COORDINATION AND MANAGEMENT OF INFORMATION FOR CONSTRUCTION DESIGN PROJECTS

A FRAMEWORK FOR PORTUGAL

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Finally, but not least, I dedicate this thesis to my husband, Eduardo, and to my son, Gustavo, you guys rock my world!

DECLARATION

The research contained in this thesis was solely carried out by me. No fraction of the work enclosed here has been previously submitted to this or any other institution for an award of a degree or any other qualification.

ABBREVIATIONS

ACBINZ	Association for Coordinated Building Information in New Zealand
AEC	Architecture, Engineering, Construction
AECOPS	*Associação de Empresas de Construção e Obras Públicas e Serviços*[1]
AIA	American Institute of Architects
BIM	Building Information Modelling
BRE	Building Research Establishment
BSAB	*Byggandets Samordning Aktiebolag*, Sweden
BSI	British Standards Institution, UK
CAD	Computer Aided Design
CAWS	Common Arrangement of Work Sections
CBI	Co-ordinated Building Information, Australia
CCDR	Coordination Committee for Regional Development
CCPI	Co-ordinating Committee for Project Information
CDCS	Construction Document Classification Systems
CIC	Computer Integrated Construction
CPG	Construction Product Grouping
CPI	Coordinated Projects Information
CPIC	Construction Project Information Committee, UK
CSI	Construction Specifications Institute
CSC	Construction Specifications Canada
CESMM3	Civil Engineering Standard Method of Measurement 3
CSTB	Centre Scientifique et Technique du Bâtiment
EN	European Standard
EP	*Estradas de Portugal*

[1] Association of Construction Companies, Public and Services

EPIC	Electronic Product Information Coordination
FCI	Framework for a classification information system to construction project design data to be developed and implemented in Portugal
FM	Facilities Management
GDP	Gross Domestic Product
HTML	Hypertext Markup Language
IAI	International Alliance for Interoperability, now buildingSMART
ICT	Information and Communication Technology
ICE	Institute of Civil Engineers
ICES	International Construction Information Society
ICIS	Interactive Collaborative Information Systems
IFC	Industry Foundation Classes
IFD	International Framework for Dictionaries
IGES	Initial Graphics Exchange Specifications
IHS	Information Handling Systems
INE	Instituto Nacional de Estatistica
InCi	Instituto da Construção e do Imobiliário
ISO	International Organisation for Standards, UK
IT	Information Technology
JCCS	Japanese Construction Classification System
NBIMS	National Building Information Modelling Standards, US
NBS	National Building Specifications
NES	National Engineering Specification
NIBS	National Institute of Building Sciences, USA
NICSCCR	National Information Classification Standards for Construction Cost Resources
NP	Norma Portuguesa
OMNICLASS	Overall Construction Classification System
R & D	Research & Development

RIBA	Royal Institute of British Architecture
SDAI	Standard Data Access Interface
SET	Secure Electronic Transaction
SfB	*Samorbetskommiteen for Byggnadsfrgor*
SPSS	Statistical Programme for Social Sciences
STABU	Foundation Bouwbreed informatiesysteem
Uniclass	Unified Classification for the Construction Industry
URL	Uniform Resource Locator
WTCB/CSTC	Belgian Building Research Institute
XML	Extensible Markup Language

ABSTRACT

In the construction industry in Portugal, the coordination and management of information for construction design projects has been neglected. The use of classification systems and protocols for the communication of information amongst the different stakeholders is poor and inefficient. This research aims to explore the viability of developing a systematic approach to the coordination of information amongst the multiple project stakeholders in the Portuguese Construction Industry. Bearing this in mind, the core research question of this doctoral thesis is:

What sort of framework and guidelines are needed for the successful implementation of a classification information system for construction project design data in Portugal, which is accessible to all stakeholders involved?

A mixed methods approach was developed for this purpose, with emphasis given to qualitative research techniques. Methods used comprised: literature review, quantitative survey, semi-structured interviews and focus group discussions. Whereas quantitative research methods contributed to a more rigorous interpretation process, qualitative research methods offered a solid description of the former. This methodology was used in order to establish and design a conceptual classification framework model for information coordination and management throughout the design project and construction in Portugal. First, constraints and enablers to framework development and implementation were identified at all levels: political, cultural and behaviour, legal, technical and educational, economic and financial, and organizational issues. Three overarching issues were also identified: corruption, lack of accountability and non-compliance timelines/deadlines. Then, a conceptual framework was developed, detailing 1) content, 2) characteristics of an environment conductive to a successful development, implementation and use of the framework, and 3) guidelines to its dissemination.

1. INTRODUCTION

This research project consists of the development of a conceptual framework for a classification information system to be developed and implemented in construction project design data in Portugal. This introductory chapter will detail the context and relevance of the project here undertaken, as well as its aims and objectives. It will set out the research questions before providing a methodology outline to guide the reader through the remainder of the thesis.

1.1. Context of the research project

In the construction industry in Portugal, the coordination and management of information has been neglected. The use of classification systems and protocols for the communication of information amongst different stakeholders is poor and inefficient.

This problem is not unique to Portugal. Other countries in Europe such as Sweden, Denmark, Norway and the Netherlands, have experienced identical issues and dealt with it by developing classification information systems such as *SfB* from Denmark. This system has been in place for more than 50 years (Howard and Andresen, 2001) and it served as a base for the CI/SfB (Ray-Jones and Clegg, 1982) U.K., commonly used in English speaking countries, as a standard to classify manufactured product information from manufacturers as well as for catalogues (Amor et al, 2004), being one of the most known and applied classification information systems in construction design projects.

In Denmark, Bjorn Bindslev has been working on classification of information since the 1960s (Howard and Andresen, 2001), and in Sweden, Anders Ekholm has developed theoretical foundations for analyzing the structure of building classification systems at least since 1996 (Ekholm, 1996) and continues his work until the present day, more recently comprehending classification and Building Information Modelling (BIM) (Ekholm and Häggström 2011) .

Holland´s STABU LexinCon, object library for building and housing has been in place since 1995, and in Norway, BARBI (1999) which developed into ISO 12006-3[2].

The Electronic Product Information Co-Ordination- EPIC (CPG, 1999) was an endeavour from European countries to respond to the need for co-operation between European product information houses on the development and operation of databases of building product information (CPG, 1999) and was designed to be a common reference system to the construction industry for access to product information across national boundaries.

Outside Europe, in the United States, the Omniclass (2011) 'The Overall Classification System' has been developed, in Japan the JCCS - Japanese Construction Classification System (Terai, 2008) and in Brazil, efforts have taken place to develop a common terminology to reach interoperability (Amorim et al, 2007) to respond to this recognized problem and reach a common classification information system.

The need to standardize procedures concerning information in the field has also been thought of and developments have been made by the International Organization for Standardization (ISO) and by the British Standards Institute (BSI). Independently, or as partnerships involving technical committees, both have developed, and made available, numerous standards to overcome the problem of communication of information.

All initiatives translate the need for a common terminology and classification information system to reach interoperability thus reducing loss and costs of information throughout construction design projects.

[2] Commonly known as IFD- International Framework for Dictionaries

Portugal has a population of about 10.627.250[3] and a 125.000 million Euros[4] GDP, of which 34.400 million Euros (28% of the GDP) derives from the Construction Industry. The economic world crisis initiated in 2008 has reduced these numbers, especially in construction, since that has been, along with the real-estate industry, one of the most affected sectors. It is expected that there will be an enormous decrease of Portugal's GDP for 2012/13, also involving the construction industry. So, there is also the concern of making this industry more effective and competent to face up to forthcoming years, increasing its productivity.

At present in Portugal, procedures for gathering construction project information as well as coordinating and communicating the information amongst all stakeholders involved in the process, are extremely bureaucratic, confusing and awfully time-consuming. The problem has been exacerbated by the increasingly complex and large nature of construction project designs with a large number of participants. There is currently a lack of a systematic approach and system that can effectively manage all information concerning construction projects design data to ensure a faster and more efficient and transparent process. This is believed to be one of the main causes of problems regarding project performance e.g. delays in construction, misplacement of information and increasing costs. These problems are not of course exclusively the result of poor coordination information as the construction industry is afflicted with many other problems, yet this is considered to contribute heavily to them.

These situations are serious and felt on a daily basis by stakeholders engaged in the project and construction field but it is not a recent problem, Monteiro reported the exact same issues back in 1998, in his thesis. The researcher's own background as an architect working in Portugal, and thus having to face the described situation

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[3] INE (Portuguese National Statistics Institute) in 2008
URL:http://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0000611&selTab=tab0

[4]Last data from 2008/09 in AECOPS report published January 2010 in
URL:http://prewww.aecops.pt/pls/daecops3/get_barometro, the data presented relates to 2008

every day, was the motivation to carry out this project, in the belief that something should and could be done to improve the current situation.

Two main problems, as well as a secondary one, have been identified.

The two main problems are:

- Portugal lacks the use of standards and a system of classification applied to the construction industry and, most importantly, it lacks a comprehensive system to manage and store the enormous amounts of data created during the design project life cycle.
- The lack of information coordination, in common semantics/language for effective communication among the stakeholders.

The secondary problem is:

- Portugal practitioners are aware of existing Information Technology (IT), classification systems, standards and technology available for collaborative work, but they have difficulty in applying it comprehensively.

Consequently:

- Stakeholders involved in the process do not have a complete understanding of which information goes where and how it can be contextualized, and later on used, on a regular and common basis.
- Where information systems regarding different areas exist, there is no report of their application. It is therefore difficult to keep everyone involved in a project informed about the status of every undertaking, and yet the underlying information needs to be addressed, used and communicated by all the stakeholders.
- Problems in project performance abound, e.g. extreme delays in construction, constant loss of information, duplicated information and

deficient, or at times inexistent, access to information concerning the whole process of a project.

- The whole process is extremely time-consuming, which results in higher costs for the client.

Context of information is a fundamental requirement for human-based knowledge exchange. At a human level it is essential that people involved know what data needs to be in such a system that can store, manage and re-use the information, without duplicating or fragmenting it, hence originating an adequate resource use. There is also a need for storage and effective use and retrieval of the information.

In efficient storage, use and re-use of data by all stakeholders in the process and life cycle of a construction design project, data sharing is of most importance. Yet there is a need to go beyond classification systems. A data management system that not only incorporates the classification system and standards, but also, and most importantly, effectively manages the undertakings of a construction project - from the moment that the petitioner initiates the project to the moment its construction is finished, and the guarantee to retrieve all necessary data for further use.

There is also the need to understand project design process and existing legislation that applies to project development and delivery in Portugal. This was thought out after the survey analyses and the semi-structured interviews had been conducted, as most respondents stated the need to engage in a different process when the state is the client, since that identity has a set of rules by which teams have to obey. Although rules differ somewhat when the state is the client, in terms of information classification, the project process itself does not differ much.

The most common life cycle (procurement process) of a construction project in Portugal, is preceded by the following identified actions:

- Hire the design team or a developer company to manage the whole process

The designer/developer then:

- Consults legislation that applies to the project. Regulations applicable are dependent on the design process and the project's nature, regarding all its characteristics, such as physical location[5]. It is also worth mentioning that the sources of these regulations are not easy to access and only a few are organized as databases and make use of a common language. Simultaneous designers must seek other procurement methods concerning other aspects of the design process, such as materials specifications, for instance.
- Design the project
- Project is delivered to the authorities in order to obtain a building permit.

At this point, the municipal authority should:

1. Evaluate the project, and check if it needs to be assessed by other government authorities, such as EP and CCDR. If so, it should then:
2. Send a hardcopy of the project to all other institutions that may be involved in its assessment;
3. Once all involved institutions have given their own appraisal of the project to the Municipal authorities, the latter will contact the petitioners informing them if the project has been approved, and if not, inform them of the necessary changes and conditions for its approval.

Parallel to this, the petitioner/developer has to bridge between the local municipal authority and the national tax department, to ensure that all different taxes

[5] For instance, if a project is to be located in land bordering a national road, the project has to take into consideration the regulations of *Estradas de Portugal*, the Portuguese institutions responsible for the management of all affairs related to national roads.

of project implementation are paid for. Only then will the building permit be issued by the Municipality. The project will then go for construction. Commonly, however, it is the designers themselves that:

1. Disseminate the project to the different government institutions involved.
2. Keep a close track of project steps, and pressure authorities to move it along the bureaucratic process.

Otherwise, the project will most likely lay forgotten at someone’s desk and in fact, often the municipal authorities ask for more copies of the project to replace those that have been lost.

It can take between 3 months to 9 years to obtain a building permit depending on the type of project, the Municipality and the other official authorities involved (semi-structured interviews and focus groups, 2011). Once the building permit is obtained, the project starts the construction process and other problems regarding data management may occur. The construction site needs permanent attention from all professionals involved, and coordinated access to information and communication with those responsible for the project - which often does not happen. After completion of the construction, authorities will check if everything complies with the project. Otherwise, designers have to present the final version of the project that was built.

Whereas part of the problem may reside in the fact that over the years the number of partakers in the process has increased significantly - which, given the poor coordination information, makes it harder to store and manage the information in order for everyone to access it, the main obstacle being the absence of a system that can effectively manage all information concerning construction projects to ensure a faster and more efficient and transparent process. Otherwise, any attempt of collaborative work between teams and authorities is automatically undermined. Also, the use of a standardized common language would most certainly result in improved and enhanced interoperability between design teams, developers and authorities.

This research intends to ascertain the requirements that a system for the classification of information in the field should comprise: it seeks to identify its constraints, enablers and guidelines in order to guarantee its successful development and implementation in the Portuguese context.

1.2. Aims and objectives

The idea of this research is to explore the viability of developing a systematic approach to the coordination of information amongst multiple project stakeholders in the Portuguese construction project design industry. The aim is thus to develop a conceptual framework that provides guidelines that can be used to implement such a classification information system to structure and represent information to proper coordination and management. The definition of framework is a systematic set of relationships or a conceptual scheme, structure, or system (Jung and Joo, 2010). The rationale for establishing a framework is to guide research efforts, to improve communications with shared understanding and to integrate relevant concepts into a descriptive or predictive model (Kirs et al, 1989; Naumann, 1986).

Bearing this in mind, the core research question of this doctoral thesis is:

What sort of framework and guidelines are needed for the successful implementation of a classification information system for the construction project design data in Portugal, which is accessible to all stakeholders involved?

There are numerous stakeholders, activities and tools involved in the construction project design development. There is thus the need to understand which requirements should comprise the classification information system to be developed, which are its constraints and enablers, and establish guidelines for its development to be a success.

Following the aim of the research study, a number of objectives were set forward and accomplished:

i. To undertake a comprehensive **literature review** under the area of existing, known and applied classification information systems, standards and protocols for the construction project design data.

ii. To conduct a **survey** in Portugal on the knowledge and use of existing classification information systems/methods and standards.

iii. To **develop and validate a conceptual framework and guidelines** for the implementation of a classification information system for construction project design data.

iv. To make **recommendations** for the implementation of the framework in Portugal and further work.

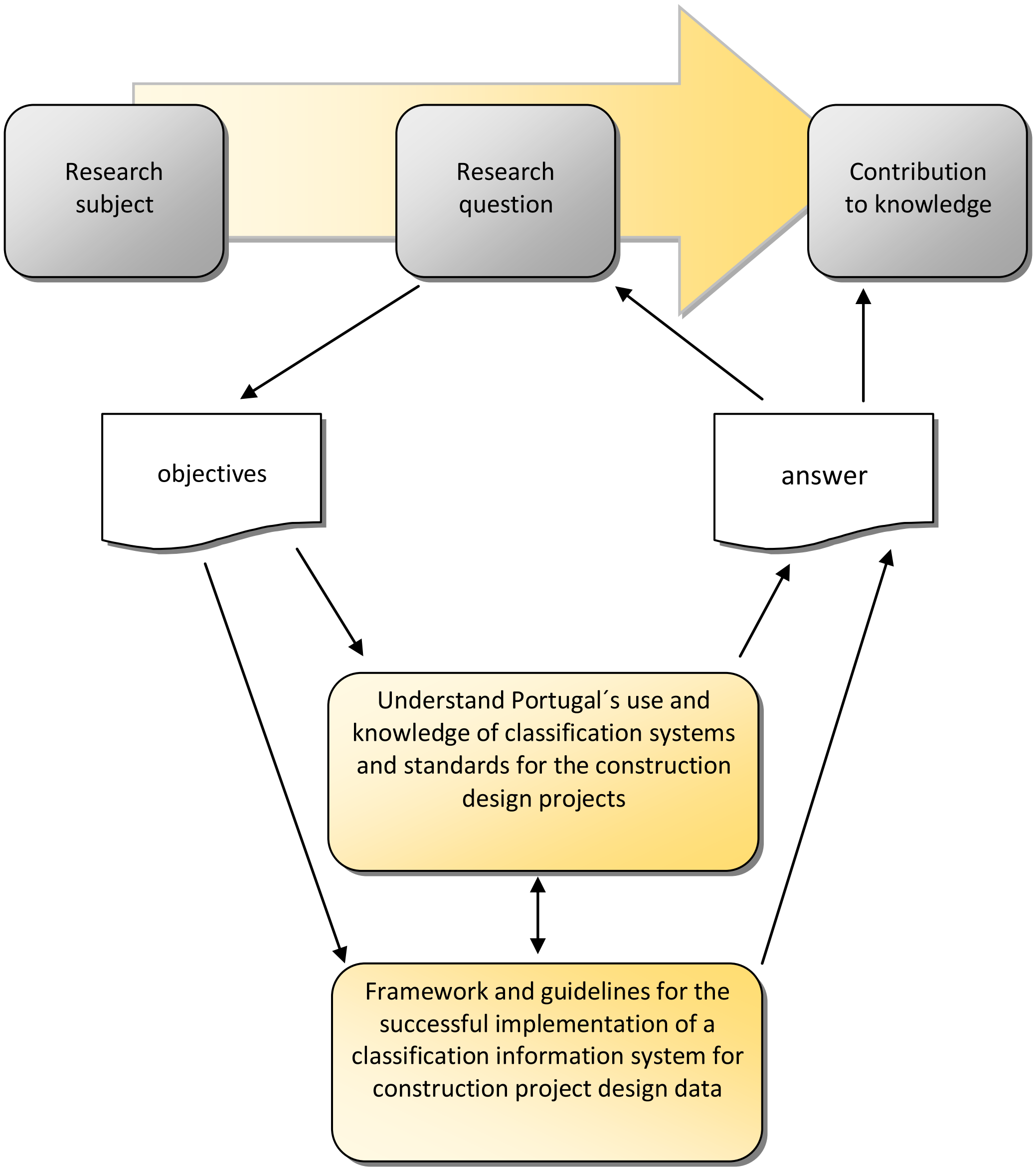

Figure 1- Objectives Diagram

1.3. Relevance of the Research Project

Information coordination in the construction industry has become of most 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, and international trading and globalisation. These factors combined together subsequently result in the need for information coordination and protocols for communicating information both at national and international levels of representation and understanding.

In fact, throughout the data gathering phase (exploratory phase), speaking with fellow colleagues - architects, engineers and owners/contractors - and during the semi-structured interviews and focus group discussions, all seemed to agree on one issue: if Portugal had a classification information system for construction design projects that was recognized by all stakeholders involved in the process, communication and collaborative work would substantially improve. Most seem to think that miscommunication of information remains a big issue in this industry and one that should be addressed properly.

During the initial phase of this research project, exploratory interviews were also conducted with two British practitioners working in the field in the UK. This was useful in order to establish a parallel with the Portuguese reality. The British construction sector has been criticised for having wasteful processes, unsafe working practices and less than satisfactory environmental awareness (Latham, 1994; Egan, 1998). But the problem previously outlined is not unique to Portugal or to the UK. Other countries experience similar situations. Elsewhere in Europe and overseas, standards and classification schemes for the construction industry have been thought-out, and effective ways to implement them are being developed and experimented with (see for instance ACBINZ- 1997 for New Zealand; NICSCCR 1999 and 2002 for Singapore; RIBA 1997 and Ray Jones & Clegg 1982 for the UK; and OCCSnet

2005 for the USA) . It was thus thought useful to look at how other countries have dealt with the issue and which solutions they have sought.

