finest specialisation of construction elements of interest. In this case, the membership relation concerns whether an object has a certain form or not. This can be objectively determined and should be part of its definition.

Classification according to the IEC 81346-series creates a tree of artificial classes based on functions, while classification by form creates a tree of natural classes, see alt. 2 below.

#### **4.5 Conclusions regarding component classification**

Function as the basis for subdivision according to IEC CD 81346-2 leads to great difficulties in the classification of components. One major difficulty is to find the right class for an object of interest. The choice of class membership becomes a matter with subjective elements. Many physical components have multiple functions of interest. It is not possible to objectively and unambiguously determine the function a component has. The benefits of the classification are liable to be a sorting for encoding. Another major difficulty is that components of the same construction are scattered among very different functions. A third major difficulty is that the structure with two to three levels of functional partition each using a capital letter code leads to difficulties in making the classification sufficiently atomized. The classification is not detailed enough to cover all classes of interest in various technology areas.

#### **4.6 Analysis of IEC DIS 81346-12:2015 for construction classification**

##### **4.6.1 Systems in ISO/DIS 81346-12:2015**

While the standard 81346-2 focuses on classification of parts of systems, ISO DIS 81346-12 has been developed to classify entire systems with specific focus on construction works and building service systems. The standard proposal is based on results from the development of the Danish CCS, and the discussion here concerns both works. The classification is also intended to be used in reference designations for objects from the same aspects as described in the Standard Part 1, function, product and location.

The standard has tables for Functional systems and Technical systems, both stated to have “inherent function” as basis for subdivision. It seems that “intended function” would have been a more suitable term. A Functional system is defined as an “object with characteristics which predominantly represent an overall function”, while a Technical System is an “object with characteristics which predominantly represent a coherent technical solution with a function”. According to illustrations in the standard, Technical systems are intended to be used as parts in Functional systems.

The standard does not relate its classes to the ISO 12006-2 standard’s construction complex, construction entity or construction element. Probably, all of these can be seen as functional systems, as indicated by the examples in Table 2 with the Ventilation plant and in Table A.1 with the Electricity production plant. A plant would be either a construction complex

or a construction entity according to ISO 12006-2. However, most of the examples in Table A.1 are in ISO 12006-2 considered to be construction elements.

Most of the main classes of functional system listed in Table A.1 use form as discriminating property, e.g. wall, slab, roof, gas- and air system, water- and fluid system etc. But a few classes are defined by function only, e.g. cooling and heating, security and safety and lighting. Technical systems for building construction are also subdivided by form. But contrary to these, the main classes of technical installation systems are subdivided by function, i.e. supply, transport, treatment, monitoring, information presenting, protecting, storage, and furnishing. The next level of subdivision, however, is mainly based on form, determined e.g. by distributed media. There are exceptions, e.g. cooling supply, heating supply, cooling distribution, heating distribution, pressure and expansion.

This subdivision by function mix different technical areas, like electrical, water and fluid, and ventilation and makes the classification less transparent and more subjective. Instead, a subdivision by form divides the systems into technical areas and is in accordance with the needs of the users of the classification.

The standard enables a more specific classification of project specific types. However, such a classification has no value to information exchange outside the project.

The classes in IEC DIS 81346-12 are intended to be used in reference designations from different aspects, marked with separate symbols for function, product and position. In the examples shown, these aspects are not applied in a consistent way. Table 2 shows that for building construction elements the product aspect is indicated as prefix, and for installation systems the function aspect is indicated as prefix. But all examples are of functional parts; i.e. they are construction elements and not assembly elements.

#### **4.6.2 Conclusion**

To conclude, subdivision by function as in ISO/IEC 81346-2: 2009, IEC CD 81346-2: 2016 and ISO/DIS 81346-12: 2015, and applied in CCS and CoClass, is not appropriate for classification of functional parts like construction elements. The idea of reference designations from different aspects in ISO/DIS 81346-12:2015 is not followed up in the subdivision of the systems in corresponding parts. It seems that the standard does not adhere to its own definitions, and the need for reference designations for parts from different aspects is not convincingly demonstrated.

### **4.7 The proposed new Swedish building classification system**

#### **4.7.1 Alternative 1**

The new Swedish construction classification, CoClass, contains tables for construction complexes, construction entities, construction elements, spaces, management activities and properties. In the development of CoClass different principles for classification of construction elements was discussed. There is a strong desire that the proposal should tie in with international standardization. Both ISO 12006-2 and the IEC 81346-series meet this requirement. The above analysis shows the weaknesses of both standards, but perhaps above all in IEC 81346-2, with its emphasis on function as the major principle of subdivision.

