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A LITERATURE REVIEW ON INFORMATION COORDINATION IN CONSTRUCTION

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ABSTRACT: Currently in Portugal, procedures for gathering construction project information as well as co-ordinating and communicating the information amongst all the stakeholders in the process are extremely bureaucratic, confusing and time-consuming. The problem has been exacerbated by the increasingly complex and large nature of construction projects involving a large number of participants. There is currently a lack of a systematic approach that can effectively manage all information concerning construction projects to ensure a faster and more efficient and transparent process. This ultimately results in problems regarding project performance e.g. extreme delays in construction, loss of information and increasing costs. The aim of this research is to explore the viability of developing a systematic approach to the coordination of information amongst the multiple project stakeholders in the Portuguese Construction Industry. This paper presents the results of a comprehensive literature review of existing methods of classification of information and protocols for communicating information. Work being undertaken to develop a framework for structuring and representing information for proper co-ordination and management in the Portuguese construction industry will also be presented.

Keywords - Communication Protocols, Construction Project, Information Coordination.

1. INTRODUCTION

The objective of this study is to understand the existing classification information methods and protocols in the construction industry worldwide in order to develop a framework to use/apply to Portugal. To accomplish this, seven major approaches were studied and compared, so that one would be adopted.

Information coordination in the construction industry has become of vital importance, due to a variety of factors. These include the use of new and improved technologies, the enormous amount of data created during a facility's life cycle, the different types of data that need to be addressed, the increase in multidisciplinary work among parties involved in the process, the need to guarantee the retrieval and re-use of information for multiple purposes, international trading. The combination of these factors results in the need for information co-ordination and protocols for communicating information at an international level .

In this study three classification information systems are outlined, from the seven considered, and procedures for the production and exchange of information are also presented. The importance of using protocols and procedures is as crucial as the importance of adopting an information coordination system, because it is only when information is collected in a proper way that we can then adequately obtain a classification system that effectively manages information throughout a built environment's entire life cycle.

2. METHODS

A comparative analysis table was used to synthesize the strengths and weaknesses of all seven information coordination systems considered. A comprehensive table was also developed concerning important aspects that a classification information system for the construction industry should comprise. The data analyzed was acquired through the internet, manuals/codes, toolkits, books and during informal interviews with professionals from the construction industry in both Portugal and U.K.

3. CLASSIFICATION SYSTEMS AND PROTOCOLS FOR COMMUNICATING INFORMATION

In this chapter we are going to look at existing/developed classification systems and protocols for communicating information. Although it might seem as they should not be considered together they are part of the whole approach to effective production and management of information in the construction industry.

The classification systems studied were: CI/SfB, *Construction Indexing Manual* (Ray-Jones and Clegg, 1982), *EPIC - Electronic Product Information Co-ordination* (CPG, 1999), CAWS - *Common Arrangement Work Sections* (CPIC, 1998), Uniclass - *Unified Classification for the Construction Industry* (RIBA, 1997), *Master Format* (CSI, 2004), OmniClass – *The Overall Construction Classification System* (CSI, 2006), BS ISO 12006-2_2001, Part 2: *Framework for Classification Information* (BSI, 2001).

From these seven, three are presented being considered of utmost importance following a comparative analysis based on their strengths and weaknesses. Of all the existing protocols and procedures for production information and management studied, two are outlined in this paper, i.e. the code of procedure for the construction industry developed under CPI, Construction Production Information (CPIC, 2003) and the AVANTI Programme (ICT, 2005).

The first is considered as it entails the principles of previous standards and procedures such as, the *BS 1192 Part 5:1998*, *Construction Drawing Practice*, *Production of Drawings* and *Project Specification* (BSI 1998). The latter intends to develop collaborative work within the construction industry and has produced and made available in September 2005 three toolkit guides to enable teams to establish methods and procedures in their work: *Design Management Principles* (Avanti, 2005a), *Project Information Management a Standard Method & Procedure* (Avanti, 2005d), and *Object Modelling Guide* (Avanti, 2005c). The AVANTI Programme has also made available, through the internet, summaries of work in progress collaboratively with companies in specific projects (Avanti, 2004).

These cover the key issues to be addressed in a construction project in order to guarantee production of quality information and communication between all parties involved in the process.