New Zealand, Singapore, the UK and the USA are some of the countries that have been working on steps to solve the problem of storage, management, reuse and use of information in the construction industry. The first step taken by all was to create standards to address problems resulting from lack of a common language and classification. The use of standards is expected to result in the production of data in a unified way. On the other hand, one could question the need for a classification information system nowadays, with all existing software and informatics systems in place in the construction industry. Yet, several facts justify this need:

- The direct crossing from the "design" by hand and collecting all information required for a design project, to computerized design work and organization. The change was made but the methods remain the same, generating confusion and misunderstandings.
- The increased multidisciplinary teams involved in the process, having to work collaboratively in an operative way, thus effectively managing all information produced and gathered to communicate within and between them.
- The increased range of materials at the designer's disposal to use in projects need to be detailed as to avoid misunderstands on site.
- It was identified by all involved in the study that the way information is gathered and produced in the phase of the design project in construction is the main source of problems that arise during and after the construction.

Recognizing and relating 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 modelling" (BIM) technologies, "Computer Integrated Construction" – CIC (Boddy et al, 2007) and construction practices have to be taken into consideration as they increase opportunities for gathering, exchanging, and archiving all information, but also raise problems due to its usage.

A computerized era cannot translate into a “messy era” in terms of information management. Stakeholders need to be accurately informed in order to make wise and cost effective decisions. For this to be a reality it is necessary to understand both the difficulties faced (constraints) and the existing opportunities for improvement (enablers) that might influence the development and implementation of such a system.

1.4. Methodology

This project was designed having in mind the establishment of requirements that a classification information system for the construction design project industry in Portugal should comprise. To accomplish the objective, a methodology was thought out (see Figure 2, pag.14) which was changed and adapted following the development of the research findings, specifically after further literature reviews and the analysis of data from the survey questionnaire.

From the initial literature review on existing classification information systems and standards and protocols for the construction industry in Portugal and elsewhere, it was not clear what the field reality was. To gain a broader knowledge, a survey, by questionnaire on the described issues, was conducted in Portugal to collect quantitative data and to understand the phenomena at hand, thus supporting further developments of the research.

The findings of the survey raised further questions that needed clarification. A set of semi-structured interviews was developed to shed some light on what practitioners within the different construction project design fields believed to be the requirements for implementation of a classification of information system and to better understand how they produce and classify information at present.

The interviews also proved to be very useful in identifying constraints and enablers of the framework development and implementation. Subsequently, the requirements for the conceptual framework were developed and two focus groups were conducted amongst practitioners from architecture and engineering offices, to test and validate the requirements and further necessary developments.

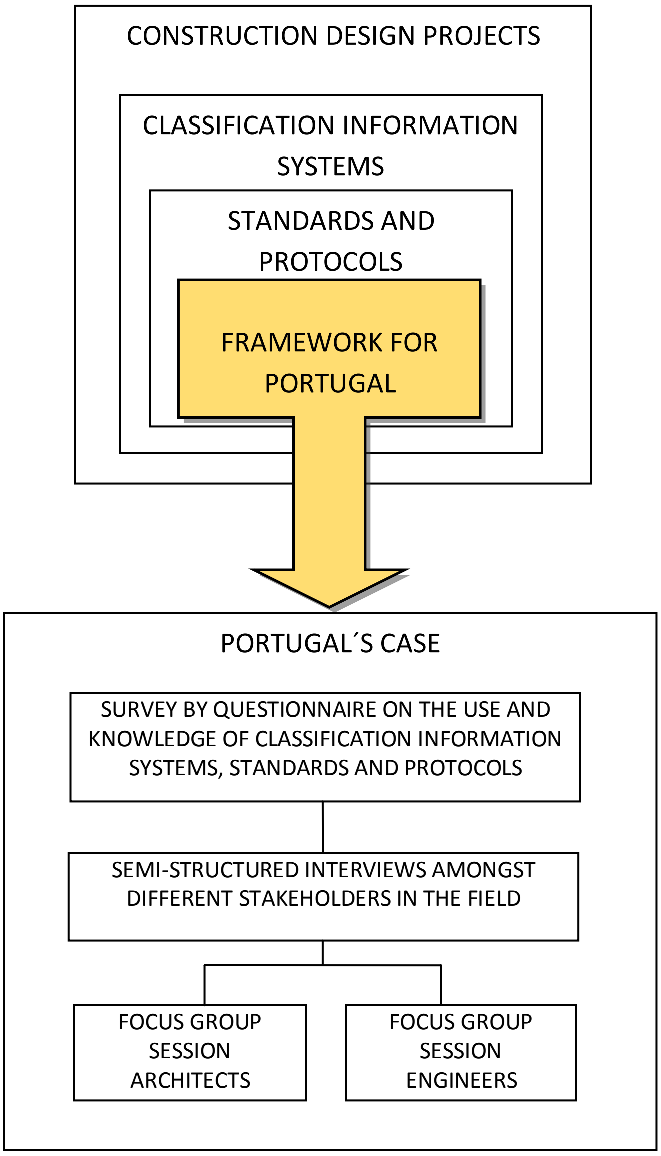

Figure 2- Scope of the Study

1.5. Structure of the thesis

This thesis is organised into seven chapters and several supporting appendices. The chapters are ordered in a manner that reflects the above outlined research methodology:

- Chapter 1: Introduction
    - Provides the context and drive for the research study, its aims and objectives, as well as a brief sketch of the methodology adopted to achieve them.
- Chapter 2: Classification of Information Systems, standards and protocols for communicating information
    - Underlines existing significant initiatives regarding classification of information for/in construction projects, their background, development, use and implementation. This chapter thus presents the most significant findings arising from the literature review undertaken throughout the project.
- Chapter 3: Research Methodology
    - Outlines the reasoning behind research methodology undertaken in this project, its approach and methods: the survey questionnaire, the semi-structured interviews and the focus group selection.
- Chapter 4: Collection and analysis of quantitative data
    - Details the survey questionnaire on the knowledge and use of existing Standards, Procedures and Classification Information Systems for Construction Projects in Portugal. It also presents the analysis of the survey data and the main findings.

- Chapter 5: Collection and analysis of qualitative data
    - Presents analyses and discusses the qualitative data gathered during this project, which served two purposes: to explore practitioners' views on the subject at hand and validate framework requirements. The first section is focused on semi-structured interviews as a means to better grasp the reality in the field. Their content analysis is presented along with the main ideas that derived from it. This section of the qualitative data collected is part of the exploratory phase of the study. The second section presents the focus group sessions carried out to validate the framework and to identify further constraints and enablers.
- Chapter 6: Framework Development
    - Presents the culmination of the work undertaken: the conceptual framework for the development and implementation of a classification information system to construction project design data in Portugal **- FCI**. It details its components: constraints, enablers and guidelines.
- Chapter 7: Conclusions and Recommendations
    - Depicts the conclusions of the work undertaken and further recommendations for possible improvements in the classification of information for construction design projects in Portugal.
- Appendices
    - Comprises supporting information for the arguments developed in the chapters. Information included here is considered of utmost importance in the explanation of project development but its inclusion in the main body of text was thought to disrupt the flow of information.

1.6. Conclusion

This chapter provided an overview of the area of research in this project. The reasoning for the research study was described; the problem of information management felt on a daily basis by practitioners working in the field, as well as its context and implications. The research problem and objectives were discussed forming the development of a novel contribution to knowledge a - **framework for classification of information of construction design projects - FCI.** An outline of the methodology employed throughout the process was provided, and finally, the thesis structure was presented.

The next chapter will draw on the review and synthesis of relevant literature, providing the theoretical background to this research project.

2. CLASSIFICATION INFORMATION SYSTEMS, STANDARDS AND PROTOCOLS FOR COMMUNICATING INFORMATION

> Without classification, there could be no advanced conceptualization, reasoning, language, data analysis or, for that matter, social science research.
>
> Bayley 1994:1

As mentioned previously, being an architect working in the field was what drove the researcher to embrace this problem and contribute to its solution. The initial **literature review** covered existing classification systems, standards, taxonomy, terminology, ontology, nomenclature, thesaurus, catalogues and library databases, resource management, collaborative working and project process and IT tools. It was crucial to identify similar systems that exist and/or are being developed and applied throughout the world to respond to this problem and identify existing gaps. The literature review was an ongoing process throughout this project and a summary of its most important findings is presented here.

Therefore, this chapter focuses on existing/developed classification information systems, standards and protocols for communicating information regarding construction projects. They are considered together as they are part of the whole approach to effective production and management of information in the construction industry. From the most important subjects studied to understand this issue, the selection presented here comprises those that contribute the most to the development and implementation of the **FCI - framework for a classification information system** to be developed and implemented in the construction and design project in Portugal.

2.1. Studied classification systems and protocols for communicating information

As expected, the literature review revealed that the problems this thesis is addressing are not exclusive to Portugal, but rather are recognized issues in Europe, U.S.A.[6], Australia and Asia. From the studied initiatives encountered during this research, only the most recognized and mentioned in the literature are presented in this chapter. It is important to explain that it would not be possible to mention all, so a selection was based on their importance to this project. The chapter also describes their relation and application. The selection comprises the following studied classification information systems:

- **CI/SfB** - Construction Indexing Manual (RIBA, 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),
- **MasterFormat** (CSI, 2004),
- **OmniClass** – The Overall Construction Classification System (CSI, 2005/6),
- **BS ISO 12006-2:2001, Part 2:** Framework for Classification Information (BSI, 2001).

From the conducted literature review these seven stood out as being acknowledged by stakeholders throughout the globe in the construction industry even if their application was not always clearly detailed.

[6] U.S.A.- United States of America

Between these seven a thorough comparative analysis table (see Table 1 pag.21) was elaborated based on their strengths and weaknesses. The complete comparative analysis table can be found in Appendix 1 of this thesis.

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 its 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.
Weaknesses	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 misinterpretations. 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.

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

Of existing protocols and procedures for production information and management studied, two are included in this section. This choice reflects the importance of these protocols in existing studies and literature:

- **CPI** - A code of procedure for the construction industry (CPIC, 2003)
- **AVANTI** programme (URL:http://www.avanti-construction.org/)

The code of procedure for the construction industry developed under CPIC, Construction Project Information Committee, *A code of procedure for the construction industry* (CPIC, 2003), is considered as it entails the principles of previous standards and procedures as, BS 1192 Part 5:1998, *Construction Drawing Practice – Guide for structuring and exchange of CAD data* (BSI, 1998), *Production of Drawings - A code of procedures for building works* (CCPI, 1987a), *Project Specification – A Code of procedure for building works* (CCPI, 1987b).

The other initiative is the *AVANTI programme*, which intends to develop collaborative work within the construction industry. It has produced, and made available from 2002, practical working documentation material to enhance collaborative work amongst different field teams in the construction industry. From the available material, three toolkit guides (2005a/c/d) are outlined, to enable teams to establish methods and procedures in their work*: Design Management Principles* (2005a), *Project Information Management and Standard Method & Procedure* (2005d), and *Object Modelling Guide* (2005c). It has also been made available through the Internet summaries of work in progress, collaboratively with companies in specific projects (2005b). Since 2006, the Avanti Project has been developed by Constructing Excellence.[7]

This covers almost all the important aspects to be addressed in a construction design project in order to guarantee good production of information and

[7] Constructing Excellence in the Built Environment available: URL:http://www.constructingexcellence.org.uk/

communication between all involved in the process. The next sections of this chapter are devoted to explore, in more detail, the classification systems, protocols and standards reviewed, before addressing the implications for this project.

2.2. Classification Information Systems

Classifications are language systems used to communicate and process phenomena in a static method. It allows practitioners to order and catalogue data in homogenised categories. Nomenclatures and hierarchic codes are used to simplify/clarify information organization.

There are three main types of classification systems (Bertalanffy, 1975):

- Enumerative: generates an alphabetical list of subject headings, assigns numbers to each heading in alphabetical order.
- Hierarchical: divides subjects hierarchically, from general to specific.
- Faceted: allows the assignment of multiple classifications to an object.

Examples of important contributions or existing classification systems for the problem previously outlined are now detailed.

2.2.1. CI/SfB, Construction Indexing Manual

The classification system most widely used by the construction industry throughout the world is the *CI/SfB.* It has been in operation for more than 37 years and is the industry standard. This indexing manual for construction products and elements was developed by Alan Ray-Jones and David Clegg, SfB Agency UK and published by the Royal Institute of British Architects (RIBA). The Indexing Manual was based on the original *SfB (Samorbetskommiteen for* Byggnadsfrsgor) from Sweden, in place for more than 50 years (Maritz et al, 2005).

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

> Every practitioner has a collection of incoming technical information and has to organise the project information he produces, to a reasonable standard at a reasonable cost. (*CI/SfB*, 1976:10)

It is a manual for project information coordination and it is used to sort out most office libraries and in production information in the UK. It can be used as a checklist for collection and storage of briefing information and outline technical specifications, which are useful in the initial cost plans for the approval building regulations. This provides a satisfactory means of structuring sets of detailed design drawings, working drawings and specifications. It also entails tables to represent the physical environment, elements, construction forms, materials and activities.

The management of general information usually involves the classification, filing, indexing and re-use of complete documents, not to use in one particular project but that can be used in any project and accessed by anyone. The *CI/SfB* can also be applicable in any office library as a classification system.

A simple framework for information versus a more detailed framework, resulted in the acknowledgement by the CI/SfB, which considered operating at varying levels of size and complexity:

> The best general advice that can be given is always to use it in the simplest appropriate way, applying the smallest range of divisions which will identify information sufficiently for the purpose required. This will mean that some applications use it in greater depth than others. (*CI/SfB*, 1976:11)

It is a handbook for project information coordination and is used for the arrangement of most office libraries and for production information in the UK.

Subject headings that make up the system are given in tables covering: the physical environment, elements, constructions forms, materials and activities. Panels giving only the main headings introduce the detailed content of each section of the table. The amount of classification and coding should always be kept to a minimum.

The CI/SfB has its application in both Project Information and General Information. In terms of Project Information, a check list for collecting and arranging briefing information can be arranged according to Tables 0 and 1. After that, an outline technical specification can be drawn using Table 1, detailed design drawings and working drawings can be arranged according to Table 1 also, specifications are prepared by following Tables 1 and 2. This process can be of most importance in planning the design:

- Outline technical specification
- Design sketch
- Initial cost plan
- Provisional list of drawings required
- Provisional list of annotations for drawings

Production of drawings can then be carried out according to a simple drawing system:

> "Structured", "systematic" or "coordinated sets, on the other hand, aim to provide a complete and readily-understood framework for information, with separate drawings for defined subjects" (*CI/SfB,* 1976:132)

It suggests a division of information between drawings. They are to be subdivided by scale, from the overall view of the whole project which means a smaller scale to a larger scale (detailed drawings). The system consists basically of three main series of drawings: Location of drawings (L series), showing the overall arrangement of the project and the geographically location of drawings; Assembly drawings (A series), showing in-situ assembly work which is not necessarily limited to one specific location, and Component drawings (C series), showing shop work, showing unfix components these drawings can often be re-used in other projects without much alteration. The drawing system can be used by any office according to their specific requirements and with simple use of Table 1. After the production of a coordinated set of drawings, and the initial cost planning, the calculation for the final cost is easier and more effective.

The management of general information usually involves the classification, filing, indexing and re-use of complete documents, not to use in one particular project but that can be used in any project and accessed by anyone. The CI/SfB is also applicable in any office library as a classification system.

The user must establish an order of priority, between buildings and elements and a rule that has to be followed in order to obtain consistency throughout the process of filing, storing and retrieval of general information. Using the same tables that are used to produce structured sets of drawings one can classify all relevant general information relevant to projects.

A problem with the use of the manual, when filing by the order of the tables 0-4, is that it goes from the particular to the general when it should be the exact opposite, following the average project process. On the other hand the system is very flexible and the order of the tables can be changed, meaning an inverted order can be used to show general before particular.

The classification of general information using the CI/SfB is in reality quite simple. Yet, the system was created before the existence and use of current technologies, including the simple use of a computer on a day-to-day basis when working in the construction and project process.

According to participants of this research project, this is the only system being considered in (some) universities in Portugal.

2.2.2. EPIC - Electronic Product Information Co-ordination[8]

This initiative started in London in 1990, when representatives of ten European countries met to discuss the need for co-operation between European product information houses on the development and operation of databases of building product information. The meeting was organised by RIBA. Since then the project has been carried out by elements from WTCB/CSTC[9] in Brussels, RIBA Information Services in London (UK), NBS[10] Services, Newcastle upon Tyne (UK), Swedish Building Centre, Stockholm (Sweden), CSTB[11], Sophia Antipolis (France), and STABU,[12] Ede (Netherlands).

EPIC was designed to be a common reference system to the European construction industry for access to product information across national boundaries. The first version was edited in 1994 and it is a system based on the *ISO 12006-2* framework. Increased Internet usage and expansion of world trade has widened the horizons of EPIC and the acronym was changed from European Product Information Co-operation to Electronic Product Information Co-operation, emphasising more world-wide electronic usage of systems.

It provides a common basic structure for product databases, which can be used as an international communication language between national databases. Its focus is on the definition of a common set of construction product groups including notations in order to facilitate the transfer of data between computerized national and/or distributed databases and to harmonize such patterns.

In the EPIC system, users' needs define the functions that are to become the content and function, and this is the primary criteria in the construction product grouping scheme. The existing fifteen sectors are subdivided to the detailed level that

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[8] EPIC at URL:http://www.epicproducts.org

[9] WTCB/CSTC Belgian Building Research Institute

[10] NBS- National Building Specifications

[11] CSTB- Centre Scientifique et Technique du Bâtiment

[12] STABU foundation (Bouwbreed informatiesysteem)

is required for an international agreement. Notation at a divisional level consists of a single capital letter (A to Q) with a single digit at the level of subdivision and each division can be used as a stand-alone table for a particular application.

EPIC's grouping scheme entails definitions for a clear understanding of series of product groups, which are: general product groups, detailed product groups and component groups.

> Product database providers have the freedom to assign their database information to the defined levels of product groups according to their specific needs, but in such a way that a particular product occurs only in one product group. (*EPIC*, 1999:5)

Product properties specified for construction products provide professionals with the means to define the qualitative aspects of construction products, e.g. designed use, appearance. This gives a more detailed product specification allowing a parametric searching. Enumeration of all product attributes would lead to an ostensibly endless list, which would become impractical. As a result EPIC concentrates on *"relevant product group attributes*" (EPIC, 1999: 4) allowing national members the flexibility to add more attributes. This is possible because its attributes work in two separate letters/tables.

Its main focus is on product grouping (identifying and organizing) and attributes. The main reasons for setting up EPIC are flexibility and user-friendliness; flexibility in defining product groups and relevant attributes, and in allowing various degrees of detail, according to specific user needs and user-friendliness in introducing more practical terms rather than abstract functional terms.

2.2.3. CAWS- Common Arrangement of Work Sections

CAWS is intended to be the UK system of classification of work sections for building work. Its practice resides in arranging project specifications and bills of quantities. This working convention was first published in 1987 and it was designed to promote standardisation of, and detailed coordination between, bills of quantities and specifications. It was developed under CPI – Coordinated Project Information enterprise and has been used for the preparation of NBS -“National Building Specification”, the NES – “National Engineering Specification” and the “Standard Method of Measurement of Building Works, 7^{th} edition”. It has been used for the preparation of building project documents for the past ten years, during which period it has gained vast notoriety and use (Caws, 1998).

CAWS is supposed to be used in association with the *UNICLASS* classification system for better production of information and its retrieval in the construction industry but it is presently in the system as Table J-“Work sections for buildings” which is bound to cause confusion.

Its aims are:

- The effective coordination between drawings, specifications and bills of quantities. This leads to a more effective reading of all relevant documents, for an effective estimation and realization of the work to be built.
- To provide easy access to location of relevant information, since the use of standard specifications sections enables better consistency of technical content and description.
- To reduce error and discrepancies between documents, ultimately leading to reduced repetition and documents being simpler to prepare and use.
- To enable contractors to divide the project information in work packages, so there is an easier distribution of information.

CAWS defines a collection of common concise and specific sections that are identified and described in order to ensure that gaps between sections are inexistent. It has about 360 work sections that were grouped according to:

> Responsibility for design and performance, methods of working, related to sub-contractor practice. (*CAWS*, 1998:10).

The sections vary according to scope and nature, as existing building materials, products, systems and sub-contractors. They represent the sum of chapters of specifications of bills of quantities that reveal types of construction activities, with skill and knowledge and the use of specific tools for income of products and labour, adding the responsibility for work adequacy of trades and sub-contractors. These are the mains principals for the use of the division of work sections for procurement intent.

The skill is related to the resources being used (input) and the parts of buildings being constructed (output) (Figure 3).

