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CONSTRUCTION INFORMATION CLASSIFICATION SYSTEMS ADAPTED TO SUSTAINABILITY: INTERNATIONAL EXPERIENCE

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Abstract

The Architecture, Engineering, Construction and Operation (AECO) sector is one of the most demanding in terms of the use of natural resources. It is estimated that this sector has a 10% stake in the Portuguese economy and a consumption of natural resources and energy of around 50%. One of the causes for this disproportion is a production model based on a linear economy, where there is great waste of raw material and little rationalization for recycling and reuse. A major challenge is then imposed on all those involved in this area: to develop production models that involve the sharing, reuse, repair, renovation and recycling of existing materials and products, thus extending their life cycle.

In addition to this new global challenge, aligned with the United Nations (UN) Sustainable Development Goals, the generation of more information in the construction field makes Construction Information Classification Systems (CICS) even more relevant in the organization, treatment, and recovery of these. But studying in more detail the structure of CICS, they need adaptations and changes that make them more efficiently classify information based on sustainable concepts and the circular economy that assist in decision-making and make the sector more sensitive in choosing more economical and environmentally efficient materials, components, and processes.

The Sustainability Enhanced Construction Classification System (SECClasS) Project presents a solution that unifies these challenges, proposing to develop and implement a CICS optimized for sustainability, based on the principles of Circular Economy, aiming to reduce construction waste and demolition, using digital tools that help and promote the careful selection and management of elements with less environmental impact.

This article describes the assumptions for the development of a Portuguese CICS, that adapts systems already established at an international level, such as: i) UniClass (United Kingdom); ii) OmniClass (North America); iii) CCS (Denmark); iv) CoClass (Sweden); and v) CCI (Estonia, Czech Republic, Norway, Denmark, Sweden, and Finland). International standards ISO 12006 and ISO 81346, as well as the Action Plan for the Circular Economy defined by the European Union in 2020 are also analyzed. The proposed assumptions aim to obtain a CICS that streamline decision-making processes in AECO sector, reducing negative environment impacts and promoting sustainability.

1. INTRODUCTION

In the last decade, the Architecture, Engineering, Construction and Operation (AECO) sector has undergone technological innovations that transform the way how the industry operates and contributed to the reduction of financial and environmental risks, such as the modernization of planning methodologies and design of projects, the introduction of new construction techniques and new principles of construction and demolition waste (CDW) management.

In the scope of the design, planning and operation of the buildings, the Building Information Modelling (BIM) methodology provided great advantages through virtual simulations with intelligent models, but also imposed new challenges on the AECO sector, restructuring the way of designing and planning the construction. The BIM methodology has created a volume of information of great potential, which requires a methodology that normalizes its treatment in a structured way. For this, Construction Information Classification Systems (CICS) are used, which, if previously useful in the processing, organization, and retrieval of information with new technology, become fundamental for the management of the high volume of data [19].

In the context of mitigating the environmental impact of buildings, the increasingly demanding conditions, impose on the AECO sector the search for innovative solutions. One of these solutions is a new concept of economy that privileges the efficiency and reuse of materials: The Circular Economy. Once again, BIM is an ally that, through information connected to sustainability and simulation software's, support the decision-making process on the impacts caused to the environment, whether on the issue of raw material consumption or on thermal, energy, gas emissions, etc. [17].

This report aims to analyze the main systems of classification of existing information, expose their most relevant concepts and support the decision-making of the methodologies to be adopted. In addition, it aims to observe constant parameters in these systems that defines classifications in the scope of sustainability, focusing on reuse, recycling, durable products, possibility of relocation of structures and minimal waste, and that contribute to the decision-making process. It is also intended to expose important concepts that serve as the basis for the standard structure of CICS, as well as concepts suggested by European legislation for a circular economy. Finally, the report proposes the choice of one of the international systems as a basis for development for the national classification system.

2. CONCEPTS, USE AND STANDARDIZATION OF CICS

The construction information classification systems for the AECO sector emerged in the 20th century to meet some needs of the sector in organizing itself rationally, facilitating the storage and retrieval of information and for the exchange of information relevant to the sector. In general, it is classified with the objective of finding the best possible order, to, after the classification of a given element, it is easier to find it within a given set. A classification system is configured in a set of interdependent elements that form an organized whole. Such systems can be developed according to the needs of each country, region or even a company, to meet their longing so as to organize themselves, as well as can follow international classification standards [19]. The classification and consequent harmonization of information through CICS, therefore, has as main objectives to make collaborative work more effective, even when carried out at a distance or in different files formats, to ensure coherence and comparability and to enable the various agents in the construction process to be less dependent on the weaknesses of third parties [20].