3.1. CI/SfB - Construction Indexing Manual

The classification system most widely used by the construction industry throughout the world is the CI/SfB (Ray-Jones and Clegg, 1982). This has been in operation for more than 37 years and it is the industry standard. This indexing manual for construction products and elements was developed by Alan Ray-Jones, Royal Institute of British Architects (RIBA) and David Clegg, ALA. The Indexing Manual was based on the original SfB (Samorbetskommiteen for Byggnadsfrsgor) from Sweden - in place for more than 50 years.

The manual can be used by both small and large architectural firms and by quantity surveyors, engineers and contractors. Stakeholders/firms involved in the building industry vary considerably in their size and especially in working methods which reflect this diversity of size and disciplines. That is why there is a need for an information classification system.

It is a manual for project information coordination and it is used to provide structure to most office libraries and in the production of information in the UK. It can be used as a checklist for collecting and storage of briefing information and outline technical specifications, which are useful in the initial cost plans for the approval building regulations. It also provides a satisfactory means of structuring sets of detailed design drawings, working drawings and specifications. It uses tables to represent the physical environment, elements, construction forms, materials and activities (Ray-Jones and Clegg, 1982).

The management of general information usually involves the classification, filing, indexing and re-use of complete documents, not just for use in one particular project but can be used in any project and accessed by anyone. The CI/SfB (Ray-Jones and Clegg,1982) can also be applicable in any office libraries as a classification system.

3.2. Uniclass - Unified Classification for the Construction Industry

Developments in Information Technology resulted in the need to update CI/SfB (Ray-Jones and Clegg., 1982). As a response to this need, the Construction Industry Project Information Committee (CPIC) and the Royal Institute of British Architects, in the UK, have developed and published the "*Unified Classification for the Construction Industry* – Uniclass" (RIBA, 1997). It is a classification scheme/index system for the construction industry that aims to organize library materials and structure product literature and project information.

Uniclass (RIBA, 1997) was developed to unify existing classification systems used in the U.K. and is based on four other important schemes: CI/SfB (Ray-Jones and Clegg., 1982), CAWS (*Common Arrangement of Work Sections for building works*, CPIC, 1998), CSEMM3 (*Civil Engineering Standard Method of Measurement*, ICE, 1991) and EPIC (*Electronic Product Information Co-operation*, CPG, 1999). It is a unified classification system that comprises almost all studied schemes and also includes new subjects such as construction products and a project lifecycle classification, which is of most importance today.

It is a classification scheme to organize library materials and structure product literature and project information. It is intended to supersede the CI/SfB (Ray-Jones and Clegg., 1982) classification system resulting from international developments and changes in technology, construction project practice and process; working as a unified system and making notation coding easier and simpler. Its strength lies in the possibility of being used by several practitioners from various disciplines and it is particularly useful where it is designed to arrange files in computer databases which CI/SfB (Ray-Jones and Clegg, 1982) didn't allow.

The tables in Uniclass (RIBA, 1997) represent different broad facets of construction information and can be used separately for the classification of particular types of information or combined to classify complex subjects. Similar words can appear in more than one table in different context, meaning that tables are interrelated.

Notation is simpler with this system because it consists of a single capital letter followed by zero or more digits, apart from Work Sections table (J and K) which have two initial capital letters in order to integrate the CAWS (CPIC, 1998) and CESMM3 (ICE, 1991) codes. It allows easier shortening of the notation because numbers are not filled out with trailing zeros to create a fixed number of digits. This seems to be a better solution for computerized organization systems but might somehow confuse filing order. .

It also provides guidance for classifying the scale/complexity of construction works and classifies documents, from small to large complex collections. The most important field considered in Uniclass (RIBA, 1997) and not in CI/SfB (Ray-Jones and Clegg., 1982) concerns retrieving information classified by the system and its use with computerised databases. It provides a means to understand storage of technical information on sorting combined codes in the correct Uniclass (RIBA, 1997) filing order in a computerised database and retrieving computerised information classified according to the system. This is essential for project information and classification management in the construction industry today.