In spite of this, a proposal for CoClass fully adapted to the IEC 81346-series has been developed and presented for public comments early in June 2016. It is not presented further here. Instead is shown an extract from alternative 2, showing a classification of construction elements that strictly follows the principles of subdivision by form as presented in the introduction.

#### **4.7.2 Alternative 2**

The second alternative to classification of construction elements in CoClass, is based on ISO 12006-2:2015 with form as basis for subdivision of classes. On this basis it is possible to make an objective classification where class membership is self-explaining. The proposal is tentative regarding its detailed content but shows that such a systematic is possible and provides a simple and transparent system.

Construction elements are grouped into 10 main technical fields and subdivided according to form. The same principle is used for construction element components. The proposal

contains 8 main groups of construction element components categorized by the main technology areas: ground and building constructions, installation systems, and furnishing and equipment. The number of components under each category varies but are in some cases up to 60, see Tables 1 and 2.

Table 1: Classes of construction elements in the first partition in alternative 2 of CoClass (author's translation).

A	Ground construction	M	Ventilation system	R	Tele system
B	Building construction	N	Cooling and heat pump system	S	Traffic control system
C-K	Reserved	P	Liquid and sewage system	T	Transport system
L	Process gas system	Q	Electrical system	U-Z	Reserved

Table 2: Construction element components in alternative 2 of CoClass (author's translation). \*Note: "in" means "as part-of".

<b>A</b>	<b>Ground component</b>	CB	Fan, pump, compressor	<b>E</b>	<b>Electrical component</b>	HA	Furnishing and equipment for road traffic
AA	Rock	CC	Gas throttle	EA	Generator	HB	Furnishing and equipment for rail traffic
AB	Ground layer	CD	Gas valve	EB	Electric cable	HC	Furnishing and equipment for sea traffic
AC	Plant component	CE	Gas treatment unit	EC	Electric treatment unit	HD	Fence
<b>B</b>	<b>Building construction component (BCC)</b>	CF	Gas filter	ED	Electric equipment	HE	Railing
BA	BCC in* ground construction	CG	Gas equipment	<b>F</b>	<b>Tele component</b>	HF	Boarding
BB	BCC in* foundation construction	<b>D</b>	<b>Component in fluid system</b>	FA	Tele cable	HG	Gate
BC	BCC in* wall, roof	DA	Fluid pipe	FB	Tele signal treatment unit	HH	Play equipment
BD	BCC in* slab, plate	DB	Fluid well	FC	Tele equipment	HJ	Sports equipment
BE	BCC in* column or beam construction	DC	Fluid pump	FD	Signal equipment	HK	Safety equipment
BF	BCC in* staircase and ramp	DD	Fluid valve	FE	Sensor, other than for fluid or gas	HL	Furniture
BG	BCC in* track construction	DE	Fluid treatment unit	FF	Fluid sensor	HM	Kitchen equipment
BH	Cladding and coating	DF	Fluid Filter	FG	Gas sensor	HN	Cleaning equipment
BJ	Complementary BCC	DG	Fluid container	<b>G</b>	<b>Component in mechanical system</b>	HP	Washing equipment
<b>C</b>	<b>Component in gas system</b>	DH	Fluid equipment	GA	Transport component	HQ	Waste equipment
CA	Gas pipe	DJ	Fluid gauge	<b>H</b>	<b>Furnishing and equipment</b>	HR	Complimentary building

The classification codes in the third level are not one letter, but numbers up to 99. It is important that the principle for coding does not interfere with the need for granularity in the classification. The IEC 81346 standards use three letters only. In order to accommodate the need for increased granularity they have introduced the idea of alternative class names. But as shown in the analysis above these often have different structural composition and should be handled as separate classes.

Which alternative that will be chosen for CoClass depends on the outcome of the public review and future implementation tests. Adaption to the IEC 81346-series classification means that the tables will be controlled by an international standardization body. A widespread international adaptation of the IEC 81346-series is a necessary requirement for such an arrangement to be meaningful. The new version of the IEC CD 81346-2, and the IEC CD 81346-12 are yet draft standards and, considering the weaknesses disclosed in this analysis, liable to change before, or if at all, being adapted as international standards.

## 5 Conclusions

Although the ISO 12006-2 standard is intended to be a framework for development of construction classification systems it fails to guide the classification of construction elements concerning relevant tables and basis for subdivision of classes. The draft standards for reference designations in the IEC 81346-series recommend function as the primary basis for classification. This causes the classification to be subjective and not suited to most of the applications in the construction processes. The analyses presented here suggests that construction elements should be classified in two separate tables, one for construction elements and another for construction element components. In both tables form should be used as main principle of subdivision of classes. The developers of the new Swedish construction classification, CoClass, need to consider this in their choice of direction for final development. Another consideration should regard the uncertain future of the proposed IEC 81346-series for construction classification as international standards.

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