Although there is no absolute way to classify, the most correct would be for all business partners to use a common language to group products [20]. To classify, the objects are grouped into classes, relating them according to the particularities of their properties. There are several types of classification that can be described and that are associated according to the objectives, scope, and particularities of the system to be developed. Ratings can be divided into: i) specialized, when it wanted to focus on a particular topic; ii) general, when it is intended to cover a universe of information; iii) enumerative, when it is seeking to list all subclasses, including composite ones, which relate to the main class; iv) by facets or hierarchical, subclasses are created from a simple and particular principle of division of the main class and defined classes composed of association of subclasses; v) document, when the main objective is the classification of documents or other types of information in order to facilitate their organization, location and storage; and vi) analytical (taxonomy or scientific), when it is intended to systematize information and provide a basis for its explanation and understanding [19].

BIM encompasses information about the enterprises throughout their life cycle, at the level of design, planning, construction, and maintenance. The classification and structuring of this information enable the integration between the different stages and specialties of the construction system, reducing errors and optimizing the process. The technology on which BIM is based allows the generated model to contain precise and detailed information about the geometry, as well as a set of data relating to the construction procedures, technologies used and the acquisition process, necessary to carry out the enterprise [12]. BIM presupposes a complete change in the flow of information exchanged between stakeholders in relation to the traditional workflow that is now centralized in the BIM model avoiding the possible loss of information (Figure 1).

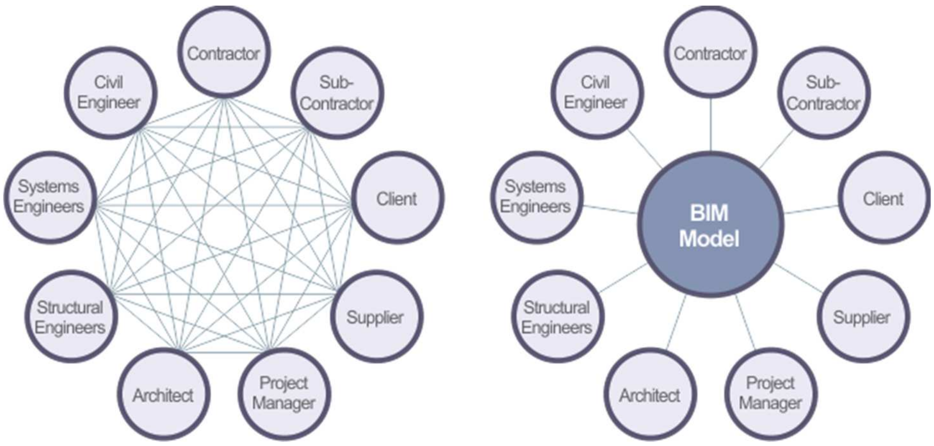

Figure 1 – Traditional vs. BIM workflows

The way of introducing information into BIM models is done through intelligent objects that are responsible for integrating valuable information about the production, communication, and analysis processes of digital 3D models, thus assuming particular importance in the creation and development of models that allow to represent virtually, in an equivalent way, the real product. In fact, the correct insertion of information in the object is fundamental for the best use of the BIM methodology. There is a need to adopt methods and strategies that enable the correct definition and implementation of these elements. This is the case of Construction Information Classification Systems (CICS), which guide and organize how information is made available to intelligent objects [19].

2.1 PROPOSED CLASSIFICATION IN THE ISO 12006-2:2015

ISO has produced standards to organize the classification and exchange of information, such as ISO 12006-2:2015 and ISO 12006-3:2006, whose major objective is to guide the structuring of classification systems. The base structure proposed by ISO aims to provide the systems in development with the necessary scope to respond to the growing size and complexity of construction work. Indeed, a classification system designed in accordance with ISO 12006-2:2015 should cover the entire life cycle of the enterprise, covering a wide variety of construction work [19].

However, there is no specific and definitive recommendation on the structuring model to be adopted for each situation, which allows the user to choose the one that best suits the system they want to classify. The standard still has another role in the development of classification systems. Due to the existence of several CICS, the exchange of information between them tends to be facilitated if they are developed in accordance with the proposed guidelines. Based on this function, tables are recommended by ISO 12006-2:2015, which can be used in combination or separately according to the user's need [16].