3.3. OmniClass - The Overall Construction Classification System

The North American AEC Industry (Architecture, Engineering, and Construction) has developed OmniClass (CSI, 2006) formerly known as OCCS, Overall Construction Classification System (OCCSnet, 2005). Its production began prior to 2000 and has been a work in progress from the Construction Specifications Institute (CSI) ever since. At that time, CSI invited parties from many sectors of the construction industry to an OCCS workshop in Alexandria, VA. Since then CSI, the International Alliance for Interoperability (IAI), and more than 50 other AEC organizations have joined in the development of this industry-wide initiative - *The OmniClass™ Construction Classification System* (CSI 2006).

The first edition of the OmniClass™, *A Strategy for Classifying the Built Environment, Introduction and User's Guide* (CSI, 2006) has been available since May 2006 on the internet. The system resulted from the recognition that there was a need for an international standard related to the management of information of any built environment (Ceton., 2000). The need for Omniclass (CSI, 2006) also resulted from the need for a coordinated classification system to organize the amount of data created during any built environment's life cycle, coordination of multidisciplinary actions and people with the developments of design and web-based communicating systems, the need to keep all parties on a project informed at all times, lack of a coherent organizational structure and accompanying thesaurus and storage and effective use of any built environment information (Ceton, 2000).

Its concepts derive from standards developed by ISO (International Organisation for Standardization) and the International Construction Information Society (ICIS) subcommittees and workgroups from 1990 to the present, ISO Technical Committee 59, Subcommittee 13, Working Group 2 (TC59/SC13/WG2), standard for a classification framework (ISO 12006-2). *ISO 12006-2* provided the basic structure for information about construction, which is grouped into three primary categories composing the process model divided then into fifteen suggested tables as a way of organizing construction information.

The system has its application in:

- Organizing library materials
- Organizing product literature
- Organizing project information
- Providing classification structure for electronic databases
- Organizing
- Electronic and hard copy
- Libraries and archives
- Preparing project information
- Communication exchange information
- Cost information
- Specification information
- Other information related to the project generated throughout its life cycle
- Sorting
- Retrieving information
- Deriving rational computer applications

It aims to be an open and extensive standard available to the AEC industry with full open exchange between participants in its development, its dissemination depends only on the industry. It is compatible with international classification systems standards

Omniclass (CSI, 2006) development committee believes that it promotes the ability to map between localized classifications systems developed worldwide. Further, the use of numeric code was an important option due to the common use of letters and alpha-numeric in inheritance documents standards/schemes, which could lead to confusion. In addition, interest has been shown by Asian countries in Omniclass™(CSI, 2006). Other systems (see for instance CI/SfB and Uniclass) frequently use alpha-numeric coding which is not easy to use in Asian countries. Numeric coding does not present this problem once it is universal. It is easy to expand the code using number combinations.

The system's success lies in its implementation in computer technology, above all relational or object-oriented database, making use of that technology's ability to relate information from a different number of perspectives and afterwards generate reports from all of them. The result is an information management tool that is flexible, rather than simple flat-file model storage of information. Unfortunately, to date, not all OmniClass (CSI, 2006) tables are ready to use.

3.4. Production Information – A code of procedure for the construction industry

This code of procedures (CPIC, 2003), endeavours to answer the problems of deficiencies in the production of information in the construction industry. It entails the principles of previous codes developed by CPI- Coordination of Project Information UK. *Production of Drawings - A code of procedures for building works* (CCPI, 1987a) and *Project Specification – A Code of procedure for building works* (CCPI, 1987b).

The developments in the construction industry and the implementation of computer technology require a code that could present stakeholders involved with the means to improve the production of information. With recent developments in IT and the necessary utilisation of recognised procedures the code is predicted to have five years of service, after which it should be revised (CPIC 2003).

It was developed under CPIC, and supported by the IT Construction Best Practice and NBS-National Building Specification, U.K. Its intended users are clients of the construction industry, designers, education and training establishments and providers of continuing professional developments. The code was developed in light of reports carried out on-site of many live projects carried out by BRE –Building Research Establishment. The conclusions were that the biggest cause of quality problems in construction was inappropriate project information, project participants' attitudes and practices which result in the lack of effective team work and the inadequate use of IT.

According to the Code (CPIC, 2003), Production Information entails:

- Drawings;
- Spatial and technical coordination;
- Accurate/correct drawing types and their content;
- Annotation of drawings: should only be given for good reason, references to other drawings and/or to the specification document;
- Arrangement of sets of work, divide the whole set of production drawings into identified groups, the key to a good arrangement is to keep it simple, regard an overall structure simple and easy to use and memorize;
- Establishment of sheet sizes and scales;
- Organization of drawing numbers and titles;

- Drawing issue and revisions;
- Specifications and bills of quantities;
- Schedules of work.