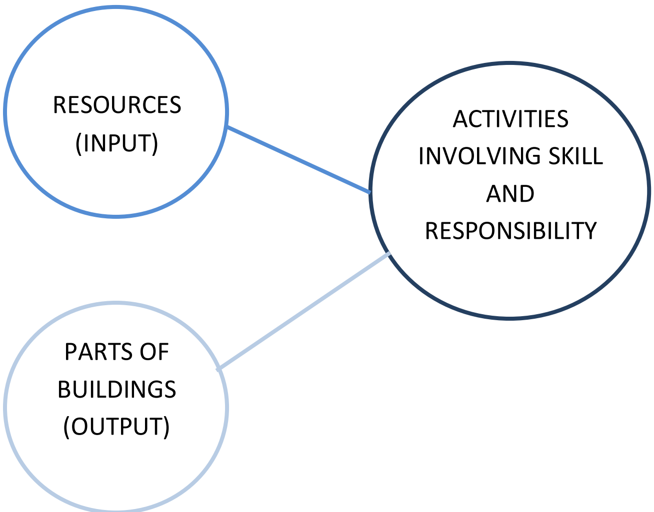

Figure 3- Relations between the resources being used and the parts of building constructed. Source in CAWS 1998:11

One can conclude that work sections involve resources being used and parts of the work being constructed including their purpose, which explains the dual concept of work sections. The work sections were named in relation to working practice industry. They are defined by resources available and used, and by their final work product. To maintain the balance between them, in order to use the manual, the outputs and inputs of each section must be understood. The manual comprehends three levels: level 1- Group, level 2-Sub-Group and level 3: Work Section.

> An overriding consideration is the need for simplicity, particularly that the section numbers should be short and easy to remember. (*CAWS*, 1998:13)

It is almost impossible to use titles that are brief, comprehensive and concisely represent the scope of the work sections, so there is a need for commitment. As such the reference should be done according to the work sections description.

The use of CAWS varies in range regarding project dimension. In sections described with considerable detail, when used on particular projects, the collection coverage is less than the section definitions. When working on small projects there is a tendency to arrange certain sections together, this is not advised though, as it originates difficulties in finding the often-elusive sundry items. It is advised to follow the standard sectional scheme in almost all circumstances, even if some sections will only include one entry or one article.

2.2.4. Uniclass, Unified Classification for the Construction Industry

Developments in computerised technology and IT (Information Technology) resulted in the need to update *CI/SfB*. As a response to this need, the CPIC in the UK, has developed and published the "*Unified Classification for the Construction Industry – Uniclass."* It is a classification scheme/index system for the construction industry that aims at organising library materials and structuring product literature and project information.

Uniclass, was developed to unify existing classification systems used in the UK and is based on four other important schemes: *CI/SfB* (Ray-Jones & David Clegg 1982), *CAWS* (CPIC 1998), *CESMM3 - Civil Engineering Standard Method of*

Measurement, (ICE 1991) and *EPIC* (CPG 1999). It is a unified classification that comprises almost all studied schemes and it also includes new subjects such as construction products and a project lifecycle classification, which is of most importance nowadays.

It is a classification scheme to organise library materials and structuring product literature and project information. It is intended to supersede the *CI/SfB* classification system due to international developments and changes in technology, construction project practice and process, working as a unified system for different scope existing systems and making notation coding easier and simpler. Its strength lies in the possibility of being used by several practitioners of many disciplines and it is particularly useful where it is designed to arrange files in computer databases, which *CI/SfB* did not enclose.

The tables in *Uniclass* include detailed subsections 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 contexts, 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* and *CSMM3* codes. It allows easier shortening of the notation because numbers are not filling out with trailing zeros to create a fixed number of digits. This seems to be a better solution for computerized organization systems but might be somehow confusing for filing order. It also provides guidance for classifying the scale/complexity of construction works and classifies documents, from small to large complex collections.

As in *CI/SfB,* it is of most importance to use the system at the simplest level appropriate for the user's needs. The most important field considered in *Uniclass* and not in *CI/SfB,* concerns retrieving information classified by the system and its use with computerized databases:

> The system is compatible with information held on computerised databases, and any existing database can simply have a field added to accept the UNICLASS code, e.g. Microsoft Access, codes from each item in the database can be assigned using UNICLASS manual and then added to the database. Simple codes from the system will automatically sort in the correct UNICLASS filing order." (*UNICLASS*, 1997:19)

It provides a means to understand storage of technical information on sorting combined codes in the correct *Uniclass* 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 industry today.

2.2.5. MasterFormat

MasterFormat, was produced by *CSI-Constructions Specifications Institute* with *CSC-Construction Specification Canada*. MasterFormat is a standard for organizing construction project information, specifications and written information for commercial and institutional building projects in the US and Canada. Although its original purpose when created in the early 1960s was the organization of the project manual, *MasterFormat* has been used for many years now to classify product information becoming the standard in the North America for this purpose (Johnson 2005).

MasterFormat is organized on the basis of work results, i.e. by how the work is done or by construction practice, i.e. how the project is put together. Significant changes in technology and construction practice, the increased use of databases, project-life-cycle issues, expansion to non-building types of construction, and flexibility for future developments, demanded a review of the standard. In November 2004, MasterFormat was updated and its structure was expanded from 16 to 50 divisions, in order to keep up with these new developments in the construction industry. The review intended to include new developments in construction, such as life safety, communication, information associated with engineering, green building and sustainability - all of which were rarely mentioned 40 years ago but are now of concern. Also, the massive amount of information generated for modern buildings have surpassed any system in place at the time.

> By following the MasterFormat numbering system, all members of a project have a standard way of communicating, which helps to ensure that requirements are being met. According to CSI, MasterFormat has a widespread reach, and it is used for more than 70 percent of commercial and institutional building projects throughout the United States and Canada. *("MasterFormat Gets an Extreme Makeover, in* [http://www.ihs.com] 2006*)*

The standard organizes information categories into divisions. Each division covers an aspect of a construction project, e.g. concrete finishes. Then, the user inserts it in the topic created for each specification. As it is a multi-purpose categorization system, it serves many facets of the construction industry. It provides a master directory of divisions, and section numbers and titles inside each division. This list is to be followed when organizing information about a facility's construction requirements and associated activities.

The aspects not favouring this system seem to be the fact that it does not establish design disciplines, trade jurisdictions, or product classifications and that there may be more than one logical location for many products, which leads to creativity in the process of classification information. Imprecise data filling is a major liability ([http://www.ihs.com], 2005*)*.

In its favour *MasterFormat* the CSI[13] and the IHS[14] invoke that the system has a structure that provides room and flexibility to accommodate future growth in construction materials and technology; that it is a flexible tool that can be used and combined in order to meet the users requirements and that it has been validated through more than 40 years of use. They also state that it offers the Facility

[13] CSI- Construction Specifications Institute

[14] IHS- Information Handling Systems

Owner/Manager the opportunity to create a database for use throughout the entire building life cycle, to provide the Designer/Consultant a meeting standard of practice and improved documentation organization and offer the Builder improved organization of cost databases, contributing significantly to projects' completion on time, within budget, to the owner's requirements. It is used by the United States Department of Defence as well as other government agencies and the AIA[15] also support its use.

2.2.6. OmniClass, The Overall Construction Classification System

The North American AEC Industry - Architecture, Engineering, and Construction Industry, has developed *OmniClass* formerly known as *OCCS, Overall Construction Classification System.* Its production began before 2000 and it 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, Virginia. 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.*

The first edition of the *OmniClass™, A Strategy for Classifying the Built Environment, Introduction and User's Guide* has been available since May 2006 on the Internet. The system resulted from the recognition of an important absence in the construction industry: an international standard related to the management of information of any built environment (Ceton, 2000). *Omniclass* is explained also as a response to the need for a coordinated classification system to organize the amount of data created during any built environment's life cycle, to coordinate multidisciplinary actions and people with the developments of design and web-based communicating systems, meets the need to keep all parties on a project informed at

[15] AIA- American Institute of Architects

all time, but lacks a coherent organizational structure and accompanying thesaurus, storage and effective use of any built environment information (Ceton, 2000).

> The construction industry has traditionally focused on organizing segments of construction information, one portion and one discipline at a time. Omniclass has entries to address all aspects of information collection, record keeping, and bidding and contracting requirements, and will serve to expedite the process of continuing facility management, all in one cohesive and realistic vision, enabling the unified storage and eased exchange of all of this information. (*Omniclass™, A Strategy for Classifying the Built Environment*, 2006:3)

Its concepts derive from standards developed by *ISO* 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[16], 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 a classification structure for electronic databases
- Organizing
    - Electronic and hard copy
    - Libraries and archives

[16] ISO TC- International Organization for Standardization Technical Committee
ISO SC- International Organization for Standardization Subcommittee
ISO WG- International Organization for Standardization Working Group

  - 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 extensible standard available to the AEC industry with full open exchange between participants in its development - its dissemination depends only on the industry, and it is compatible with international classification systems standards.

Omniclass 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 use by inheritance documents standards/schemes, which could lead to mix-ups. Furthermore there is interest shown by Asian countries in Omniclass™. Other systems frequently use alphanumeric coding which is not easy to use in Asian countries. Numeric coding does not present this problem, as it is universal; it is easy to expand the code using number combinations.

In the *Omniclass™* system, each table represents a different facet of construction information and can be used independently to classify a particular type of information, or entries from different tables can be combined to enable the classification of more complex subjects.

The *ISO 12006-2* standard provided the basic structure for information about construction, which is grouped into three primary categories: construction resources, processes and results, composing the process model divided then into fifteen suggested tables as a way of organizing construction information.

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 originate reports from all of them. The result is an information management tool that is flexible, rather than being a simple flat-file model storage of information (OmniClass, 2006).

Unfortunately, to date not all OmniClass tables are ready to use ([http://www.omniclass.org/index.asp] accessed in 2012). Other strengths that the system might possess are the fact that like Uniclass, Omniclass is compatible with information stored in computerized databases and the fact that is freely available to anyone, makes it stronger in dissemination.

2.2.7. BS ISO 12006-2:2001, Building Construction - Organization of Information about construction works- Part 2: Framework for classification of information (EU, UK)

As previously outlined, existing classification systems are based in frameworks, as is ISO 12006-2:2001. The ISO 12006-2 was prepared by the Technical Committee ISO/TC 59, *Building Construction*, Subcommittee SC13, *Organization of information about construction works*.

ISO 12006, Building Construction- Organization of information about construction works, consists of:

- **Part 2: Framework for classification of information**
- Part 3: Framework for object-oriented information exchange

Until 2001 there was almost no detail on international standardization of classification for construction, since classification of information varies from country to country. This separation occurs for many reasons; the first being culture, followed by legislation and many others. This results in each country developing its own methods for classification of information. ISO 12006-2 embraces many existing classification systems that were established since the first formal construction classification *SfB*. The general approach taken by these is that they organize things by some characteristic or aspect, which might be described as "views" or "facets".

The standard defines a framework and a set of recommended table titles supported by definitions and not the detailed content of these tables, and it is intended to be used by organizations that develop and publish classification systems and tables on a national or regional basis. It does not intend to nor provides a complete operational classification system. It identifies classes for the organization of information and indicates how they are related and so classification tables may vary in detail to suit local needs. It covers the complete life cycle of construction works from the design to production, maintenance and demolition in both building and civil engineering.

> Construction resources are used in or required for construction processes, the output of which are construction results. (*ISO 12006-2:2001,* 2001:5)

Framework basic process model:

1. Identify the life cycle stage of a construction entity once it affects the nature of the resources used, the type of construction process and the resulting state of the construction entity.
2. Production of construction entities as are Inception/Design, Production, Use and Maintenance, Decommissioning and Demolition.
3. Resources used are included in the design stage, design aids, the design brief, reference information and the designer.
4. Results obtained at various construction entity lifecycle stages.

In short:

> The process model categories of results, processes and resources provide a high level structure for the classes which are of greatest interest and importance in the organization of construction information. (*ISO 12006-2:2001*, 2001:6)

All construction entity lifecycle stages, all resources involved in each, and all results arising from it, have properties and characteristics. These characteristics are to be used in the subdivision of classes into inner levels of detail that specify requirements or organize a list of properties. The list of classes comprises construction results, processes, resources and characteristics.

The framework presents a diagram of classes and the general relationships between them, which can be very useful when trying to understand how classes and relations between them work in the construction information process.

Tables can be used independently or in combination with each other, according to need.

> Provided that each country uses this framework of tables and follows the definitions given in this part of ISO 12006, it will be possible for standardization to develop table by table in a flexible way; e.g. country A and country B could have a common classification table of elements, for example, but different classification tables for work results without experiencing difficulties of "fit" at the joints. (*ISO 12006-2*, 2001:9)

This is what any classification system nationwide should aim to provide: a common set of rules to be followed that allow for an easy cross referencing of information within the country and beyond national barriers, the standard aims to provide those guidelines.

2.3. Protocols for communicating information

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

This code of procedures endeavours to answer the problematic issue of deficient 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 work* (CCPI, 1987b).

The developments in the construction industry and the implementation of computer technology generate the need for a code that could present stakeholders involved with the means to improve the production of information. With developments in IT and the necessary actualization of recognised procedures the Code is predicted to have five years of service, after which it is supposed to be revised. It was developed under CPIC – Construction Project Information Committee and CPI and supported by the IT- Information technology Construction Best Practice and NBS-National Building Specification, UK.

Its object 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, opponent attitudes and practices which resulted in the lack of effective team work and the inadequate use of IT. According to the Code, 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 in identified groups, the key to a good arrangement is to keep it simple, regard an overall structure as simple and easy to use and memorise,
- Establishment of sheet sizes and scales:
- Organization of drawing numbers and titles,
- Drawing issue and revisions.
- Specifications and bills of quantities,
- Schedules of work.

In good production of information an essential part of effective production drawing resides in making the best use of CAD – Computer Aided Design. All the requirements above mentioned might be applied using CAD systems, as explained in the Code. 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 and the Code guides us through the steps necessary to achieve that goal.

2.3.2. 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 is part of the problem. Collaborative work needs improvements also.

Technology available for collaborative work has grown and become available in order to enable the construction industry to work collaboratively. The problem is that no one seems to know how to adopt and adequately use such technology. Users dealing with it on a day-to-day basis need help understanding, managing and correctly performing actions that result in good production of information. Improvements on costs, quality and responsibilities are expected results of these procedures. To address this problem the AVANTI programme[17] – 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.

> It aims to secure faster, better and more cost effective delivery of construction projects, from the concept design through detailed design and procurement to production. (URL:http://www.avanti-construction.org/ accessed in 09.2005)

Their primary subjects 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 effort is based on facilitating people to work collaboratively providing processes and adequate tools that enable collaboration, by mobilising existing enabling technologies. 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.

Its major strengths are that its support is available on-line, by handbooks, toolkits and on-site mentoring and that it is based on teamwork and access to a common information model throughout the project life cycle; and was led by a team of industry practitioners. This tends to result in improvements in business performance by increasing the quality of information ultimately resulting in predictability of outcomes and reducing risk and waste.

[17] Formerly in URL: http://www.avanti-construction.org/, accessed last on 09.2005, since July 2006 URL: http://www.constructingexcellence.org.uk/ceavanti/about.jsp

2.4. Frameworks and related existing standards

Existing classification information systems being developed, or already developed such as CI/SfB, Construction Indexing Manual (Ray-Jones & David 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), MasterFormat (CSI, 2004), OmniClass – The Overall Construction Classification System (CSI, 2006), BS ISO 12006-2:2001, Part 2: Framework for Classification Information (BSI, 2001), prove that there is a need to find an understandable method that may facilitate practitioners in the process of production, storage and retrieval of information regarding construction design process.

Other initiatives that have been, or are being, developed in European countries, include Holland´s STABU LexiCon[18] object library for buildings and housing since 1995, and Norway's BARBi[19], 1999, presently developing to ISO 12006-3, commonly known as IFD - International Framework for Dictionaries[20] and the efforts to develop an infrastructure for sharing interoperable and semantic flow of information on all levels in a building project - IFC and IFD integration (Bell, H., 2004). In Sweden, the original SfB Classification and Coding system and Byggandets Samordning Aktiebolag – *BSAB96* (The Swedish Building Centre, 1999), and also the work of Anders Ekholm and others in the development of theoretical foundations for analysing the structure of building classification systems (Ekholm, 1996), structuring properties of construction objects (Ekholm, 2002), and defining a concept of space for product modelling (Ekholm & Fridqvist 2000). His work also concerns ontologies (Ekholm, 1999), and the analysis of the possibilities to

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[18] STABU Bouwbreed Informatiesysteem, the foundation behind LexiCon

[19] BARBi or Bygg og Anlegg ReferanseBibliotek, is a project initiated by the Norwegian construction industry to establish a reference data library with a complete collection of all concepts and objects from the building construction industry.

[20] IFD started as a collaboration between The Netherlands and Norway, develop by IAI, buildingSMART, and ICIS members. In 2006 expanded to USA, Canada. URL:http://www.ifd-library.org/index.php/Main_Page

integrate the Swedish *BSAB* building classification system with the IFC (Ekholm, Tarandi & Thaström 2000) together with continuous work on classification information in the construction industry and standards coordination for classification and interoperability (Ekholm, 2005).

In Denmark, Bjorn Bindslev developed a variant of the original *SfB* and continued his work since 1960 towards the consistency in the presentation of data as the most important requirement for the full collaboration of the various parties in the building team and Rob Howard, with his work on the knowledge and application of classification information systems in the building industry in Europe (Howard & Andreson, 2001) with special interest in Danish developments (Howard, 2002). Other developments took place in Finland with *Building 90*, The Finnish building classification system (Building 90 Group, 1999) and in the UK that seem to provide some classification information appliances in the field. All these countries and authors have been, and still are, involved in developments of Information Foundation Classes (IFCs) and related projects.

Outside Europe a prototype for Construction Document Classification System – CDCS - was developed and its feasibility tested in the U.S.. The authors of this system describe and evaluate a methodology for customized hierarchical document classification as they defend that:

> automated document classification methods can be used to improve information organization and access in current information management systems as well as being a foundation for integration of construction documents in emerging model-based systems. (Caldas & Soibelman, 2003: 398)

They experimented with different methods that could be used and applied in each phase of the document classification process.

The Japanese approach JCCS - Japanese Construction Classification System was also studied (Terai, 2008). It is intended to be a standard terminology system for classification – IFD, to enable the successful implementation of an ICT oriented construction project called the Construction CALS/EC,[21] initiated in 1997 by the Ministry of Land, Infrastructure and Transport of Japan to improve cost-effectiveness in the construction industry in Japan. It has been developed on the basis of International Standards ISO 12006-2 and ISO 12006-3.

In search of a common terminology to reach interoperability, is also Brazil, with CDCON (Amorim et al, 2007) a government-sponsored project whose

> objective is to consolidate a terminology with associations and logical relationships between terms, defined by the approach to construction processes. (Amorim et al, 2002:5)

In Portugal, although some IFD initiatives of "buildingSMART"- IAI, have taken place in Lisbon,[22] not much attention has been paid to these issues by practitioners in the field. Monteiro (1998), in his thesis on *Classification of information in the construction Industry - Perspectives and Paths,*[23] reinstates the fact that although the subject has been considered for a long time (since new technologies such as computers became mainstream), it is still a problem in the construction industry in Portugal. In fact, the survey undertook in context of this research project suggests the same, revealing that ten years later the same problem subsists when speaking about information coordination and management in the construction industry in Portugal.

With the increased use of modern communication and technologies, the electronic exchange of information about the building environment also increased and developed nationally and internationally, so the organization of information has become of utmost importance in the process. There is also the problematic issue of existing IT technology for exchanging information within teams in the construction project industry. Nowadays there are many different commercial products that certify the exchange of information amongst different field teams working in the whole-life

[21] CALS/EC Department at: http://www.cals.jacic.or.jp/english/gaiyou/index.html

[22] The launch of IFD Library - International Workshop held in Lisbon in September 2006

[23] Original title: *Classificação da Informação na Industria da construção, Perspectivas e Percursos*

cycle process of project construction, although not all are effective or recognized by practitioners involved.

Web-based construction information systems and their prerequisites have to be taken in to consideration (Scott et al, 2003) and studies carried out in the United Arab Emirates (El-Saboni et al, 2008), concerning the impact of electronic communication management systems in construction projects have also been found enlightening on the search for a more proficient way of exchanging and managing information.

In order to guarantee effective information exchange at this level there is the need for a clear terminology so that all involved might communicate. Some argue on the use of blogging systems to enable collaborative work (Wang and Xue, 2008) others emphasise the "*value of adopting alliance-based modes of operation*" (Rezgui et al, 2011:2).