2.2 PROPOSED CLASSIFICATION IN THE SERIES ISO/IEC 81346

The standards of the ISO/IEC 81346 series constitute the latest series of standards for the identification of components belonging to any technical system. The standards deal with technical systems in the broadest sense of the word, including construction (structures and technical installations), industrial systems, as well as machinery in general, and, moreover, are of considerable importance for the documentation base of the European Directive on machinery and equipment, as this documentation links the marking of components and associated documentation [2].

ISO/IEC 81346 series-based systems are structured differently from ISO 12006-2:2015. They have a smaller group of Functional Systems, Technical Systems and Components – items corresponding approximately to the elements, results/working systems, and product tables of ISO-based systems 12006-2 – and differentiates them by assigning different properties, for example, a port is always designated as a port, but subtypes are defined by their properties, which is reflected in the designation or classification. Additional notations are attached to the initial/root notation, as the item is progressively defined throughout the design and documentation process. This results in a stable and recognizable designation throughout the life of a project [13].

The standard is divided into four parts: i) Part 1: Basic rules (IEC 81346-1); ii) Part 2: Classification of objects and codes for classes (IEC 81346-2:2019); iii) Part 10: Power Plants (ISO/TS 81346-10, IDT); iv) Part 12: Construction Works (ISO 81346-12). Parts 1 and 2 also bring rules for the creation of unambiguous identifiers that define, through the Reference Designation System (RDS), a combination of well-defined relationships (part and type of relationships) and different aspects (function, product, location, and type) [3].

3. CIRCULAR ECONOMY

The concept of Circular Economy has received political and academic prominence in recent years as an alternative capable of social, economic and environmental impacts mitigating associated with the current economic model and thus achieving the sustainable development goals of the United Nations [25].

Circular Economy introduces a new paradigm for resource management that is not limited to reducing the impacts of the current economic and industrial model but promotes its healthy and resilient long-term growth [6]. Thus, it disassociates the economic growth of raw material extraction through the maintenance and exploitation of regional stocks [22]. It is defined by the Ellen MacArthur Foundation (EMF) as a "restorative and regenerative industrial system by intent and design" [11], where technological and biological products remain separated at their highest intrinsic value and constantly circulating in the economy [5] [11].

Circular resource management is based on three fundamental strategies: narrowing flows through sufficiency and eco-efficiency; slow down flows by maintaining, repairing, and reusing products; and close flows, through the recycling of by-products, waste and waste [4] [11] [14].

As the AECO sector is a major consumer of raw materials, energy and waste producer, the impact exerted by this sector emphasizes the need for a complete and systemic transformation that considers all phases of the life cycle of buildings and the value chain of construction, and the development of strategies that promote energy efficiency, bio-efficiency, and material efficiency [10].

In 2015, with the launch of the Circular Economy Action Plan (CEAP), renewed in 2020, the European Union (EU) presents measures for the sector to encourage circularity in construction: i) addressing the performance of construction products in terms of sustainability; ii) promote measures to improve the durability and adaptability of assets built; iii) use the Level(s) approach to integrate life-cycle assessment into public procurement and the EU framework for sustainable financing; iv) consider a review of the targets set out in EU legislation for the recovery of construction and demolition waste; and v) promote initiatives to reduce the level of soil waterproofing, rehabilitate abandoned or contaminated industrial spaces and promote the safe, sustainable and circular use of excavated soils.

The Level(s) approach is a framework proposed by the EU and developed by the Joint Research Centre (JRC) for sustainable buildings and in line with the principles of the Circular Economy. The tool aims to unite the entire value chain of the sector around a common European language and provide a complete view of the entire life cycle of buildings. The common structure of the approach is organized into three levels that represent the increasing complexity of the stages of a construction project: i) concept design; ii) detailed design and construction; and iii) as-built design and use. In addition, the approach suggests 16 performance indicators for buildings, divided into six macro-objectives into three main thematic areas.