To produce quality information, an essential part of effective production drawing depends on making the best use of CAD – Computer Aided Design (CPIC, 2003). All the above requirements can be put into practice using CAD systems as explained in the Code (CPIC, 2003). The most common use of CAD systems is to improve the presentation of drawn information but what is necessary is to improve the quality of information. The Code (CPIC, 2003) guides us through the steps necessary to achieve that goal.

3.5. AVANTI Programme

Codes, manuals, and procedures developed are not the only efforts made to improve production, use and retrieval of information in the construction industry as part of the problem being addressed in study. Collaborative work needs improvement also

Technology available for collaborative work has grown and became available to enable the construction industry to work collaboratively (Avanti, 2003). The problem is that no one seems to know how to adopt and adequately use such technology. Users deal with it on a day to day basis but need help understanding, managing and correctly performing actions that result in the use of accurate production information. Improvements to costs, quality and responsibilities are expected results of these procedures. To address this problem the AVANTI programme – ICT Enable Collaborative Working has set out to develop procedures to use existing IT and make them work "on the field" with multidisciplinary teams involved in the project design and construction process (Avanti, 2003).

Their primary focuses are people and process. The AVANTI Programme is set out to do something far more important (at this point) than to create software for managing data. Its focus is on facilitating people to work collaboratively providing processes and adequate tools that enable collaboration, by mobilizing existing enabling technologies (Avanti, 2005a). The programme is an approach to collaborative working that enables construction project partners to work together effectively allowing early access to all project information by all partners, involvement of the supply chain, and sharing information, drawings and schedules (Avanti, 2005b).

Its major strengths are that its products are available on-line in the form of handbooks, toolkits and on-site mentoring. It is based on teamwork with access to a common information model throughout the project life cycle and is led by a team of industry practitioners. The intention is to demonstrate improvements in business performance by increasing quality of information ultimately resulting in predictability of outcomes and reducing risk and waste.

Table 1 - Comparative analysis table of seven information coordination systems studied

Acronym	**CI/SfB**	EPIC	CAWS	**Uniclass**	MasterFormat	**OmniClass**	BS ISO 12006-2_2001,
Correlation compatibility	SfB	Uniclass OmniClass	CI/SfB To be used with Uniclass	CI/SfB, CAWS, CSEMM3 EPIC To be used with CAWS	To be used with the National CAD Standard v3.1(U.S) and it is compatible with OmniClass.	Intended to be ISO compatible.	Uniclass, EPIC and OmniClass are based on it.
Work practice	37 years in operation	Reported since 1999	Since 1987	Since 1997	Since the early 1960s	It was released in 2006	Since 2001
Strengths	Flexibility. Easy to use and comprehend. Most widely used.	Flexibility. User friendliness (introducing more practical terms rather than abstract functional terms).	Consistency of technical content and description. Allows division of project information in work packages (easier distribution of information).	Broader scope/range. Aims to unify and comprise existing classification systems. Can be used by several practitioners of many disciplines. Designed to sort files in computer databases.	Its actual structure enables flexibility to accommodate future growth in construction material and technology. Enables the creation of a database throughout the entire lifecycle of a building. Provides a meeting standard of practice and improves documentation organization. Numeric coding.	Compatible with international classification systems standards. Its development and dissemination depends only on the industry. Uses numeric code. Enables expansion of the code allowing an open-ended structure. Subjects addressed at any level in a table are broad in scope and content. Compatible with information stored in computerized databases Freely available to all.	Defines an international standard framework and set of recommended table titles, and relations between them. Supported by definitions and not their detailed content. Applies to the complete lifecycle of construction works.
Weakness	Filling order goes from detailed to general information. Created before the existence and use of actual technologies.	Limited in range coverage and application.	Has to be used with other systems to obtain full coverage. Not easy to understand by all involved.	Is based on CAWS and advised to use with it: may present confusion and misinterpretation. It is alphanumeric.	Does not establish design disciplines, trade jurisdictions or product classifications. Enables creativity. Not applicable to engineering work.	It doesn't have sufficient practical application.	A framework for object-oriented information exchange approach had to be developed to complement it.