Also when speaking of information exchange within different practitioners that are part of the design and construction process, one has to take into consideration the existing standards in the field. Examples of this are CAD standards (Howard and Bjork, 2006) that were created and are used to produce, maintain and share CAD data/drawings in the electronic environment. The ideal situation would be that all companies and authorities involved in the construction industry could share a single CAD standard method.

The use of classification systems, standards and protocols is of vital importance. They are used (or should be used) to represent information hence they provide: common language, syntax and semantics to share information between computer systems (integration), and different parties. Although this seems to be understood within some working groups that are developing them across the world, and making efforts to implement them, its use is not all that straightforward for common users.

The British Standards Institution – BSI, in the UK and the National Institute of Building Sciences – NIBS, in the USA[24], have developed standards based on their countries' company standards procedure. By doing so they have contributed to the creation of the international standards published by ISO (International Organisation for Standards, UK).

Other classification and information exchange initiatives include:

- *Uniform drawing system* – UDS, a U.S National CAD Standard developed by the CSI updated and incorporated in the NCS Version 4.0 – U.S. National CAD Standard in 2008. UDS establishes consistent guidelines for organizing and presenting building design information. It is used to organize and manage construction drawings for virtually any project and project delivery method, for the entire life cycle of a facility.
- *NCS Version 4.0* (CSI, 2008) - a United States National CAD Standard that classifies electronic building design data. It intends to simplify the exchange of building design and construction data from project development throughout the lifecycle of a facility.
- *Industry Foundation Classes* (IFCs), a data exchange standard that stipulates elements used in building construction in a manner that defines a common language for construction. It is intended to provide a foundation for the exchange and sharing of information between software applications of a shared building project model. The IFC data model is neutral, independent of a particular software vendor and is an open format for building information models, which is also its commonly used format. The format, known as IFC2x3 (current version) is currently supported by Autodesk, Graphisoft, Nemestchek

[24] USA - United States of America

and Bentley25. It is registered by ISO as ISO/PAS 16739:2005 (see section 2.4.2. for further details).

- *UniFormat, A Uniform Classification of Construction Systems and Assemblies*, a standard system for organizing preliminary construction information that provides a logical way to analyse building design. It was developed by the CSI and CSC, from 1998, and is presently being revised.[26]

Some examples of these standards were also studied and their knowledge and application queried in the field questioned in the postal questionnaire (see Appendix 2).

The most important ones are:

- BS 1192-5:1998 *Construction drawing practice,* Guide for the structuring and exchange of CAD data, British Standards Institute, UK, 1998.
- BS 1192:2007 Collaborative Production of Architectural, Engineering and construction information - Code of practice, British Standards Institute, UK, 2007.
- IAI - IFC, *Industry Foundation Classes*, an industry standard for holding and exchanging digital data. BuildingSMART – International Alliance for Interoperability (URL:http://www.iai-tech.org/).
- ISO Standard 10303-STEP, *Standard for the Exchange of Product Model Data*, International Organization for Standardization, ISO TC184/SC4, 1994.[27]
- ISO/TR 14177:1994, *Classification of information in the construction industry,* International Organization for Standardization, 1994.

[25] In URL:http://www.iai-tech.org/ and URL: http://www.buildingsmart.com/bim

[26] In URL:http://www.csinet.org accessed last in 01. 2010

[27] In URL:http://www.steptools.com/library/standard/

- BS ISO 12006-2:2001, Building Construction - Organization of Information about construction works - Part 2: Framework for classification of information, British Standards Institute, UK, 2001.
- ISO/PAS 12006-3:2001.[28] Building Construction - Organization of Information about construction works - Part 3, Framework for object-oriented information exchange.
- ISO 13584, *Industrial automation systems and integration - Parts library*, Series of International Standards for representing and exchanging part library data, International Organization for Standardization.
- EN ISO 11442:2006 (Ed. 1) *Technical product documentation. Document management* (ISO 11442:2006), International Organization for Standardization, 2006.
- NP EN ISO 13567-1:2002[29] (Ed. 1) "*Documentação técnica de produtos. Organização e designação de camadas ("layers") em CAD. Parte 1: Visão geral e princípios*". Portuguese version of the EN ISO 13567-1:2002 and identical to ISO 13567-1:1998.
- NP EN ISO 13567-2:2002 (Ed. 1) "*Documentação técnica de produtos. Organização e designação de camadas ("layers") em CAD. Parte 2: Conceitos, formatos e códigos utilizados na documentação de construção*". Portuguese version of the EN ISO 13567-2:2002 and identical to ISO 13567-2:1998.

[28] ISO/PAS 12006-3:2001. *Building Construction - Organization of Information about construction works - Part 3, Framework for object-oriented information exchange* is since 2007, an International Standard ISO 12006-3:2007

[29] NP- Portuguese Standards are produced by IPQ - Instituto Portugues da Qualidade (Portuguese Quality Institute).

- BS ISO 22263:2008, Organization of information about construction works – Framework for management of project information, British Standards Institute, UK, 2008.
- NP EN ISO 9000:2005 (Ed. 2) *Sistemas de gestão da qualidade. Fundamentos e vocabulário*, Portuguese version of EN ISO 9000: 2005.
- NP EN ISO 9001:2000 (Ed. 2) *Sistemas de gestão da qualidade.* Portuguese version of EN ISO 9001:2000.
- AecXML *Standard framework for using the eXtensible Markup Language* (XML), standard for electronic communications in the architectural, engineering and construction industries (IAI, 2006[30]).

From the above initiatives, STEP, IFC´s and aecXML standards are outlined in more detail in the following sections of this chapter. These stood out in the literature review, and uncovered the reasons particular to each one's emphasis in published works: STEP stood out in terms of application and standard development; IFC´s are taken as promising for the near future and; aecXML standard is perceived as a possible language standard for effectively communicating information. Their importance in the literature reviewed is what makes them worth developing further here.

2.4.1. STEP, Standard for the Exchange of Product Data, formally known as ISO Standard 10303

STEP describes how to represent and exchange digital product information. It dates from 1983 and was based on IGES (Initial Graphics Exchange Specifications),

30 "AecXML", International Alliance for Interoperability, (URL: http://www.aecxml.org accessed on 09. 2006)

VDAFS[31] (DIN[32] 66301, Standard used for the transfer of freeform shapes), SET (Secure Electronic Transaction), and CAD (Computer Aided Design). Parts of this standard were issued in 1994 as international standards.

> Digital product data must contain enough information to cover a product's entire life cycle, from design to analysis, manufacture, quality control testing, inspection and product support functions. In order to do this, STEP must cover geometry, topology, tolerances, relationships, attributes, assemblies, configuration and more. (STEP Tools Inc.[33]).

STEP has been created as a multi-part ISO standard. The main parts are complete and published, while others are still being developed. STEP is otherwise known as ISO 10303, and intends to provide a mechanism that is capable of describing product data throughout the life cycle of a product, independent from any particular system. The nature of this explanation makes it suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases and archiving (ISO[34] 2011). The most important aspect of this standard is extensibility: it is built on a language that can formally describe the structure and correctness of conditions of any engineering information that needs to be exchanged.

EXPRESS is the language used to detail the information required to describe products of that industry. This language can document constraints as well as data structures. Most of its infrastructure is complete, but industry specification protocols are open-ended. Application Protocols are available for some industries including the AEC industry. EXPRESS language can be identified in two ways, textually and graphically. Its graphical representation is called EXPRESS-G.

STEP Model development methodology:

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[31] VDAFS- Verband des Automobilindustrie

[32] DIN- Deutsches Institut für Normung or in English- The German Institute for Standardization responsible for DIN Standards.

[33] Accessed in 2007 at URL: [http://www.steptools.com/support/stdev_docs/about_step.html]

[34] ISO- International Standards Organization accessed in 2011 at URL:http://www.iso.org/iso/iso_cafe_step.htm

> Produce standard product models for use within specific areas of application (AP´s) and to strive to harmonize and coordinate these models across application areas to the greatest extent as possible. (Froese, 1996:411)

The AP´s development according to Froese (1996) is based on:

1. Identification of the industry's needs, well formulated and understood.

2. AAM (Application Activity Model): given an industry's need, it documents the role of the AP. It identifies the business process in which the AP is used. It is the first boundary between the industry participants in the modeling process and it is the primary tool for determining how the model is to be used.

3. ARM (Application Reference Model): depicts information that needs to be included in the AP using the terminology and concepts of the application domain. Its development encompasses the bulk of the model development effort, still within the scope of industry experts.

4. AIM (Application Interpreted Model): a model that fully defines all the necessary data representation structures in a way that is compatible with other parts of the STEP standard. It is the result of the interpretation process.

5. AIC (Application Interpreted Construct). Where the interpretation process leads to the same basic concepts being represented in two or more AIM's, these model segments are defined in AIC for use in future AIM's.

The first attempt to shape STEP was with an Application Protocol Planning Project for Building and Construction (APPP-BC) initiated in October 1993 (Froese, 1996). The APPP identified related models required to represent information from building construction industries. Important APs developed within the construction industry are:

- *AP225 - Building Elements using Explicit Shape representation (ISO 1995).* It aims at representing buildings as assemblies of elements along with the explicit 3D geometry of each element and some additional information such as material properties, building element classification or element versions. It deals with the exchange of geometry. It has been developed as a German funded project and experimental implementations have been completed that exchange complex CAD models between heterogeneous CAD systems. According to *prodAEC, European network for product and project data exchange, e-work and e-business in Architecture, Engineering and Construction* regarding *"Standard Analysis-Current AEC Situation – Building Models" 2002* report (Liebich and Wix, 2002), AP 225 is recognized and used in Europe, mainly in Germany, although the E.U. is trying to implement it by funding research and development projects that use it.

- *BCCM - Building Construction Core Model project* is part 106 of STEP building construction group (UK and The Netherlands). It is an Integrated Application Resource, a model intended to serve as a unifying reference for building construction AP´s identified roles for BBCM (Wix and Liebich, 1997) and it was one of the forms from which BIM´s[35] as we know them derive (Isikdag et al, 2007).

The main arguments for the use of STEP are (Loffredo, 2003; Froese, 1996):

- It is the largest effort to develop standards for representing information regarding different industries.
- It is intended to provide an ISO for computer-based description and exchange of the physical and functional characteristics of products throughout their life-cycle.
- It provides the overall framework and implementation technologies for representing product design and production data in a form that can be exchanged between computer systems as files or through direct on-line access.

[35] BIM- Building Information Modeling

- It has been pursued as a major enabling technology of future international commerce in the global economy and as a key to implementing informational technologies for productivity improvement throughout enterprises.

- It is a standard that can grow. It is based on a language (EXPRESS) and can be extended to any industry. A standard that grows will not be outdated as soon as it is published.

- The EXPRESS language describes constraints as well as data structure. Formal correctness rules will prevent conflicting interpretations.

- STEP is international, and was developed by users, not vendors. User-driven standards are result-oriented, while vendor-driven standards are technology-oriented. STEP has survived changes in technology and can be used for long-term archiving of product data.

- STEP was designed for, and is proven to, handle large volumes of structurally complex engineering data.

The offset of STEP standard implementation is that it can be difficult to understand by the uninitiated; and most of the AEC industry's participants/stakeholders belong to that category. Knowing about construction and project issues does not make one an expert in computerized language.

2.4.2. IFC, Industry Foundation Classes – ISO Standard 16739

IFC Building Model Standard:

> "provide a universal basis for process improvement and information sharing in the construction and FM (Facility management) industries.
> ([http://www.ucinet.info/members/iai.jsp], 2011)

Prototype implementations were first shown at the ACS Computer Systems in the AEC Industry Show in Frankfurt in 1996, and the first commercial implementations certified by the IAI were in May 2000: Architectural Desktop from Autodesk, ArchiCad from Graphisoft, and AllPlan from Nemetschek.

The IFC model resulted from an initial pilot project undertaken within the United States of America by Autodesk.Inc. and twelve industrial companies to test the ability of the new object oriented concept being developed within AutoCad release 13. A key element in the development of the IFC model has been the early commitment of software implementers and development of the model in response to their sight. The model is constrained to be used on its own (rather than with multiple applications as in *STEP*), it uses a multi-layered approach and enforces strict rules about defining relationships between entities (classes) at each layer of the model.

IFC, Industry Foundation Classes, Data representation standard and file format for defining architectural and constructional CAD graphic data, so that CAD users can transfer design data to and from rival products with no compromises. It uses a 3D object-based CAD concept.

The IFC describes building objects representations and its first version to have commercial software implementation support was IFC release 1.5.1. in 1997. Since then it has been continuously updated with its last version dating from 2011 (Liebich, 2011). The idea was of a shared building product model which would cover all necessary information for a buildings' lifecycle: requirements management, different design activities and construction and maintenance processes (Kiviniemi et al, 2005) and its goal is the continuous maintenance of project data through to building management (Kiviniemi, 2006) (Figure 4 and Figure 5, pag.57).

Image removed due to copyright restrictions

Figure 4 - Present information exchange scheme: Source, Kiviniemi, 2006:5

Image removed due to copyright restrictions

Figure 5 - Intended share project model with IFC: Source, Kiviniemi et al, 2005:1

In 2002, only a small percentage of all on-going construction projects were planned using building models. The results reported from these projects were promising: in general, higher productivity, better cost and risk were controled and a higher flexibility to address client demands were acknowledged (Liebich and Wix, 2002) .

Examples of commercial construction projects using IFC were found in Germany, Norway and France with several risk shared projects, partially funded by the European Commission or national R&D (Research and Development) projects in Finland, Denmark, Great Britain, and Sweden. Extension projects are being developed in Finland, Japan, Finland/USA, Germany, Finland/Germany, Singapore, United Kingdom, USA/United Kingdom, Australia, Norway and Korea.

These results are part of a report from the "prodAEC", European network for product and project data exchange, e-work and e-business in Architecture, Engineering and Construction: "Standard Analysis - Current AEC Situation – Building Models" 2002 (Liebich and Wix, 2002). Development of the IFC object Model draws extensively on model schema that form part of the STEP standard, in particular, ISO 1030 - Part 11, that defines the data definition language EXPRESS,[36] in which IFC is implemented; 21 that specifies the physical format of files used for data exchange; 22 (SDAI[37]), defines access to databases that store IFC based information, and 40 series parts which refer to integrated resources.

The IFC methodological structural design defines a set of important principles leading to the IFC model organization that:

- Provides a modular structure to the model,
- Provides a framework for sharing information between disciplines within the AEC/FM industry,
- Eases the continued maintenance and development of the model,

[36] *EXPRESS* language is described above in STEP

[37] *SDAI, Standard Data Access Interface*

- Enables information modellers to reuse model components,
- Enables software authors to reuse software components.

IFC[38] is one of the most recognized used free standards for the construction industry to the present date, and developments in its use within BIM technologies are ongoing initiatives to enable collaborative work and effective communication of information regarding construction projects amongst stakeholders.

2.4.3. aecXML Standard

aecXML[39] (IAI, International Alliance for Interoperability), is a framework for using Extensible Markup Language (XML), an interoperable computer language, for use in the Architecture, Engineering, and Construction (AEC) industry. Its aim is to describe things as they are and not to sculpt or model them, and to establish standard ways of structuring building data enabling as much automatic processing of data as possible.

> The aecXML system is designed for all the non-graphic data involved in the construction industries, and has a place alongside the IFC system, although some of the more recent moves to extend the IFC system to non-graphic data do seem to overlap. (Geoff Harrod, at [http://ciaux.dbm.com.au/editorial/aecxml.htm, accessed in 2006])

The aecXML system uses data-type tags (as in HTML, Hyper-text mark up language), so that a data processing program can easily be made to search for the relevant tags and extract the required data text or numbers, securing that the correct amount of data can be found. It should have particular use in the fields of estimating, quantity surveying, and project management.

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[38] Implementations of IFC can be found at: http://www.iai.fhm.edu/ImplementationOverview.htm

[39] Aec - architectural, engineering and construction XML- “extensive mark-up language” aecXML at [http://www.fiatech.org/projects/idim/aecxml.htm] accessed in 2009

2.4.4. BIM - Building Information Modeling

During this project, advances in new improved technologies for the construction industry were undertaken, and a particular process concerning information in construction undertook a considerable leap, which could not go without mention - the Building Information Modeling process.

References to BIM appeared in the literature review a handful of times over the five years the researcher has endeavoured in the study of classification information systems for construction design projects. In the past two years however, BIM has gained more prominence and was in fact mentioned in the semi-structured interviews conducted in Portugal under the scope of this project (see Chapter 5 of this thesis). BIM thus features in this literature review even if the overall and practical effectiveness of BIM utilization is difficult to assess at this stage (Jung and Joo, 2010). There are many articles on BIM implementation but little is written on its core. What is BIM? How does it work? Where does it come from? To whom does it apply? Not all questions were clearly answered by the literature review.

As Eastman (1999) pointed out, all phases in a building lifecycle - starting from a pre-design phase of feasibility studies, then design, construction planning, construction, facility management and operation – all these can be described as one holistic process. The previously mentioned standards STEP and IFC´s have given their contribution for BIM’s development: STEP in providing a basis for the exchange format of BIM models and IFC`s in providing for the component-based data library with descriptions of building parts and their interrelation in standardized classes (Holzer, 2007).

BIM is considered to be one of the most important areas in construction project design nowadays, although the literature found shows some misunderstandings or misconceptions on the subject. Some mentioned that BIM is a set of software tools for the representation of a building and others perceived it as a process – a building process - for producing and representing a building facility (Eastman, 2009). The use of BIM has proved to be very valuable to construction projects (Azhar et al, 2008) but is only now becoming widespread because the technology behind it has been slow to develop and because of a tendency to resist change in the construction industry.

Overall, BIM is the process of generating and managing building data during its life cycle, based on an IT enabled approach that involves applying and maintaining an integral digital representation of all building information for different phases of the project lifecycle in the form of a data repository. The building information involved in the BIM approach can include both geometric data as well as non-geometric data and in its simplest form, BIM is used to model a building in 3D as opposed to the traditional 2D CAD model.

Stated to be critical to successful integration of computer models into project coordination, simulation and optimization is the inclusion of information - the "I" in BIM (GSA[40], 2012 at [http://www.gsa.gov/portal/content/105075]). In Bentley´s site[41] one can read that BIM is a new way of approaching the design and documentation of building projects where:

- Building refers to the entire lifecycle of the building including (design/build/operations);
- Information - all information about the building and its lifecycle is included;
- Modeling - defining and simulating the building, its delivery, and operation using integrated tools.

Vendors and developers (Bentley, Autodesk and ArchiCAD) mention that it is an integrated tool that manages graphic representation of the building but also information that allows the automatic generation of drawings and reports, design analysis, schedule simulation, facilities management, enabling different teams to make better informed decisions thus providing for consistent drawings, cost estimation, bills of material and clash detection.

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[40] GSA- United States General Services Administration site:http://www.gsa.gov/portal/category/100000

[41] Bentley site: http://www.bentley.com/en-US/Solutions/Buildings/About+BIM.htm in 2012

Under development and implementation, since 2005 until the present day, is the National BIM standard in the United States although some versions have already been made available (BuildingSMART alliance[42], 2011) and it is intended to be applicable worldwide by keeping the core of the standards as common to all as much as possible with only a minimum number of changes to make it country specific:

> BIM can represent viewpoints – graphically and in text and table form, of a building from any practitioner perspective – Architect, Specifier, Engineers, Fabricators, Leasing Agents, General Contractors and so on. As such, it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life cycle from inception onward. (NBIMS by the National Institute of Building Sciences, 2008:2.)

This is quite ambitious and it seems that the same problem continues to arise as far as information management is concerned and standards and classification systems are still needed to access information. The BuildingSMART Alliance in the United States has developed the national BIM standard and the UK AEC[43] industry has developed its own standard for existing applications of BIM, such as Bentley and Autodesk Revit (AEC, UK, 2009) which is based on it. Both efforts strive in defining BIM modeling workflows and co-ordination of collaborative working, advice on separation of modeling data, reference use and procedures, workspace organization and object naming recommendations. Also, both entail, comprise and are based on, existing and already mentioned standards for construction design projects (e.g. ISO BS 1192:2007). It is the intention of all that the standards developed for BIM application derive from CAD standards and incorporate them so that the transgression from CAD application is solid and effective.

It is intended that the single model is broken into separate files, during the scheme, design development and construction documentation phases, to enable

[42] BuildingSMART alliance at http://www.buildingsmartalliance.org/index.php/nbims/about/ in 2011

[43] AEC. Architectural, Engineering and construction industry in the United Kingdom can be accessed at http://aecuk.wordpress.com/

multiple designers to work on the information and construct the full model using repetitive references (AEC, UK, 2009).