4. INTERNATIONAL CLASSIFICATION SYSTEMS

Considering the analysis of several CICS used in Europe and around the world, the development of the present paper is based on a study conducted by the Faculty of Civil Engineering of the Czech Technical University in Prague, Czech Republic, in association with the Czech Agency for Standardization (PS03). The research includes 18 international CICS, that through pre-established criteria were evaluated: i) horizontal details, dealing with more complex classifications and referring to the scope of CICS; ii) vertical details, consisting on checking the basic classifications suggested by means of ISO 12006-2:2015 tables; iii) chronological details, concerning the classification of the phases of a construction project and the state of the structures; iv) the main properties, comprising ontological, functional and license; and v) compliance with other systems, regarding compatibility with BREEAM, LEED, etc., certification systems and with BIM systems, namely Revit, ArchiCAD, Tekla and other. In the study conducted by the Czech researchers, the UniClass 2015 (United Kingdom), CoClass (Sweden) and CCS (Denmark) systems were the best evaluated. In addition to these, it was defined that, because they are globally consolidated CICS, OmniClass (North America) and the CCI (a system under development by several northern European countries) would also be included in the analyses carried out by the project framework.

The CICS developed by the United Kingdom, the UniClass 2015, under the responsibility of Nation Building Specifications (NBS), has great advantages in comparison with others. Its structure based on the concepts of ISO 12006-2:2015, is wide, hierarchical and its tables make relationships with each other. The complement of its terminology and coding database is flexible, allowing the introduction of new elements. The system is adapted to the constructive process of the European market, facilitating adaptation to the national AECO sector. Its updates are systematic, and documentation is available in English. NBS also provides tools that enable interconnection with BIM modelling software. In addition, the Sustainability Enhanced Construction Classification System (SECClasS) Project was authorized by NBS to translate and use UniClass 2015 as the basic system for a national CICS.

CoClass was created in Sweden, between 2017 and 2018, in response to the construction industry digitization and its connection to BIM. This is a complex CICS, and its use is mainly linked to the country of origin [1]. CoClass is structured differently from the "classic CICS", therefore brings differences with respect to UniClass and OmniClass. Its general structure is based on ISO 12006-2:2015 but uses ISO 81346 series for classifications of functional systems, techniques systems, elements and spaces. The CICS proposes to have a human-readable and machine digital language, using the RDS coding system, proposed in ISO 81346, to codify references to products. CoClass has some disadvantages: the documentation is partially available in English and most in Swedish, and CICS is not fully open source, having costs of use, providing only basic tools and classifications for free. Its updates are systematic and allow development and insertion of new classifications. The system considers the state of the structures. Analyzing the Property table, information can be found regarding durability, mechanical durability, object state or year of reconstruction, according to real estate registration data. Due to limited access to the system, no further information can be verified.

Cuneco Classification System (CCS) originates in Denmark, under the responsibility of Molio – Construction Information Centre, BuildingSmart's Danish partner. The development started in 2010, using ISO 81346 series, in the 2009 version. The purpose of the system is to ensure that digital data can be clearly exchanged between production chains, phases and software's, thereby helping to increase construction productivity. Provide a unique identity for each part of the building and be able to be applied to all parts of the building, from design to operation, so that all parties using the same concepts can be based on each other's information and classify the information. The documentation is in Danish, limited to a part of it and tables translated into English. CICS is available in the basic version free of charge but requires annual subscription for full use of resources. CCS provides tools for sorting objects, along with a system for defining codes and definitions that can be accessed using the CCS Navigate tool. The connection with the modeling software, Revit and ArchiCAD, is made using plug-ins [1]. No sustainability classifications were found.

OmniClass is a CICS developed by the Construction Specification Institute (CSI), the Construction Specification of Canada (CSC) and the American Institute of Architects (AIA) to serve the AECO sector of those countries. It is considered a traditional system, as UniClass 2015, which has its structure based on ISO 12006-2:2015. The biggest difference between them is the construction process in which they use as a base, with OmniClass being adapted to the processes of the North American construction sector, but still compatible with other international systems. This CICS is a standard *opensource* to any person or organization, promoting the exchange of information between stakeholders. The development and update have the participation of the industry, but is verified an outage, being the last occurred in 2019. The system has good connection with BIM modelling software, documentation in English and, although the study of the Czech Agency for Standardization affirm that the license terms allow editing and distribution, the information could not be verified about the commercial use. A great advantage of OmniClass to the SECClasS Project is the classifications in the property table, capable to classify information associated with sustainability.