4. CONCLUSIONS

CI/SfB (Ray-Jones and Clegg., 1982), is the better known system of classification and the one that all others seem to derive from. This system is still implemented in several countries, e.g. Portugal, mainly because it was the first to enjoy widespread recognition and because it has been in use for more than 30 years. The most reported problem is that it does not cover the use of computerized technologies (Ray-Jones and Clegg., 1982). Although it can be adapted to computerized technologies, its adoption for that purpose is bound to demand the use of creativity by its users, hence loosing its standardized characteristic.

There is also the matter of exchanging information at an international level. This was not considered in a classification system until the British Standards Institution developed and published BS ISO 12006-2, *Building Construction - Organization of Information about construction works- Part 2: Framework for classification of information* (BSI, 2001), which intended to overcome this problem, since it identifies classes for the organization of information and indicates how they are related. However, as a framework, it allows classification tables to vary in detail to suit local needs and does not provide a complete operational classification system.

This framework can be of utmost importance when trying to develop a system of classification and has helped produce Uniclass (RIBA 1997) and Omniclass (CSI, 2006). These two schemes, apart from being the most recent, seem to be the ones that present tables and principles that cover different and broader aspects of the construction industry activities, people and tools. They also provide some space to accommodate emerging developments, such as developments in technologies and products.

CAWS (CPIC, 1998) and MasterFormat (CSI, 2004), as classification systems of work sections and elements (specifications and cost analysis), are the most widely used systems but do not, in themselves, offer an answer to classification information in a broader way; they have to be complemented with the use of classification systems such as Uniclass (RIBA, 1997) or Omniclass (CSI, 2006).

Uniclass (RIBA, 1997) is considered to be the substitute of CI/SfB (Ray-Jones and Clegg., 1982), and is a classification system for the construction industry that aims to organise library materials and structure product literature and project information. Being based on CAWS (CPIC, 1998), and advised to be used with it, also presents a handicap.

Omniclass (CSI, 2006), system of classification is reported to be tackling the total classification problem (Johnson, 2005) and appears the most adequate solution thus far. Indeed, Omniclass (CSI, 2006) raises high expectations regarding its use and implementation, which is hardly surprising. OmniClass's aims to go further than any other classification system. It is the most recent published initiative in classification information in the construction industry, encapsulating almost all other initiatives being held so far, and it intends to classify all information created during the whole life cycle of the built environment. We await to see if OmniClass's implementation will meet these expectations. Is there a real possibility to develop and create a unique international standard classification system that can be used or adapted to different or similar realities? Omniclass (CSI, 2006) and Uniclass (RIBA, 1997) aim to be that classification system, and ISO 12006-2 (BSI, 2001) appears to effectively be that framework, given most of the initiatives derive from it.

But some questions are still unanswered. If Uniclass (RIBA, 1997) is the U.K equivalent to US Omniclass (CSI, 2006), then the systems should allow cross-referencing - yet the literature lacks any remarks regarding this issue. Also, since OmniClass (CSI, 2006) system comprises MasterFormat (CSI, 2004), that in theory, should make the latter redundant, but again here literature is silent.

In order to establish a classification system framework, as the one being studied for application in Portugal, development efforts should always strive to be ISO-compatible, enabling smoother exchange of information, and using existing systems and compatible initiatives to avoid duplication of work.

Recognizing and relating all the activities, people, tools (entities, resources and results) involved in the process of the built environment is of utmost importance in designing a system. Advances in “smart building technologies”, “building information management” (BIM) technologies and construction practices have increased and should always be taken into consideration as they increase opportunities for gathering, exchanging, and archiving all information, but also raise problems due to its usage.

The work being undertaken to develop a framework for structuring and representing information for proper coordination and management in the Portuguese construction industry, is based on ISO 12006-2:2001 framework (BSI, 2001), Uniclass (RIBA, 1997) and OmniClass (CSI, 2006) systems and existing protocols and standard procedures for production information, as they provide the best guidelines and seem to address the important problems concerning information production, management and users.

It is not desirable or intended to develop a different framework from the rest of the world but there is a need to understand the Portuguese reality and work towards a successful approach to its problems.

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