BIM standards and applications also entail the use and full comprehension of the Uniclass classification system in the AEC UK standards' case and, in National Building Information Modeling Standards (NBIMS-U.S) case the Omniclass classification system, IFC´s application and the International Framework for Dictionaries (IFD Library). This continuously proves the need for a fully comprehended classification information system, as the absence of one results in problems in the information exchange amongst all practitioners involved in the process.

The standards set the basic framework to work with building information models to be applied to any project, as long as the basic rules are set previously at the beginning of each project. It comprises guidelines to work with: building geometry, spatial relationships, geographic information, quantities and properties of building components as stated above to be BIM´s main purpose. According to Azhar et al (2008) its benefits are:

- Faster and more effective processes – information is more easily shared, can be value-added and reused.
- Better design – building proposals can be rigorously analyzed, simulations can be performed quickly and performance benchmarked, enabling improved and innovative solutions.
- Controlled whole-life costs and environmental data – environmental performance is more predictable, lifecycle costs are better understood.
- Better production quality – documentation output is flexible and exploits automation.
- Automated assembly – digital product data can be exploited in downstream processes and be used for manufacturing/assembling of structural systems.

- Better customer service – proposals are better understood through accurate visualization.
- Lifecycle data – requirements, design, construction and operational information can be used in facilities management.

The use of BIM has increased progressively in recent years throughout the world (Khemlani, 2007). Reports were found on its use and application in Singapore, China, UK, Scandinavia and the USA (Khemlani, 2012). Its use has been made mandatory in Government building programmes in the UK in 2011. In May of 2011, the UK Cabinet Office published the "Government Construction Strategy" (CabinetOffice, 2011) that comprised an entire section on "Building Information Modeling," within which it specified that the Government will require fully collaborative 3D BIM as a minimum by 2016 (Khemlani, 2012). The document also acknowledges that the lack of compatible systems, standards and protocols, and the differing requirements of clients and lead designers, have inhibited widespread adoption of BIM (CabinetOfiice, 2011). This could be stated about other countries as well.

But although the literature found on BIM forces the idea that it seems to be the future and that it almost reaches perfection in terms of a working structure, the survey undertaken in September and October 2010 by the NBS[44] (2011) in the UK (the only country that reportedly makes the use of BIM mandatory through Government policy) does not exactly reflect this. The results showed a clear split in the industry. Almost half admitted they were not even aware of BIM; however, the rest were aware and seemed to be in the process of making preparations to adopt it on the majority of their projects. Some see BIM as a new specialist activity that is too big a leap to take. The report indicates other interesting factors such as:

- CAD drawings are not produced by the majority of respondents and are mainly used after drawings have been done by hand.

[44] National Building Specifications

- Many practitioners are just aware of BIM or not aware at all, and not using it. Only quite a small percentage of respondents are currently aware and using it.

The BIM process will also mean that project processes, as we know them, will suffer adjustments to say the least. Interoperability and changes in the way of producing information will obviously have repercussions on the methodology for developing projects. These issues are never easy and we may fall into previous situations as we pass directly from the drawing board to computer drawing in algorithms without considering the effects that would have on the production of information as a whole.

2.5. Conclusions from the literature review

CI/SfB 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, Portugal included, mainly because it was the first to be recognized widespread and secondly because it has been in use for more than 30 years. The most reported problem is that it does not cover nor comprehend the use of computerized technologies. 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 losing its standardized characteristic.

There is also the matter of exchange information at an international level. This was not considered in a classification system until the *British Standards Institute* developed and published *BS ISO 12006-2, Building Construction - Organization of Information about construction works - Part 2: Framework for classification of information*, which intended to overcome this problem, since it identifies classes for the organization of information and indicates how they are related. But 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* and *Omniclass*. In the faceted classification system 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, and they also establish some space for increased developments where issues might incur, such as developments in technologies that are applied and product developments.

CAWS and *MasterFormat*, 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 of information in a broader way; they have to be complemented with the use of classification systems such as *Uniclass* or *Omniclass*.

UNICLASS is considered to be the substitute of *CI/SfB*, 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*, and advised to be used with it, it also presents a handicap.

The *Omniclass* system of classification is reported to be tackling the total classification problem (Robert, 2005) and appears as the most adequate solution thus far. Indeed, *Omniclass* raises high expectations regarding its use and implementation, which is hardly surprising: *OmniClass* aims to go further than any other. It is the most recently published initiative in classification of information in the construction industry, entailing 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. It remains to be seen if *OmniClass'* 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* and *Uniclass* aim to be that classification system, and *ISO 12006-2* appears to effectively be that framework, given that most of the initiatives derive from it. But some questions are left unanswered. If *Uniclass* is the British equivalent to the US *Omniclass*, then the systems should enable cross-referencing, yet, literature lacks any remarks regarding this issue. Also, the *OmniClass* system comprises *MasterFormat*, which in theory should make the latter redundant, but again here the literature is silent.

In order to establish a framework for a classification system, 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.

Developments in technologies to improve communication amongst stakeholders involved in the project construction process have been considered and represent possible methods for disseminating and exchanging information throughout the project and construction process, but they also present practitioners with problems related with their use and implementation (Howard and Björk, 2008) and this has also to be considered. If one has the tools but does not know how to use them in an efficient way, then what is the point of constantly developing or upgrading them?

It is interesting to find that the UK is no different from Portugal in this regard: in both countries practitioners in the field have an established idea that BIM is the future but only a really small percentage seem to know exactly what that means. Many practitioners do not know what this means and the semi-structured interviews conducted in Portugal showed exactly that (see Chapter 5).

The study and integration of BIM in this project is motivated by the ideas arising from the survey on the subject: practitioners mentioned it although none of them seemed aware of what it is and so the researcher felt compelled to further investigate this matter. It is now clear that BIM, either referred to as a process or a technology, is not the answer to the recognized problem of classification of information in the construction design project in Portugal, at least not on its own. This is not the same as saying that the solution will not pass through its effective adoption.

Already BIM standards are incorporating classification systems and once again different countries are applying, within BIM standards, their own classification systems - Omniclass in the U.S and Uniclass in the UK. This is not necessarily a setback but it remains to be seen if BIM work production, which is in its core intends to enable interoperability, will in fact do so.

Building Information modeling initiatives being held are also IFC and STEP integrated with the resource to EXPRESS and XML languages and specifications which apparently make perfect sense, but in reality the information model application by stakeholders involved in the process is still far from IFC´s ideal.

If the researcher, who is truly committed to this project, has faced some obstacles in understanding some of these concepts and learning some of the proposed applications, how will the average practitioner in the field react to them?

A common factor within all these initiatives is that classification information systems and standards for communicating and exchanging information on the construction industry are extremely important, and even if practitioners are not aware of them they have to exist, especially in a globalized world.

The fact is that the process of project construction has changed considerably throughout recent years - methods have evolved, and outstanding innovation developments have occurred. Yet it seems that the human factor has not yet been thought through. There is a need to enable people working in the field to understand what they are doing when dealing with information management processes or, from a different perspective, information technology gets such an incredible boost that software development comprises all standardisation needed and classification and practitioners are free to ‘create’ without breaking or leaking the process of information management. Can software become that user friendly? Or will practitioners still need to know what they are doing to information throughout the construction process? It is believed that both are possible, and even better for the construction industry if combined.

3. METHODOLOGY

The purpose of this research project is to establish a conceptual **framework for** the successful implementation of **a classification information system** for construction project design data in Portugal **- FCI**. The researcher believed that this problem should be addressed to enable a better communication process amongst stakeholders involved in construction design projects in Portugal. In seeking to understand this phenomenon, the study addressed the research question by seeking to understand which classification information systems, standards and protocols for communicating information in construction project design data were known and applied in Portugal and elsewhere. It also sought to examine existing project processes and protocols.

The previous chapters have detailed the research domain, its aims and objectives, including the research question, and the main findings arising from the review of literature undertaken throughout the project. Here, the focus is diverted to the research design strategy (Table 2, pag.70), its implementation and the research methods used detailing the basis on which they were chosen and their appropriateness.

This chapter presents and justifies the research methodological design adopted to address the aim and objectives of this research. The need for a “nested” approach integrating research philosophy, approach and techniques employed is presented as well as the choice of a philosophical stance of interpretivist. Subsequently the use of a mixed methods approach to address the research question is detailed, followed by the different research techniques employed. The process of data collection and analysis is examined in each technique description. The chapter concludes with a discussion of the validation process of this research.

RESEARCH THEME	***Explanation***	***Method***
Identify the research need	Identification of the problem statement for the research	Personal involvement in the construction design process in Portugal as an architect; literature review and consultation with stakeholders involved in the process
Conduct a review of existing literature	Review of existing literature to obtain a deeper understanding of the research context	Extensive literature review on existing classification systems, protocols and standards for communicating information
Methodology	Understand and identify appropriate methodology strategy	Extensive study on research methodology, philosophy, research approaches and techniques
Survey questionnaire	Empirical evidence to support the research as identified in the literature review	Survey questionnaire to understand the knowledge and use of existing classification systems, protocols and standards in Portugal
Semi-structured interviews	Gain in-depth understanding of the process of production and classification of information amongst different practitioners in the field	Semi-structured interviews with ten stakeholders from different fields within the construction industry
Framework development	Synthesis of the findings of the literature reviews and from the data collected with the survey questionnaire and the semi-structured interviews	Combining findings of the literature review, survey analysis and semi-structured interviews, content analysis
Validate the framework	Validation of the framework	Conduct two focus group discussions with practitioners from the field to validate the framework
Conclusions	Summary of findings	Analyse focus group discussions and draw conclusions regarding the validity of the framework. Make recommendations for improvements and further work

Table 2- Research Design Strategy

There is no contestation that a research investigation must be based on a rigorous scientific methodology. In fact, although the concept of research might have different meanings to different individuals there seem to be some consensus regarding some of its main principles; research is the process of inquiry and investigation and it is systematic and methodical (Denzin, 1978).

The purpose of research is to gain knowledge, learn (Denzin, 1978; Chadwick et al, 1984) and to put it in colloquial terms, *"finding things out"* about the world (Ackroyd and Hughes, 1992) and thus generate theory i.e. a fact-based framework to understand and explain phenomena, gaining solutions to problems or answers to unsolved questions. A theory is *"a set of interrelated constructs (variables), definitions, and propositions that presents a systematic view of phenomena by specifying relations among variables, with the purpose of explaining natural phenomena"* (Kerlinger, 1979 in Creswell, 2003:120). The primary goal of theory is then to answer questions of how, when or where, and why (Bacharach, 1989). Research methodology represents the logical development of the research process used to generate theory (Kerlinger, 1979 in Creswell, 2003). According to Creswell (2003), the guiding principle for developing any research methodology is that it must completely address the research question.

Research methodology can also be described as the *"... systematic, formal, rigorous and precise process employed to gain solutions to problems and/or to discover and interpret new facts and relationships"*(Waltz and Bausell, 1981:1); with its design being understood to be "... *the architectural blueprint of a research project, linking data collection and analysis activities to the research questions and ensuring that the complete research agenda will be addressed*." (Bickman et al, 1998:11).

In this study the "nested" approach was adopted for the design and development of the research project. This chapter details the nature of the chosen methodology and why it was deemed necessary and adequate for this project.

3.1. Research Methodology: "Nested" approach

There are many diverse approaches and methods to design and execute research to be found in the literature. However it is not always clear as to how to use and combine them when conducting a particular type of study, and how to evaluate the data.

The main intention of any research is to add value to the accumulated knowledge through the means of identifying, investigating and producing solutions to an unsolved problem (Remenyi et al, 1998). Frankfort-Nachmias and Nachmias (1996) state that a research methodology is a system of explicit rules and procedures upon which research is based and claims for knowledge are evaluated. As such the research process is not a clear-cut sequence of procedures following a neat pattern, but a messy interaction between the conceptual and the empirical world - deduction and induction occurring at the same time (Gill and Johnson 2002) - as there is no single universally accepted scientific methodology. Rather a combination of methodological paradigms is used to form the methodology (Lee, 1989). This said, while there are a variety of research methodologies available to the researcher, every methodology is unique and applicable only for its intended purpose.

Research methodology looks into the philosophical aspects of the research, which in turn helps to identify the overall research strategy (collecting, analysis, and interpretation of data); evaluating various research methods and identifying their limitations; increasing the compatibility of research approaches and research techniques (Easterby-Smith et al, 2002).

Research in the built environment, as is the case here, usually involves human behaviour and its understanding and study to some extent. After the initial literature review proved to be limited regarding Portugal's reality, there was the need to evaluate existing phenomena in the big picture of the country. To accomplish a holistic, fitted methodology that was sympathetic to the issues being investigated was in order, or in Linstone's words, *"to suit the method to the problem, and not the problem to the method"* (Linstone, 1978 in Sexton, 2000:75; Robson, 2002).

While studying classification information systems in the Portuguese construction industry it was thought that an assortment of demands to understand Portuguese reality in the field would be encountered, as they were, and that those aspects would be best served by a variety of research methods. As such, to provide the necessary contingency-based research methodology to accommodate these differing demands in a coherent and consistent way, the overall research model or “nested" approach (see Figure 6) described by Kagioglou et al (2000) and Sexton (2000) provided a holistic, integrated research method, generating a framework that “*provides the researcher with a research approach and techniques that benefit from epistemological level direction and cohesion*” (Sexton, 2000:76).

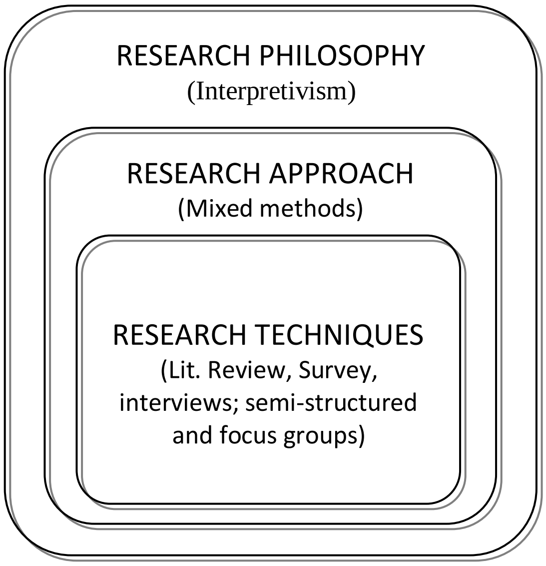

Figure 6- Adapted “Nested” approach of research methodological design.
Source: Kagioglou et al, 2000:143

When following a methodology there is the need to understand its constituent elements and their interaction thus providing the appropriate alignments between the method and the study area. Those elements include the research philosophy, approach and techniques. Research philosophy is the core of any research guiding and unifying the research strategy and techniques. The research approach regards the formulation and logical relation of concepts, i.e. the approach taken towards data collection and analysis, and research techniques focus on the mean by which data is gathered and manipulated (Sexton, 2000). The use of research approaches and techniques is not advised without some philosophical view. As recognised by Easterby-Smith et al (2002), research philosophies are the basis for effective research design and failure to adhere to philosophical issues can negatively affect the quality of the research.

The following sections further describe, in detail, the research philosophy, research approach and research techniques pertaining to this research.

3.2. Research Philosophy

As research methodology can be defined by the principals and procedures of logical thought processes, which are applied in a scientific investigation (Fellows and Liu, 1997), one can establish it to be the overall strategy to achieve the aim and objectives of the research. According to Gill and Johnson (2002), there is no best approach to research but that which is a compromise between the options based on the philosophical understanding or the basic beliefs about the world.

The philosophical stance of the researcher strongly influences the reasoning of the research and both will influence the data required by the research and the analysis of such data. All scientific research aims at generating theory. Epistemology is *"the theory or science of the method or grounds of knowledge"* (Blaikie, 2007:18). Therefore, it refers to the assumptions made about the ways in which it is possible to gain knowledge about reality, presenting a view and justification for what can be regarded as knowledge (Easterby-Smith et al, 2002).

While undertaking any scientific research it is important to consider different research branches of philosophy namely ontology and epistemology. As these philosophies describe perceptions, beliefs and assumptions and the nature of reality and truth they can influence the way in which the research is conducted. From design through to conclusions it is important to guarantee the researcher's approaches are congruent to the nature and aims of the particular inquiry adopted, ensuring that researcher biases are understood, exposed and minimized. Also, methods must be compatible with the researcher´s philosophical stance, guaranteeing that the final work is not undermined through lack of coherence (Easterby-Smith et al, 2002).

A third philosophical branch associated with ontology and epistemology is axiology, the philosophical branch that studies the judgments about value. Our values are the guiding reasons for all human action (Heron, 1996). The simple fact of choosing one research topic over another and the way the researcher goes about doing it shows precisely that. Our values are probably the drivers of our philosophical stance. Ontology seeks to identify the nature of the reality; epistemology shows how we acquire and accept knowledge about the world and axiology is the nature of the values the researcher place on the study (Sexton, 2003; Easterby-Smith et al, 2002).

Ontology being *"the branch of philosophy concerned with the articulating the nature and structure of the world"* (Wand and Weber, 1993:220), discusses the claims and assumptions that can be made about the nature of reality and how they interact with each other (Guba and Lincon, 1994). According to Blaikie, ontology is the *"science or study of being"*(2007:3) and seeks to answer the *"claims about what exists, what it looks like, what units make it up and how these units interact with each other"*(2007:3) and epistemology is *"the theory or science of the method or grounds of knowledge"*(2007:18). Therefore, it refers to the assumptions made about the ways in which it is possible to gain knowledge about reality, presenting a view and justification for what can be regarded as knowledge (Easterby-Smith et al, 2002). The most popular examples of ontological positions are objectivism[45] vs. constructivism (Sustrina, 2009; Grix, 2002). Objectivism being the ontological position that defends that phenomena and their meanings have an existence that is independent from the actors (Sustrina, 2009), and constructivism stands that

[45] Gill and Johnson (2002), defend that where objectivism entails two views of realism namely; ontological realism and epistemological realism. This is often called 'objectivism', i.e. *there is a real social and natural world existing independently of our cognitions which we can neutrally apprehend through observation.*
Sayer (2000:2) argues that there is a misconception of the term as realism is sometimes used as objectivism.

phenomena and their meanings are continually being accomplished by the actors. For objectivists there is one objective reality experienced the same way by each and every one of us, whereas for constructivists, reality is a "construct" seen by each and every one of us differently and is in a constant state of revision (Sustrina, 2009; Easterby-Smith et al, 2002).

According to Sexton (2003) contrasting viewpoints on research philosophies are characterized by contrasting views taken on the ontological, epistemological and axiological assumptions. The author further explains that ontological assumptions can differ by whether reality is external to the individual and imposed on him with predetermined nature and structured realism; or whether reality is perceived in different ways by individuals - idealism (Burrell & Morgan, 1979 in Kulatunga, 2007). The representation of Sexton´s ontological and epistemological stances and their implications in research methodology are represented in Figure 7.

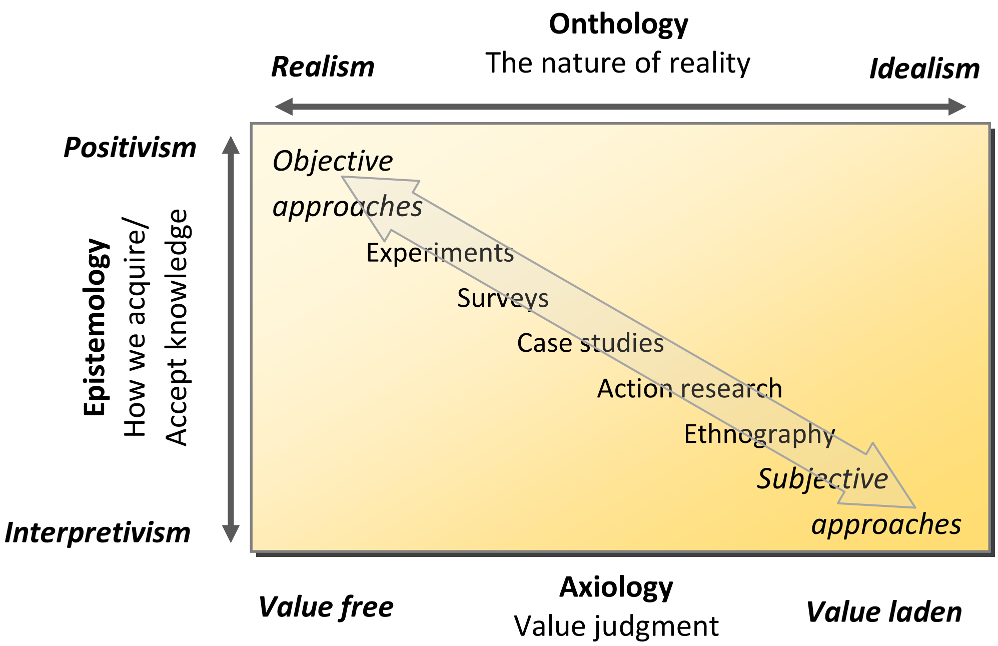

Figure 7- Sexton´s (2003) "Dimensions of research philosophy: Bringing it all together!"