The origin of the development of the Construction Classification International (CCI) arises from Estonia's need to develop its own CICS that would serve that country. Soon other neighboring nations would feel the same need and together the Czech Republic, Finland, Norway, Denmark, Sweden join Estonia for this goal. The CCI working group then decides to use CoClass and CCS as the basis for the new international CICS, believing that the implementation of a common a cross-border classification system improves cooperation, increases standardization, and improves digital working methods. As a result, the CCI core is the common element between ISO, CCS and CoClass standards [21]. The system uses ISO 12006-2:2015 in its general structure and the ISO 81346 series for systems and components. The system aims to be developed in English with possible translations into the languages of the countries that are part of the project. According to the letter of intent signed by the developers, CICS must be free of cost, but a formal use license document as well as upgrade protocols is not available yet. The sustainability component also cannot be evaluated because of the development stage.

5. CONCLUSIONS

The BIM methodology, admittedly, brings advantages to the AECO sector. The applications generate a large amount of information needed to provide designers an increasing number of possibilities for simulation and operationalization of assets. CICS becomes an essential tool, but not the only one, in the management of this information. Therefore, and with the national demand for a CICS that meets the needs of the Portuguese market, the SECClasS Project seeks to develop a system based on European and North American experiences that also adds an unexplored component in existing CICS: sustainability.

A more in-depth study of the concepts of circular economy was carried out to seek classification parameters that aim to assist in sustainable decision-making, focusing on reuse, recycling, durable products, possibility of relocation of structures and minimal waste. To achieve these concepts, the new Action Plan for the Circular Economy of the European Union stipulates targets and indicators that can be used as parameters for the classifications to be developed by the SECClasS Project. Creating a correlation between these indicators and the classification system could have an impact on the dissemination of the system in the national AECO sector, taking as an advantage the association of legislation and achievement of targets proposed by the European Commission.

The study, carried out by researchers from the Faculty of Civil Engineering of the Czech Technical University in Prague, in association with the Czech Agency for Standardization, was analyzed in this report and the conclusions were compared with the objectives of the SECClasS Project presenting the following results:

i) None of classification system is perfect, as the requests of each user group are distinct. The flexibility and adaptability of the system is essential, as each country will always have its own classification needs;

ii) The CICS's purpose must be in accordance with the BIM methodology and able to increase the sustainability and circular economy, responding to current uses, but also to future uses;

iii) Systems that are hyper-adapted to a specific type of construction or a life cycle phase should be avoided;

iv) Correspondence with other systems is essential, so they must be in accordance with international standards, in this case ISO 12006-2:2015;

v) More complexes CICS have greater breadth of future application and development. However, the level of complexity should always be evaluated, so as not to derail human interaction and perception;

vi) The oldest CICS have advantages such as greater consolidation in the market, acceptance by professionals and the language availability;

vii) The CICS's future maintenance, including, but not limited to its expansion, updating and maintenance, are factors to consider, and it is important to define a clear methodology, including and defining responsible and resources;

viii) The license to use and adapt, the current dynamism of the entity(s) holder of the rights in the expansion, correction and improvement and responsiveness to external contributions should be investigated and considered in decision-making for a basic CICS.

Based on the reasons presented, and the existence of an open license and the authorization for its translation and adaptation, degree of dissemination and implementation in object libraries, the choice for the base system for the SECClasS Project falls on the UniClass 2015 system, managed by NBS. The next steps are, first, establish a methodology for adapting and translating the system into the Portuguese language and reality. Secondly, establish how to include the sustainability component. Finally, it is of the utmost importance to engage the technical environment and collect and incorporate your feedback.

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The implementation of BIM in Portugal is a reality and professionals demand for a National Classification System that facilitates the processing, communication and sharing of information and models that maintains standard communication between all agents involved and throughout the construction life cycle.

SECClasS is a project funded by The EEA Grants with the purpose of developing a Construction Information Classification System for Portugal, with a component focused on sustainability, supporting decision-making that encourages reuse, recycling, durable products, possibility of relocation of structures and minimal waste.

The project aims to facilitate the Circular Economy in Construction by introducing a CICS optimized for sustainability, oriented to the BIM methodology and that will serve not only the sustainability component, but also the other BIM uses. It will also allow unifying terminology at all scales, facilitating communication, selection of materials and components, as well as an accurate assessment of the impacts of buildings throughout their life cycle.

With the development of the SECClasS Project, it is expected to achieve the following results: i) National classification system that will allow more advanced BIM uses based on traditional systems with sustainability component: environmental impacts, reuse, recycling; ii) Manual and Library of BIM Objects, with traditional and sustainability components; iii) Online platform with Artificial Intelligence tools that learns from users.

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