For the purpose of this study, the most pertinent philosophical assumptions are those related to the basic epistemology which guides research. Epistemology is concerned with claims of what is assumed to exist and can be known by the 'knower or to-be-knower' (Guba and Lincoln, 1994). It looks at the theory of knowledge, especially with regard to its methods, validation and the possible ways of gaining knowledge in the assumed reality. Epistemological foundations refer to the assumptions about knowledge and how it can be obtained (Sexton, 2000). Two main schools of thought have been dominating the epistemological debate on how to best conduct research, describing different and competing inquiry paradigms that can be placed at two extreme ends of a continuum: positivism vs. interpretivism (Easterby-Smith et al, 2002; Sustrina, 2009).

Positivist research philosophies assume that reality is objectively given and can be described by measurable properties which are independent of the observer (Sexton, 2000) and should be measured through objective methods rather than being inferred subjectively through sensation, reflection or intuition (Easterby-Smith et al, 2002).

Positivist studies generally attempt to test theory, in seeking to increase the predictive understanding of phenomena. Positivism refers to *"all approaches to science that consider scientific knowledge to be obtained only from sense data that can be directly experienced and verified between different observers"* (Susman and Evered, 1978:583). This includes rigorous observations to generate scientific knowledge. As such, it is associated with quantitative and experimental methods used to test hypothetical-deductive generalizations (Blaikie, 2007). Positivism searches for causal explanations and fundamental laws, and usually reduces the whole to its simplest elements in order to facilitate analysis (Easterby-Smith et al, 2002; Remenyi et al, 1998). Although a survey by questionnaire was used in this project, its adoption was considered with the intent of exploring the phenomena at hands and support further developments of the research.

A positivist believes that the process of research is value free, in terms of axiological assumption, and will search for causal explanations and fundamental laws using the deductive approach for the research (Easterby-Smith et al, 2002; Gill and Johnson, 2002; Remenyi et al, 1998). As a result, the researcher detaches him or herself from the research environment and takes the role of an independent observer without interfering with the research environment and will not allow values and bias to distort the research result (Kulatunga, 2007). In the present case, even if all precautions were taken not to interfere with the research environment, the fact is that the researcher engages in this project because she was involved in the process.

At the other extreme of the continuum (Sustrina, 2009), interpretative research philosophies assume that access to reality is obtained only through social constructions such as language, consciousness and shared meanings. Interpretive studies generally attempt to understand phenomena through the meanings that people assign to them (Sexton, 2000) and emphasis is given to observation and description in generating hypotheses (Silverman, 1998). Which was precisely the case here; the researcher valued stakeholders' opinions and insights on the subject and through them tried to understand how they go about information concerning construction project design.

According to Easterby-Smith et al (2002), social constructionism (interpretivism) focuses on the ways that people make sense of the world, especially through sharing their experiences with others via the medium of language. It is one of a group of approaches of interpretative methods: people construct their own words and give meaning to their own realities and the focus should be on the ways they communicate with each other to try to understand and explain why people have different experiences; this was very important in this project. By observing, the interpretivist somehow constructs its own "truth" for him or her - reality can only be interpreted (Sustrina, 2009). This type of enquiry uses mainly qualitative approaches to understand and explain a phenomenon (Easterby-Smith et al., 2002) which was the case here.

Both inquiry paradigms have had their share of criticism as to their understanding and application in research (see Table 3, pag.80) for implications of both paradigms). On one hand it is argued that through interpretative[46] research it is not possible to create generalisable theory as two individuals observing the same phenomena could reach different conclusions due to their different preconceived notions and background beliefs (Harriss, 1998). On the other hand, positivism was originally used to study natural science and thus was criticized when applied to social science as the latter deals with human behaviour and it is argued that humans cannot be treated as objects and theories, which lead to definite laws, because humans are influenced by feelings and perceptions (Kulatunga, 2007). Seymour et al (1997) critiques the use of positivist approaches in the area of built environment management, stating that it is important to have a greater proximity between researcher and real life problems. Others advocate a similar argument as to the positivist model applied to organizational research, as by limiting its methods to what it claims is value-free, logical and empirical, it produces a knowledge that may only inadvertently serve and sometimes undermine the values of organizational members (Susman and Evered, 1978).

[46] Also referred to as phenomenology; it concerns phenomena.

Table removed due to copyright restrictions

Table 3- Contrasting implications of positivism and interpretivism (social constructionism). Source Easterby-Smith et al, 2002:30

Interpretivism is the epistemological assumption that the properties of reality can be measured through subjective measures and be determined by examining people´s perceptions (Easterby-Smith et al, 2002). Thus instead of searching for causal explanations or for external factors, for an interpretivist, emphasis is given to the different views that people place on their experiences which enables the researcher to have closer interactions with the research environment unlike in positivist studies (Kulatunga, 2007). Furthermore, it recognises the individual viewpoints of practitioners and researchers involved in the process (Seymour et al, 1997) which was precisely the case with this research. Due to that close interaction, interpretivist research is value laden, and thus choice of what to study and how to study it is determined by human beliefs and interests (Easterby-Smith et al, 2002). According to Miles and Huberman (1994), human activity is seen in interpretivism as 'text', i.e. a collection of symbols expressing layers of meaning, and research is concerned with a deep understanding of such meanings.

The aim of this research is to develop a conceptual framework for classification of information in construction design projects in Portugal. This can only be accomplished by identifying the factors influencing the adoption of such a system and understanding stakeholders´ views and actions in the field - how do they classify information regarding design projects, are they aware of existing information classification systems in the field, what about protocols and standards for that purpose?

The idea of a conceptual framework involves the identification and underlying assumptions of social-cultural behaviour issues and factors acting as constraints and enablers to the development and implementation of any classification information system. The complexities of such issues are studied more appropriately through interpretivistic philosophy. Also, the researcher´s drive for this study was rooted in the experience of regularly having problems of production, storage and retrieval of information, whilst working in the field as an architect. The focus of the research is therefore on the built environment from an holistic perspective, and specifically in the core activities and strategies of construction project design. Therefore the interest in the actors' actions was imperative.

The epistemological option for this research is based on the interpretative school of thought, since the actions that entail this project are related with the study of human behaviour in the built environment. The subject nature of the study supports the adoption of an interpretative research philosophy in detriment of a rather positivist research philosophy that perceives reality as "objectively" constructed.

The researcher valued ideas, opinions and perceptions of experts based on their experience within different areas of the construction industry and uses both quantitative and qualitative approaches to inductively and holistically understand human experience in context specific settings.

3.3. Research Approach: Mixed methods

A research approach is a way of describing how a researcher goes about the task of doing research; embodying a particular style and employing different research methods. It is a way of collecting evidence that indicates the tools and techniques used for data collection (Weick, 1989). This section will describe the research approach applied to satisfy the research design model (Table 2, pag.70). The justification behind the chosen research methods will be described in the next section.

As the guiding principle for developing any research methodology is that it must fully address the research question (Creswell, 2003), the research approach should be a blueprint for directly collecting observations and data connected to the research, making explicit the questions the researcher should answer, developing a data collection methodology and discussing the data in relation to the initial research questions. According to Easterby-Smith et al (2002) the research approach includes the type of evidence, as well as the process of interpretation used to obtain satisfactory answers for the questions being posed.

The preliminary idea of this research was to determine how stakeholders produce, develop, store and retrieve information concerning construction design processes in Portugal. The researcher had her own experience working in architecture offices and within multidisciplinary teams from the field – the drive for this study. Those circumstances where only the triggers for this project.

The initial literature review showed that there were existing classification information systems elsewhere, but not in Portugal, that there were also protocols and standards developed for that purpose, some were even translated to Portuguese. Although this information was regarded and assimilated, the researcher still had no other information on this matter than that provided by her colleagues in the field; architects, engineers, owners and contractors from construction companies. This was definitely identified as an issue by all but the literature was silent - it was thus thought necessary and timely to conduct research on this matter in Portugal.

Different issues have been considered in determining the most appropriate approach to satisfy the research aims and objectives, as follows:

- The focus of the research is on existing proceedings with little control over the variables under analysis;
- The aim is to answer "how" practitioners are working and "what" do they know exists in the field;
- There is a need for more primary data on existing knowledge and application of classification information systems, protocols and standards in the field that allows for an holistic view of field reality;
- There is a need to get a more in-depth knowledge of different field areas in information management processes, which involve more sensitive data gathering;
- There is a need to entail discussions that provide outcomes from the FCI development as to its requirements and adjustments; and
- The researcher's own personal experience and knowledge in the field is present throughout the whole process of research.

These issues provide the justification for a mixed methods approach considered to be a clear path to develop this investigation.

Overall there are two broad methods of reasoning; deductive and inductive approaches. Both refer to the logic of the research, the role of the existing body of knowledge gathered in the literature review stage and the way the researchers exploit the data collection and subsequent data analysis. A deductive research reasoning entails the development of a conceptual and theoretical structure prior to its testing through empirical observation (Losee, 1993) and it is argued that positivistic research philosophy is more predisposed towards this approach while the interpretivistic (social constructionism) philosophy is more in line with the inductive approach, due to the distinctive philosophical stances of both (Easterby-Smith et al., 2002).

Deductive reasoning works from the more general to the more specific and arguments based on the pursuit of the principles of scientific rigour to maintain independence of the observer. Meaning, at the end of the study, results are expected to be generalised to the population (Saunders et al, 2003) and conclusions follow logically from available facts. On the other hand, inductive reasoning is usually described as moving from specific observations to broader generalizations. The researcher is here considered to be part of the research process, conclusions are likely to be based on premises thus involving a certain degree of uncertainty as observations tend to be used for arguments. Generalizations of theory are not expected as the inductive approach is particularly concerned with the contexts of the research (Saunders et al, 2003).

The main difference between deductive and inductive research thus resides in the use of the current body of knowledge and the distinct role of data collection (Sustrina, 2009). Researchers following a deductive reasoning base their hypothesis on existing stock of knowledge and conduct data collection and analysis to test the hypothesis whilst those engaging in inductive reasoning tend to keep their mind open while formulating an hypotheses for any possible results and conduct data collection and data analysis to resurface findings while using the existing body of knowledge to inform their data analysis when they see proper (Sustrina, 2009).

Although research reasoning is divided into two main groups, some researchers stress the importance of not considering them as two closed divisions in terms of research approach. Instead they emphasize that combining the two is possible and it may enable the researcher to reap benefits from both (Saunders et al, 2003; Yin, 2003; Gill and Johnson, 2002).

> "…theory that is inductively developed will be fitted to the data, thus more likely to be useful, plausible and accessible to practitioners" (Gill and Johnson, 2002:40).

In a mixed methods approach, the researcher tends to use theory either deductively, often linked with quantitative research or inductively as in qualitative research (Creswell, 2003). Thus, of relevance here is also the discussion regarding the benefits and limitations of using quantitative versus qualitative data.

Whereas traditionally a research project would adopt either a quantitative or qualitative paradigm, in the past decades social scientists have engaged in debates regarding the usefulness of a mixed method approach (introduced by Denzin in 1970), i.e. applying both quantitative and qualitative methods to one given research project. The idea being that whereas quantitative research methods may contribute to a more rigorous interpretation process, qualitative research methods may offer the first a solid description.

In what concerns the integration of methods from both quantitative and qualitative paradigms in one given research project, the established literature seems divided between those who argue that it is possible to combine/integrate them both, if they are properly understood and rigorously applied since they address the same phenomena (e.g. Mayring, Cupchik, Kelle, Man, Bowker, Burguess, Fielding & Schreir and Sieber in Fielding & Schreir, 2001; Bryman 1988; Brannen 1992; Denzin 1978, Flick 1992, Fielding & Fielding 1986, Tashakkori & Teddlie 1998); and those who argue that it is impossible to combine them successfully since they are based on distinct theories of knowledge and as such their differences make them incompatible (Lincoln and Guba 1985, Smith 1983, Kleining & Witt 2001; Fielding & Schreir, 2001).

Arguments for the integration of mixed methods vary *“from rather abstract and general methodological considerations to practical guidelines for mixing methods and models in one research design”* (Kelle, 2001:2). For some, like Sieber (1979) one paradigm can be combined with the other as a means to fill in holes and/or solve problems that can arise from using a single methodology approach. Kelle (2001) and Man (2001), for instance, both provide examples of single paradigm research projects that almost failed and were ultimately only overcome when bringing in the other paradigm and combining methods. There are those, however, who go further and defend that although the two paradigms have only to gain from being combined, they need to be inter-related and not just sequenced

(Mayring and Chupchik, Fielding & Schreier 2001). By inter-relating them, quantitative research gains proximity with the research subject and qualitative research gains systematisation ultimately increasing prospect for generalising results. The idea being that both approaches attribute meaning to data. Others yet (Campbell, Fiske and Webb 1959, Kelle 2001; Denzin 1978) value combined methods not for their complementarity but for their validation potential, arguing that *"a hypothesis which had survived a series of tests with different methods could be regarded as more valid than a hypothesis tested only with the help of a single method"* (Kelle, 2001:3).

There are also those, like Kleining & Witt (2001) who alert us for the traps of indiscriminate use of methods from both paradigms. Witt argues that using both does not necessary translate in getting better results, and that in some contexts it is more productive to use a single paradigm (Fielding & Schreir 2001). He is particularly concerned with the use of qualitative methods, believing that due to its interpretative character such methods may often lead in error and only quantitative methodologies can be accurate. One could argue, however, that it might be naive to think that quantitative methods lead to exact and accurate truths. Social sciences have been subject to many different paradigms – positivism, hermeneutics, phenomenology, postmodernism to name but a few – but there are today a few central tenets accepted by most. After Foucault (1966 and 1976) and Kuhn (1962) it is generally recognised that knowledge is historically embedded and related to power. Following from this, is the acceptance that any claims to truth are relative to a particular situation – truth is relative and not final. Knowledge is thus socially constructed and social reality is malleable to multiple interpretations (Delanty & Strydom 2003; Delanty 2005). Thus, quantitative data is also relative as the author's own initial research question is already influenced by position, and social and historical context. Not to mention that survey questions are influenced by the researcher's preconceptions of the issue at hand and that even the most positivist quantitative data is subject to some level of interpretation.

Nevertheless, Witt's argument has merit in that it leads us to an issue of utmost importance: that no matter how much one values the application of combined methods, *"methodological reflections on the integration of methods have to be based on theoretical considerations about the social processes under investigation"* (Kelle, 2001:15). This concern is shared by many (Keller 2001; Shank 2001; Fielding & Shreider, 2001; Dreher, 1994) who believe that research methods to be applied in a given project, whether quantitative or qualitative, should focus on the question one seeks to answer and not so much on the confrontation of paradigms (see Table 4, Creswell, 2003).

Table removed due to copyright restrictions

Table 4 - How quantitative and qualitative paradigms can emerge in a mixed methods approach, adapted from Creswell (2003:13)

Bearing in mind the above discussion and in particular this last point, it became evident when designing the research methodology for this project that a mixed methods approach would be the best option. As we have seen, different methods can be applied to the same research study to acquire a broader picture of the phenomena under study. The intention with the present research methodology design was not to apply different paradigms as a way to validate each other but to gain understanding from a bigger perspective to a smaller scale to better grasp the reality at hand. The methods/techniques that comprise the mixed methods approach for this research are described in the next section.

3.4. Research Methods/Techniques

As identified in Figure 6 (pag.73)., the nested model places the research philosophy in the outer ring and the research approach in the middle ring. The inner ring thus holds the research methods and techniques. After the core considerations of any research regarding its philosophical stance it is important to understand how the adoption of certain methods pertains to be in line with the research philosophy and approach. Figure 7- Sexton´s (2003) “Dimensions of research philosophy: Bringing it all together!” on pag.76) shows the relationships linking research philosophies, approaches and applied methods.

Bearing in mind that while positioning as more intrepretivist (rather than positivist), a mixed methods approach was adopted in this study, even if emphasis is given to qualitative research techniques. Methods used thus comprise: an ongoing literature review; a quantitative survey by postal questionnaire; semi-structured interviews and two focus-group discussions[47]. The discussion will now expand further on the justification for each of the applied methods and how they relate to each other.

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[47] Survey data resulted in changes to the original thesis structure. The initial project’s outline envisaged the use of case studies, which was subsequently eliminated. The case studies, to be conducted in two offices intended to access their current use of Standards and Classification Systems. As it became apparent that offices do not tend to have such systematic use of these, the use of case studies for this purpose became redundant.

The following figure illustrates how these different methods were applied in order to establish and design a classification framework model for information coordination and management throughout the design project and construction.

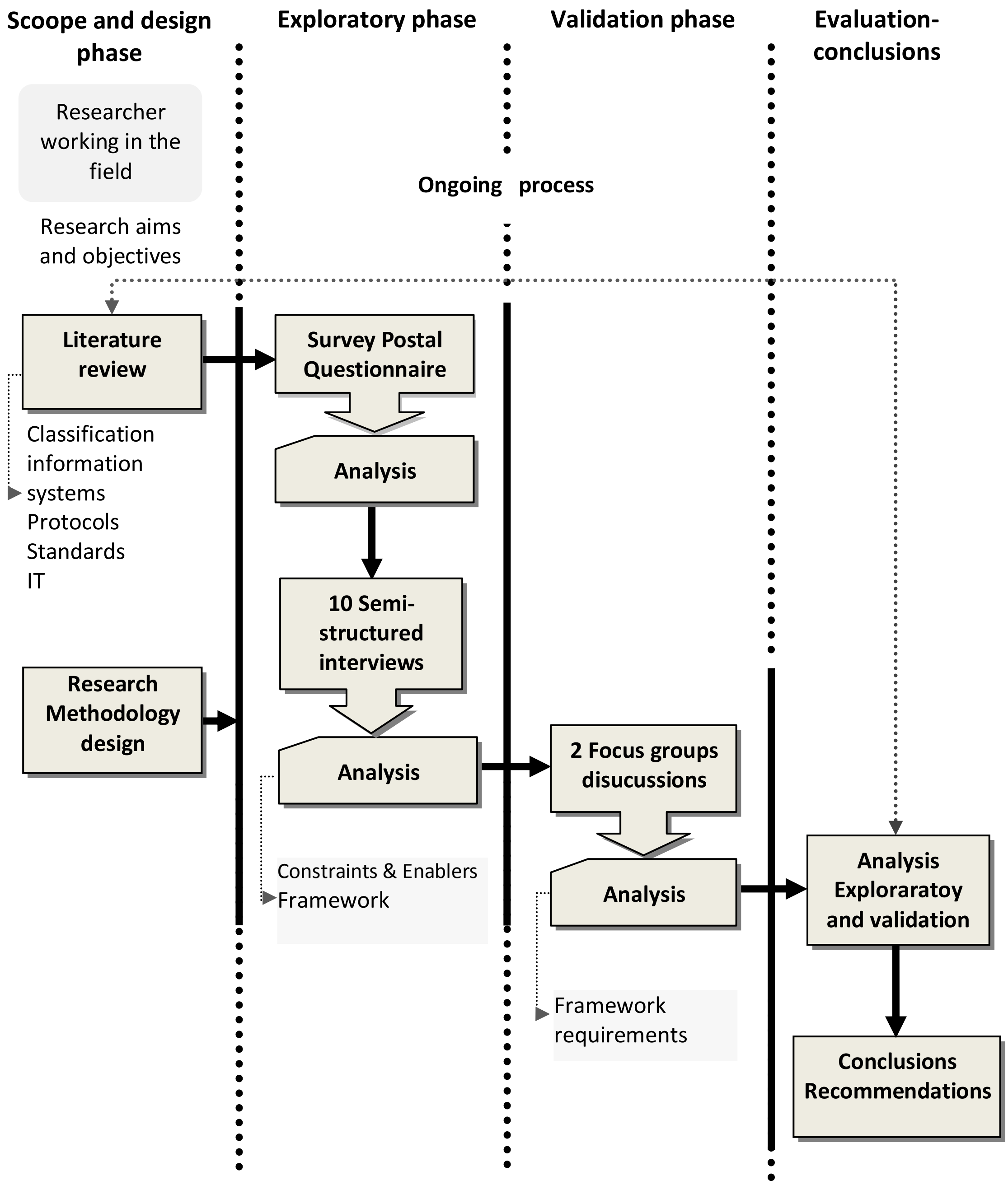

Figure 8- Framework for Research methodology and data collection for this research project

3.4.1. Literature review

The preliminary stages of any research project involve an initial literature review which reveals to the researcher established and generally accepted facts of the state of affairs on the chosen field/theme (Cohen and Manion, 1994) and enables the identification and understanding of the theories or models that have been used by previous researchers in the field (Yin, 2003).

For Eisenhardt and Graebner (2007), a strong literature review is the basis for sound empirical research to identify the research gap and to suggest research questions which address the gap. The literature review is thus a significant source of information as to the developments of further research on any topic as it provides researchers enough information to describe the chosen topic to allow them to refine research directions. It also presents a clear description and evaluation of theories and concepts and it might help in clarifying the relations to previous research and providing researchers with possibilities that have been overlooked so far in the existing literature. Further, it provides insights on the topic of interest, demonstrates powers of critical analysis and equips researchers with arguments to justify new research through a coherent critique of what has been examined and conceptualised before (Gill and Johnson 2002).

There are, however, dangers and limitations to the literature review. There might be a tendency to develop an exhaustive literature review on the topic, becoming overwhelmed with what has been done so far on the field in study. This tends to result in work far too descriptive of previous work instead of building an argument/critique (Gill and Johnson, 2002) that enables the researcher to continue its work in a underexplored area. Also there is often a certain tendency to develop a major amount of descriptive work not having enough time to develop genuine creative work in the field. This is not unusual and in this particular project the researcher struggled with these same issues from the start.

The aim of the literature review in this specific project was thus to enable the researcher to discover what was already known about the theme at hand and allowed the research to be built on previous experience. The initial literature review, as part of the designed methodology, was conducted aiming for a better understanding of existing classification systems. The starting point was the initial research question; ***"How can we design a comprehensive classification information system for project design data in Portugal, accessible to all stakeholders involved?"***

As such, a systematic reading of previously published and unpublished information relating to the area of investigation was conducted. These comprised standards, taxonomy, terminology, ontology, nomenclature, thesaurus, catalogues and library databases, resource management, collaborative working, project process and IT tools. All the above were crucial to identify similar systems that were being developed and applied throughout the world to respond to this recognised problem and identify existing gaps.

Existing classification information systems, standards and protocols for communicating information in the construction industry in other parts of the world were found, and studied. In Portugal, literature was silent as to practitioners' knowledge and use of these systems and no new effective systems developed in Portugal, and in use, were found.

The critical review of existing literature drove the research to the next stage: How could the researcher know what was being done in terms of classification information in the field? To get a more in depth idea of the current scenario and following the methodology design, a survey by postal questionnaire was developed. The researcher faced severe time constraints and as such had to conduct the investigation in a specific area of the construction process and the construction design project was naturally the chosen direction since it covers the first stages of any construction project.

The literature review was an on-going process as it informed the research design process and it was informed in turn by preliminary insights gained during data collection. The initial and on-going literature review conducted throughout the whole research process was carried out resorting to a wide variety of primary and secondary sources including books, journals, conference proceedings, technical reports, PhD theses and the Internet. Its main findings and analysis are detailed in Chapter 2.

3.4.2. Survey questionnaire

Survey questionnaires are a common way of collecting data for theory testing and they are concerned with

> “ ...finding out how many people, within a defined social-cum-geographical area, hold particular views or opinions about things, events or individuals, do particular activities; possess particular qualities; and so on.” (Ackroyd and Hughes, 1992:65)

They are usually conducted for subject matters that are difficult to study by either direct observation or experimental manipulation (Atkinson et al, 1990). There are two main types of questionnaires (Oppenheim, 1992), the descriptive and the analytical survey. The descriptive survey aims to answer questions such as, *how many? who? what is happening, where? and when?* (Naoum, 1998) and it concerns inferences about a population from a representative sample. The analytical survey aims to establish relationships and associations between variables and is used to test specific hypotheses. Analytical statistics are used to interpret the meaning of descriptive statistics.

The survey questionnaire approach in this study was thought to be the most appropriate way to gain knowledge on current conditions, attitudes and to find out what exists at the moment in the construction industry. As such, a descriptive analysis was considered thus facilitating the support of the qualitative research by quantitative research also allowing for some cross-references in trying to understand why certain situations exist. It was hoped, however, that the survey would collect data that could eventually be used analytically in a follow-up research project. However, while the survey was successful in its descriptive component (of utmost importance for the current project), the response rate was insufficient to allow future use for further analytical work and extrapolation of hypotheses.

To understand how a framework for classification information system for construction project design data in Portugal can be considered, one needs to have an idea of who knows what and what is being used in the industry. The initial literature review analysis showed existing approaches such as standards and information classification systems developed elsewhere. Following the work of Ackroyd and Hughes (1992) who support the use of survey questionnaires as a means of understanding and generating factual and attitudinal information, the aim here was to support the research need by understanding to what extend classification information systems and standards are actually known and/or are being used in Portugal. As mentioned above, the literature was silent in terms of empirical evidence in the field. As such, a postal survey questionnaire was included to gather data on the knowledge and use of existing standards and classification information systems in Portugal, as only a survey approach would allow the researcher to reach a broad spectrum of respondents.

Types of surveys

Questionnaires and interviews are commonly used in surveys (Easterby-Smith et al, 2002; Denzin, 1978; Naoum, 1998). With the survey questionnaire the questions are self-administered and in the survey by interview the researcher poses the pre-determined questions.

The idea when conducting the survey was to browse the field for facts on what systems for classification of information were known and were being used. As such, the following had to be considered when deciding the type of survey to administer:

- Portugal is not a small country and the researcher had limited time;
- Information classification systems in the construction project design data process involves architectural firms, engineering firms,

construction companies and local and municipal authorities as well as project owners. The latter are difficult to identify so they were not part of the sample;

- Most Portuguese companies in the construction field are small in size or are family companies;
- People do not tend to have the time or drive to answer questionnaires;
- Classification of information would start at the beginning of the design process chain with designers, architects and engineers;

A survey by postal-questionnaire was thought to be most appropriate for the quantity of data required. Also the completion of postal survey questionnaires is faster and cheaper (Naoum, 1998), requiring only the cost of packaging as opposed to the time and money that would be spent if personal interviews were to take place. As such, it was thought that this way a wider range of the country could be covered. Also postal questionnaires can be completed whenever respondents have time and will, thus not restraining them with a schedule and timed interview.

Postal questionnaires are not without limitations of course. The average response rate is usually low and may be unsuitable for certain groups of people, e.g. those with literacy, language problems or very young respondents (Oppenheim, 1992). These issues were considered when choosing the postal survey strategy. Also in the survey questionnaires, misunderstandings are not possible to correct. Postal survey questionnaires are prone to “closed-ended” or “fixed-alternative” questions (Ackroyd and Hughes, 1992) that require a specific response such as “yes” or “no” or “don´t know” being the simplest, or ranking the important factors[48] as opposed to interviews that generally entail “open-ended” questions, stated to draw biases by some as the interviewer might exert some influence on the interviewee by exalting

[48] One of the most commonly used form of questions importance ranking is the Likert scale (Oppenheim, 1992)

some expectations on his/her wishes regarding the responses (Sayer, 1984). In both there is always the risk of respondents wanting to satisfy the interviewer by providing the answers they believe the interviewer wants to see or hear or the “correct answers” (Oppenheim, 1992; Naoum, 1998). The method of semi-structured interviews as part of in-depth interviews was adopted in the subsequent phase of this investigation and it its characteristics are further explained.

In terms of validity, one has to argue that most postal survey questionnaires are completed without supervision or control therefore it is not possible to know if the respondent filed in the questionnaire seriously, if he had the necessary knowledge and understood the questions being posed. This could be argued to lead to some degree of variability in the results. To minimize this problem the sample selection was chosen carefully in terms of the construction industry field and an item on the respondents’ profile within their company was included. Although this is an issue to attend to in the interpretation of results, it was also considered to be an important finding in its own right, to see who is in charge of coordination of information in the field, i.e. who was delegated with the task of answering the survey.

There is also the matter of the length of the postal questionnaire used. It is argued that postal questionnaires should entail “closed-ended” questions and that they should be short (Easterby-Smith et al, 2002; Naoum, 1998). This was not the case here. Although questions were “closed-ended” and very straight forward, the questionnaire was of considerable length. This was a choice of the researcher in trying to understand more from the field of study and now acknowledges that the validity of the findings from the survey is more dependent upon the quality of its design and subsequent analysis.

The sample

Conducting a survey questionnaire also implies the appropriate choice of respondent’s sample characteristics. In all cases the sample has to be drawn from its population (Oppenheim, 1992; Naoum, 1998). Sample selection is important in the survey design as it will have a direct impact on the survey results. The sampling characteristics have to be the same as its population and representative of the population as a whole (Ackroyd and Hughes, 199; Naoum, 1998). Survey sampling is usually made either randomly or non-randomly[49].

Using random sampling it is important to identify the population from which the sample is to be drawn; in the present case importance was given to companies that would be representative of different fields in the construction industry with major impact on project design, as are architecture offices, engineering offices and construction companies.

Local Municipal Authorities were also considered as they are, in most cases, the ones that examine and approve construction design projects - in this case the choice was not random, it was a selected sample from existing ones. This occurred because it was deemed important to select Local Municipal Authorities that presented higher levels of population (and construction activity). Here the sample was very limited but the rationale behind this decision justified the choice. Not all Municipal Authorities in Portugal have a Project Development department and when they do, these tend to be used for projects related to public equipment and public services, which are not part of the research project here discussed. Additionally it was thought that cities presenting higher population rates might also be the ones with more projects to approve and build and therefore would not only be able to answer the survey, but their insights would be more relevant to the study. Further explanations on the sample selection are given in Chapter 4.

Oppenheim (1992) refers to the need for motivation amongst respondents and suggests some measures for it. For instance, sending a preliminary post-card, the promise of a reward, sponsorship, covering expenses or simply the belief that the survey will have some impact in the future. Response rates might also be increased by sending advance warning letters, inviting participation and guaranteeing participations´ confidentiality and anonymity.

[49] Randomly means that sample selection of respondents is done arbitrarily and without purpose

In this survey questionnaire a letter from the University of Salford was included (see Appendix 2) to attest both the researcher and the survey's credibility. A cover letter was also included stating the nature and purpose of the survey (Ackroyd and Hughes, 1992; Chadwick et al, 1984; Hague, 1994), asking for practitioner's attention and help concerning this issue. The letter also detailed how the data was to be used and ensured confidentiality and anonymity. The researcher did not have the resources to reward respondents but asked for their help in improving the current scenario concerning information in the construction industry. This was proven useful as some participants responded and even put themselves at the researcher´s disposal for further developments in the area. Some survey participants, by their own free will, have expressed the importance they give to this issue, again emphasising the important contribution that this project seeks to make. Ethical approval was obtained throughout the whole process.

Survey questionnaire design

When designing a questionnaire, and not excluding the thoughtful considerations mentioned in the prior sections, it is also important to consider the type of questions to pose, the order by which they should be administered and their wording (Ackroyd and Hughes, 1992; Naoum, 1998). For instance, some filter questions might be asked in the beginning of the questionnaire to filter respondents from particular groups of questions if they are not relevant to them. Also, a decision must be made as to the use of "open-ended" or "closed-ended" questions. The first allow for respondents to speak their mind by using their own words but for this to happen constrictions of space for written responses must be addressed and as they allow for "opinions" they are not easy to analyse and code. Closed-ended questions are easier and faster to answer and are also easier to code and analyse although they do not comprise respondents' thoughts in the subject nor they allow space for, literally, out-of-the-box answers. The researcher chose to pose factual questions related with the background of the individual and company/organization answering, and some opinion questions were also posed.

The need for more information on the knowledge and use of classification systems, protocols and standards for communicating information was the motive for the survey and so when conducting a questionnaire on the field it seemed easier for respondents to provide answers in the form of multiple-choice checklists of existing options (of standards, protocols etc) and see which ones they recognised, which ones they used, how far they understood and worked well with them. In the multiple-choice questions, the response options included the set of all possible choices. These types of questions, closed-ended, factual and opinion were used in the design of the questionnaire as they were thought to be easier and faster to answer if participants had little time.

The researcher acknowledges that “closed-ended” questions might not include the respondent’s preferred answer and this might introduce bias in the response. Further, checklist questions are designed for groups of respondents that have accurate information and can answer questions with a high degree of certainty but they may also induce bias as some answers that might have not been considered are suggested.

To try and minimize these issues the questionnaire begins with ‘easy’ questions requiring answers in ticking boxes and then moves forward to those that require more thoughtful consideration from respondents (Hague, 1994), with some response alternatives always given. Also, some “open-ended” questions were included in the final section of the questionnaire but space for written responses was given to allow for a more personal opinion on the subject.

Ackroyd and Hughes (1992) and Chadwick at al (1984) argue that when designing the questions, one must pay attention to the order by which they are posed - if more relevant questions on the subject are to come first or towards the end. Question wording must be considered - wording should be clear avoiding sophisticated, uncommon and esoteric language, ambiguous meanings and leading questions. For instance, always avoid questions that might induce bias, such as “do you agree with…..” (Hague, 1994).

So as to avoid some sensitive questions to participants in the "fixed-alternative" questions, some alternatives should be given like "I do not know" or "unsure" (Ackroyd and Hughes, 1992) and "others" in fixed response questions (Hague, 1994). These options were included in the questionnaire as an effort to cover as many ranges of responses as possible thus reducing the non-responses and it was felt, to enable any statements that were inapplicable or understood to the particular respondent to be easily identified. Screening questions were also included but used carefully as to reduce confusion and proper instructions as to its follow up were given (Chadwick et al, 1984). Once the questions were devised, they were grouped and categorized in main headings into a logical sequence so that the overall survey would be easier to complete and analyse (Hague, 1994). The first part of the questionnaire entailed instructions to participants as to how fill it out.

All aspects of the questionnaire, including question content, wording, sequence, form and layout, question difficulty, and instructions were tested by several practitioners representative of the population it was designed for: architects, engineers, contractors and municipal authorities. Only after the necessary adjustments were made was it carried out nationwide. The adjustments made were mostly in wording and length, although respondents that tested it stated that it was not difficult to answer. The researcher admits that the length of the questionnaire might have decreased the number of participants.

The survey was then sent by post and each envelop sent contained a cover letter, a letter from the University of Salford attesting the researcher's credibility in conducting a survey as part of her research on classification information for construction design project, a copy of the questionnaire and a self-addressed, stamped return envelope.

Statistical analysis

Typically the measures for each respondent are entered into a computer and manipulated in a variety of ways. Usually, various averages are calculated, percentages are computed, the data is analysed for statistical significance and correlations, in short, to *"make sense of data"*, i.e. test the hypothesis, and to compare results for various sub-groups (Oppenheim, 1992).

Oppenheim (1992) and Chadwick et al (1984) refer to two ways to analyse the data generated by survey questionnaires: descriptive analysis or statistical inference, corresponding to the descriptive and analytical survey types described above.

Chadwick et al (1984) identifies five steps to be taken in survey data analysis;

1. *Coding*; responses are converted into numbers to make their handling easier;
2. *Data entry,* coded data are entered on to computer and every variable is checked to make sure that there are no illegitimate or impossible answers*;*
3. *Descriptive analysis*, refers to evaluating how responses to individual variables are distributed using methods such as frequency measures of central tendency to describe a central representative point (e.g. mean, mode, median), and measures of variation which describe the spread of scores around the average score (e.g. standard deviation). These measures help to describe findings;
4. *Cross-tabulation*, where relationships between two or more variables are examined;
5. *Testing relationships between variables*, attempt to assess the relationships or associations revealed by the data, measurements that are conducted to allow the researcher to determine if a relationship is statistically significant - *inferential statistics* and/or *measures of association* are the statistics that assess the strength of the relationship between variables. Statistical tests of significance are applied for hypothesis testing.

Descriptive statistical analysis was first used to report the findings from the data gathered and cross-relations were used to describe particular relations between data, e.g. if practitioners working with or within international teams or projects might show more knowledge and application on existing systems and standards than the ones that only work with Portuguese teams or in projects in Portugal. The quantitative analysis of the data gathered was done through a statistical package, SPSS, Statistical Products and Service Solutions[50], version 16, licensed to the researcher via the University of Salford.

Reliability and validity

Validity seeks to ask every researcher's daunting question: how can we be sure that the survey measures the attributes that it is supposed to measure? (Easterby-Smith et al, 2002) Validity then refers to the accuracy of the measurement process, and this is not easy to ascertain as of course, " *if one had a better way of measuring the attribute, there would be no need for a new instrument*"(Easterby –Smith et al, 2002:134). Reliability on the other hand, regards stability and measurement of consistency, i.e. to what extent a measuring device yields the same results if applied to the same person or group of people, under similar conditions, more than once on different occasions (Easterby-Smith, 2002; Gill and Johnson, 2002).

According to Oppenheim (1992) and Gill and Johnson (2002) reliability and validity are not always related, as reliability is necessary but not sufficient for validity and invalid measures may be reliable. As such the reliability and validity of a survey should not be considered in separation and procedures employed should be uniform in order for both conditions to exist.

As seen from the above discussion, in questionnaire design, for a survey questionnaire to be reliable it must be consistent, reproducible, well administered and coded. A survey cannot be considered reliable if it is confusing, if it allows for ambiguity and misinterpretation, if it does not provide sufficient depth to measure

[50] Formerly known as Statistical Package for Social Sciences.

what is being tested and if results were obtained on different occasions or incorrectly scored. This was carefully thought through when developing the survey for this particular project; the research aimed at straightforward, “closed-ended” questions that would be easy to answer, the survey was conducted nationwide and all questionnaires sent out at the same time.

To ensure reliability, certain procedures can be adopted. Gill and Johnson (2002) defend that the most simple manner to test reliability is to replicate; either by administering the same questions to the same respondents at different times or by asking the same questions in different ways at different points in the questionnaire. Oppenheim (1992) agrees and suggests the inclusion of trick/bogus questions on multiple-choice questions.

This is relatively easy in “closed-ended” questions and the researcher necessarily limits subjects’ answers to a preset set of responses which have encoded the requisite measures and thus are readily compared and calculated, allowing for comparison and statistical manipulation (Gill and Jonhson, 2002). In opinion questions this is not so easy to achieve as questions cannot be asked twice using different wording since if the wording is changed it automatically becomes a different question which is not the intention (Oppenheim, 1992). Reliability can be increased by using sets of questions relating to an attitude to maximize the more stable components of the attitude being measured.

The complex linkage between attitudes and behaviours as to their unpredictability makes it hard for external validity as no secondary information source is directly related to them. This is not the case with factual questions where external checks can be done using secondary information as in official records or second informants. Open-ended questions leave participants free to answer in their own way but due to the lack of structure are difficult to code and analyse across large samples. Yet they avoid some traps of closed questions which can limit, distort and be so fixed as to not allow respondents to speak their mind and thus prevent certain data being collected (Gill and Johnson, 2002).

Easterby-Smith et al (2002) argue that tests for reliably and validity should be done at the pilot stage of the research before the main phase of data collection, but this is not always possible due to time and costs constraints. The survey questionnaire designed and applied in this project considered the described issues of reliability and validity. All surveys were administered and scored in the same way and a pilot was conducted before they were sent out. Attention was also paid to issues of validity and reliability at the pilot stage of the survey and reliability was ensured when the wording was changed after the tests were conducted. Replication, though, was not used as often as it would be desired because it would increase further the length of the survey, but the feedback given by respondents of the pilot survey indicated that the answers were being correctly understood in any case and that no options in the multi-check answer list were missed. Data arising from the survey postal questionnaire is presented in Chapter 4.

3.4.3. Semi-structured interviews

Based on insights arising from the survey data analysis, semi-structured interviews were designed to be conducted with practitioners and relevant authorities in order to clarify and contextualise issues arising from its data analysis by identifying the requirements involved in a construction project in Portugal and to find out if and how they use standards. The use of mixed methods here was thus a means to produce a more complete picture of the phenomena under investigation.

The most fundamental of all qualitative methods is that of in-depth interviewing (Easterby-Smith et al, 2002). Their importance as a qualitative method is to describe, decode, translate and/or understand the meaning, not the frequency, of occurring phenomena in the social world. They provide a rich account of the interviewees' experiences, knowledge, ideas and impressions, which can be documented (Alvesson, 2003). According to Boyce and Neale (2006), in-depth interviews are a qualitative research technique that involves conducting intensive individual interviews with a small number of respondents to explore their perspectives on a particular idea, program, or situation. Therefore, the in-depth interview is a technique designed and used to extract a vivid picture of the participant's perspective on the research topic. In the words of Burgess, the interview *"(...) provides the opportunity for the researcher to probe deeply to uncover new clues, open up new dimensions of a problem and to secure vivid, accurate inclusive accounts that are based on personal experience."* (1993:165). In this sense, in-depth interviews yield a richness of information.

The objective of their application in this phase of the project was a means to establish and validate the factors influencing the development and adoption of a classification information system in Portugal to thus enable the researcher to formulate the FCI.

In-depth interviews comprise a broad range of types of interviews from totally unstructured or non-directive open interviews all the way to the structured interview. Somewhere in the middle of the continuum are semi-structured interviews (Easterby-Smith et al, 2002; Burgess, 1993, Ackroyd and Hughes, 1992). Cohen and Manion (1994:273) prefer to group interviews into four kinds: 1) the structured interview, 2) the unstructured interview, 3) the non-directive interview, and 4) the focused interview. Oppenheim (1992), on the other hand, grouped interviews essentially into two kinds, exploratory, depth or free-style interviews and standardised interviews, such as the ones used in market research and government surveys. However one wishes to categorise different kinds of interviews, the importance is that the interview is prepared by the interviewer to the degree of structure that he/she intends for its purpose. In this case a semi-structured interview approach was adopted as a means to allow for the interviewee to express thought on the subject allowing enough freedom to deviate to some extent from some questions. This was thought to provide a more clear insight on what practitioners think of classification of information and exactly what they do about it without the interviewer losing track of the conversation.

In any form of in-depth interviews, the researcher conducting the interview has a decisive role and must be able to make the most of the opportunity to gain insights from the interviewees. This is not easy, as one can easily be distracted or not fully sensitive to the interviewees actions and the result might be a superficial exchange of information (Easterby- Smith et al, 2002).

Alvesson (2003) and Easterby-Smith (2002) point out that although interviews are considered one of the best methods for data gathering, its complexities are sometimes underestimated by researchers as they are in situations that are socially, linguistic, and subjectively rich. Yin (2003:86) described the main weaknesses of interviews as being:

- Bias due to poorly constructed questions;
- Response bias;
- Inaccuracies due to poor recall;
- Reflexivity- the interviewee gives what the interviewer wants to hear.

There are key characteristics that set in-depth qualitative interviews apart from a regular interview, and according to Boyce and Neal (2006) and Guion (2006) these entail;

- Open-ended questions;
- Semi-structured format;
- Questions seek clarity and interpretation;
- Style is conversational, but never forgetting that the researchers' role is that of a listener;
- Recording responses, observations and reflections.

In-depth interviews involve more than asking questions - they involve the systematic recording and documenting of responses attached with probing for deeper meaning and understanding of the responses. An important issue in the interview is the researcher´s skills to conduct them. Many authors mention this (Easterby-Smith et al, 2002; Chadwick et al, 1984; Ackroyd and Hughes, 1992; Denzin, 1978) but Openheim (1994:70) summarised it well *"the interviewer should be able to maintain control of the interview, to probe gently but incisively and to present a measure of authority and an assurance of confidentiality."* In fact when conducting interviews, researchers have to develop their skills as to make interviewees at ease and not induce bias.

One might see an interview as an absolutely normal conversation between two or more individuals, but the fact is that in-depth interviews demand, from the interviewer, the capacity to effectively and actively listen, be patient enough to allow interviewees to speak, be able to notice and react to nonverbal clues, be flexible, be open minded and establish a conversation with a stranger about a particular topic that might even be sensitive to the respondent. All this has to be accomplished in a determined time frame.

Examples of useful "*probes*" given by Easterby-Smith et al (2002) are;

- The *basic probe* involves repeating the initial question;
- *Explanatory probes* involves building on incomplete or vague statements made by the respondent. e.g. "what did you mean by that?"
- *Focused probes* are used to obtain specific information, e.g. "What sort of...?"
- The *silent probe* may be used when the respondent is either reluctant or very slow to answer the question posed, it involves pausing and letting the interviewee break the silence;
- The *drawing out* technique can be used when the interviewee has halted or dried out and it involves repeating his/her last few words and saying, "tell me more about that";
- *Giving ideas or suggestions* is about offering the interviewee an idea to think about like "have you thought about...?", "have you tried..?"

- *Mirroring* or *reflecting* involves expressing in the interviewers own words what the respondent has just said.

Semi-structured interviews have predetermined questions, but their order can be modified upon the interviewers` perception of what seems appropriate at the time (Ackroyd and Hughes, 1992). This way they allow the interview to have a general purpose and focus, but still be flexible enough to explore emerging issues.

The interviews conducted as part of this research project had an exploratory and clarifying nature. Semi-structured interviews seemed the most appropriate approach as it gave focus to the interviews but still allowed for exploration of emerging issues. The researcher understood the weaknesses mentioned and to reduce their effects on the interviews she recorded and accurately transcribed all interviews. By audio taping the interviews the effects of poor recall were diminished and allowed for descriptive analysis to be conducted. Further notes on respondents´ behaviour when asked certain questions were also taken.

In this project, the researcher sought to maximise interview skills in order to minimise the pitfalls and limitations mentioned above. This was accomplished through extensive reading on interview skills and through conducting practice ‘mock’ interviews with a variety of ‘mock’ respondents. This proved very successful in helping to understand and develop appropriate posture and attitude as an interviewer.

The process of conducting in-depth interviews follows the same general process as happens with other research approaches, including planning, developing instruments, collecting data, analyzing data and disseminating findings (Boyce and Neale, 2006). Kvale (1996 in Guion, 2006) details seven steps to conduct in-depth interviews, namely:

- *Thematizing:* refers to the establishment of the purpose of the interviews and to determine what the researcher pretends to find out;

- *Designing*: establishing an interview guide with a list of focus questions that guide the interviewer through the interview;
- *Interviewing*: entails also the researchers and the study introduction, asking permission for recording and note taking;
- *Transcribing*: listening through the interviews and reproducing them verbatim;
- *Analyzing*: determining the meaning of the information gathered and relating it to the purpose of the study to make sense of the data;
- *Verifying*: checking for credibility and validity of information gathered;
- *Reporting* the research findings through the interviews conducted.

These seven points, along with the reflections detailed above, were considered when developing and conducting the semi-structured interviews within the scope of the research study.

Content analysis

Content analysis is one of the most traditional procedures for analyzing textual material wherever it might be from; media products or interview data (Bauer, 2000 in Flick, 2006):

> "Content analysis is any technique for making inferences by objectively and systematically identifying specified characteristics of messages" (Holsti, 1969 in Chadwick et al, 1984)

The interviews conducted in this project involved ten practitioners from different field areas within the construction industry and the purpose of the interviews was to gain in-depth knowledge of field reality in terms of stakeholders' thoughts and ideas regarding information classification for construction project design data. The design and conducting of the interviews generated data that allowed for appropriate treatment to make sense of the data. The content analysis of the interviews was done manually and mainly based on the technique described by Schmidt (2004), which comprises the following five stages;

1. In response to the material, *categories for the analysis were set up*; this was done through an intensive reading of the material (interviews) and identification of topics that were discussed, individual aspects that could be related to the contexts of the research question and topics that arose and were not foreseen;
2. *Categories were brought together in an analytical guide*; in this case categories for analysis were constructed based on the research question;
3. *All interviews were coded according to the analytical categories*; coding means relating particular passages and expressions used by interviewees in the text of an interview to one category;
4. On the basis of the coding, *case overviews* can be produced;
5. *Detailed case interpretations*; the goal of this stage is to discover a new hypothesis or to test a hypothesis on a single case.

Since interviews were conducted among ten stakeholders in this last stage, the researcher chose to draw some conclusions and ideas from more than one case, and in the overall semi structured analysis, cognitive mappings[51] were drawn from notes taken by the researcher as a means to better understand and relate the thoughts/insights of respondents. The researcher agrees with the thought defended by Easterby-Smith et al. (2002) that, however tackled, the method should permit the researcher to draw key features out of the data, whilst at the same time allowing the richness of some of the material to remain so it can be used to evidence the conclusions drawn and to help to let '*the data speak for itself*'.

Although none of the interviewees asked to have their names disguised in the thesis or any publications deriving from this work, there was no particular need to

[51] Cognitive mappings are used to structure, analyze and make sense of accounts of issues mainly used in focus group discussions, offering an holistic picture without losing detail thus providing the researcher with a perspective the data gathered as well as a useful way of planning the next steps (Easterby-Smith et al, 2002)

disclose their identities. As such, and following standard research procedures, their names have been changed. The same applies to focus group participants.

3.4.4. Focus groups

Focus groups can be used for a multitude of purposes, and in a variety of settings. In focus group discussions a small group of informants is brought together to discuss a particular issue. This approach is usually used as part of action research.[52]

The researcher, assuming the role of moderator, asks open questions or raises issues to the group while facilitating the discussion. Because they foster discussion and interaction among informants on a particular topic, focus groups are particularly valuable in generating new ideas and facilitating a better understanding of people's perceptions and concerns. They allow informants to share and discuss among themselves their own experiences and opinions (Stewart et al 2007: Morgan 1997: Hopkins 2007). As pointed out by Easterby-Smith et al (2002), focus groups take the form of loosely structured *"steer conversations"*.

According to Morgan (1998) focus groups are useful for orienting oneself to a new field, generating hypotheses based on informants insights, evaluating different research sites or study population, developing interview schedules and questionnaires or getting participants' interpretations of results from earlier studies. Bearing this in

[52] The aim of action research is to have a direct and immediate impact on research and therefore it is accepted that change should be incorporate in the research process. The main idea is that when trying to understand something well, one should try changing it. In action research high importance is given to the establishment of collaboration between researcher and research participants as a way of developing shared understandings (Easterby-Smith et al, 2002). According to Gill and Johnson, (2002) the first conscious use of the expression is generally attributed to Kurt Lewin in the 1940s, a social psychologist concerned with applying social science knowledge to solve social problems. Its main feature was that it should be focused on problems and it ought to lead to some kind of action and research on the effects of that action by understanding the dynamic nature of change and studying it under controlled conditions as it took place. In action research " *the solution of the problem,frequently some aspect of organizational change, is both the outcome of the research and a part of the research process*." in Gill and Johnson, (2002:11)

mind, focus group discussions were conducted with practitioners from different fields of architecture and engineering to test and validate the FCI, in order to better identify 1) its strengths and flaws, and 2) other elements, constraints and enablers that might need to be altered, deleted or incorporated.

In the semi-structured interviews the role of the researcher was that of an interviewer and it involved certain skills, as seen above. In the focus groups discussion the researcher's role is that of a "moderator" and the added complexity of the situation means that the skills of initiating and facilitating discussion are most relevant in groups (Easterby-Smith et al, 2002). According to Flick, (2006), the task of the researcher is even more insidious as the interviewer/researcher has to sometimes prevent single participants or partial groups from dominating the discussion and the whole group, while at other times should encourage reserved members to be more involved and participate with their own views in the discussion thus obtaining opinions from the whole group to cover the topic as well as possible. Also there is a need for the researcher to have the sensibility to balance two roles in the discussion: 1) steering up the group and 2) to moderate it when needed. This involves direct and non-direct interventions from the researcher (Easterby-Smith et al, 2002; Flick, 2006).

Patton (2002) defends focus group discussions as interviews arguing they should be seen as such, with the strengths being that it is a highly efficient technique of qualitative data collection providing some quality controls on data collection since *"Participants tend to provide checks and balances on each other which weeds out false or extreme views. The extent to which there is a relatively consistent, shared view can be quickly assessed"* (Patton, 2002:386). Its weaknesses are the limited number of questions and the problem of note taking while being a moderator (Flick, 2006). This was diminished by providing a board with the FCI as well as its enablers and constraints which the researcher previously identified through the survey postal questionnaire and the semi-structured interviews. The board was also used as a means to write and draw participants' ideas and opinions. Further, it was asked if the focus group discussions could be recorded and this was permitted.

As the framework is intended to be used and understood by professionals engaged in the design stage of the construction project, like architects or engineers, focus groups were composed of practitioners with those skills but located at different hierarchical levels. The existence of such power hierarchies within each focus group may raise concern as individuals located lower ranks may be reluctant to speak against the opinions expressed by those above them. This can only be minimised by being attentive to the focus groups dynamic, and by interviewing individually a small sample from each focus group in order to validate findings from focus group sessions.

One of the offices where the focus groups discussion took place is an architectural firm where the researcher has worked as an architect before, but not at present. Having chosen an office where she has worked and established personal and professional relations with its staff has the added advantage that the researcher is more tuned to the power dynamics of the group, but may lead participants to want to ´be nice´ in their feedback. This was minimised by assuring that the researcher was not personally offended by their negative comments or remarks on the work undertaken and that their honest feedback was of utmost importance to the project. Also the focus group was conducted in their architectural office facilities, but some participants were not employees of that office The second focus group session was carried out in an engineering company office and it comprised engineers from different specialities and again, from different companies.

In both focus group discussions, the researcher presented the framework, its enablers and constraints and asked participants to recognize or redraw what they didn´t see fit to be there and explain why. After, they were asked for clues/ideas as to how the issues identified as constraints could be overcome. This allowed stakeholders involved to gain a broader idea of the problem and the perceptions of their peers (the survey respondents and interviewees) as well as engage them in the solution.

After the focus group discussions, the researcher transcribed the notes as well as the sound scripts collected with the help of an audio recorder. The boards' ideas and insights from participants were also noted down. Focus group discussion analysis was accomplished through the cognitive mapping of the sessions and content analysis. A cognitive map is a description of an individual or several individuals' concepts about a particular domain, being composed by ideas and links between these ideas (Miles and Huberman, 1994).

Taking into consideration focus group feedback and analysis, the FCI was subsequently altered accordingly. Only with a focus group approach was it possible to gain an overview of feedback from the work undertaken in this study in trying to understand what should be the requirements of a classification information system for the construction design process in Portugal.

3.5. Validation

The researcher fully understands that the qualitative data collected as part of this research project can be limited on the basis of lack of measurability. Although procedures were installed to overcome this in the data analysis, the data gathered through the survey was triangulated with the one gathered from the semi structured interviews and focus group analysis. The FCI presented is thus a product of the convergence of the results through the overlapping of data sources. According to Yin (2003) and Morse (1991), this allows researchers to observe the empirical evidence in different ways to seek a convergence of the results through the overlapping of data sources, adding scope and breadth and supporting the construct validity of the research design.

The combination of methods in a study of the same phenomenon was applied to develop a deeper understanding of the hypotheses and was not used merely to prove that the hypotheses were correct but rather to try to develop a deeper understanding of the subject. Campbell and Fiske (1959) argued that more than one method should be used in the validation process to ensure that the variance reflected is that of the quality and not of the methods - as such the research design should be sufficiently rigorous to provide support for the study to be credible and honest (Fielding and Fielding, 1986; Kelle, 2001).

Sustrina (2009) defends that the integrity of the findings in qualitative research is demonstrated through rigour, thoroughness, the appropriateness of the method adapted to tackle the research question, representativeness, demonstrating that the research subject are in position to corroborate or disapprove the researcher’s interpretation on the matters being discussed. To do so, it is not unusual to overlap various data sources thus providing results from different angles.

Lincoln and Guba state that: *"since there can be no validity without reliability, a demonstration of the former [validity] is sufficient to establish the latter [reliability;]"* (1985: 316). With regards to the researcher's ability and skill in any qualitative research, Patton (2002) also defends that reliability is a consequence of the validity in a study.

As seen in the section dedicated to the survey, the terms validity, reliability and generalization should be considered in the research process as their meaning varies considerably with the philosophical viewpoint adopted (Remenyi et al, 1998; Easterby-Smith et al, 2002). As interpretative research is different in nature from positivist approaches, the standards used should also be different, and they usually refer to whether there has been consistency and integrity of the data and the appropriateness of the methods used in carrying the research project (Sustrina, 2009; Remenyi et al., 1998).

Ethical issues were also considered as an essential component of the credibility of the research findings. These entail the appropriateness of the researchers´ behaviours in relation to the rights of subjects of the research or those who are affected by the research (Saunders et al, 2000).

3.5.1. Validity

The issue of validity is viewed differently from within the various approaches to social inquiry as mentioned before. In this project, from an interpretivist position, validity concerns whether the researcher has gained full access to knowledge and meanings of respondents (Remenyi et al, 1998). In this study the researcher promoted the necessary contacts for this to occur.

A variety of sources of evidence and multiple informants were consulted in this project aiming to address the issue, thus allowing the triangulation of data collection and analysis, seeking to achieve robustness throughout the process. Different techniques were used to gather data aiming to provide support for definitive conclusions and further recommendations. As mentioned in the described methods applied in this study, there was always a concern with guaranteeing process transparency not only in the choice of informants and the techniques employed, but also in the analysis of data. The researcher established good relations with the informants and the resulting outcome - the FCI - is thought to be useful in the implementation of a classification information system for construction design projects in Portugal.

3.5.2. Reliability

According to Easterby-Smith et al (2002), and Gill and Johnson (2002) reliability refers to how replicable the study is, meaning the extent to which another researcher would produce similar observations on a different occasion. This is not without difficulty as it is argued (Remenyi et al, 1998) that it is not possible to obtain the exact same results by replicating the same procedures as each organization is different and each researcher has its own perceived ideas of the world.

The researcher is aware that there is no way to be sure that if another researcher was to conduct the same project using the same approach on a given time there was no change in extraneous influences such as an attitude change that might have occurred which could lead to a different set of outcomes. The consistency of data is achieved when the steps of the research are verified through examination of such items as raw data, data reduction products, and process notes (Campbell, 1996 in Golafshani, 2003).

3.5.3. Generalisability

The generalisability of research findings refers to the extent to which it is possible to draw conclusions from the selected sample to the wider population (Easterby-Smith et al, 2002). In other words, it concerns the applicability of theories developed in one setting to any other setting (Robson, 2002).

Based on the in-depth investigation undertaken with different stakeholders involved in the construction design project process, and using the identified techniques, the outcome of this research could be applied to similar realities. More specifically, the knowledge and understanding gathered that led to the identification of the constraints and enablers affecting the development and implementation of a classification information system can be applied to the whole country, since research participants´ work in different parts of the country.

The framework developed could thus be generalized and might even be used in similar realities as the survey sample included large, medium and small companies, which was compounded with in-depth analysis of field work with stakeholders from different areas of design projects. Although the researcher has some reservations on the idea that generalization can be drawn for countries with a cultural background much different from that of Portugal, this framework can be seen as a template to be adapted to local specificities or a starting point for others to build from. Data resulting from semi-structured interviews and focus group discussions is presented in Chapter 5.

3.6. Conclusions

This chapter discussed the methodology devised for this research project, where an interpretivist research philosophy was adopted and emphasis was given to a mixed methods approach. The chapter presented a discussion of key conceptual and methodological design issues that were central to this project and to understand the factors that influence the adoption of a conceptual framework for the classification of information in the construction project design in Portugal. It has also addressed issues of ethics, and features of validity, reliability and generalisability.

Overall, the methodology devised proved successful in collecting and analysing data needed to adequately answer the research question and in overcoming limitations inherent to this research project. It provided the conceptual, analytical and practical tools that allowed development of the framework that this doctorate sought to devise.

The following two chapters will present the discussion of data collected before the framework is presented in the final chapters.

4. COLLECTION AND ANALYSIS OF QUANTITATIVE DATA

Chapter three focused on setting out the design and development of the methodology used in this research. This chapter concentrates on describing the main quantitative data collected and its analysis, within the context of the research question.

The literature review showed that there are systems in place in several countries, and most importantly for the project at hand, in Europe. Considering that these systems are available and that there are no references regarding their use in Portugal, or of any other systems for that matter, the question arises of what stakeholders do with the information produced, gathered and stored during a project's design life cycle?

A survey was thought necessary to collect data, not only on the knowledge of Standards and Procedures and Classification Information Systems by stakeholders in construction projects, but also about the use they make of these. To design a framework, it is first necessary to identify the user's requirements and knowledge on the subject under study. As such, it was essential to understand the reality on the ground, i.e. what Portuguese practitioners know about the matter at hand and the use/application they make of it throughout a project's data process. As it is intended that the framework (**FCI**) is capable of cross-referencing with other countries and working within and between teams, it also became of utmost importance to understand what is known and used in Portugal so that the framework could be developed from there. Thus, to accomplish the objectives of this project, a questionnaire was sent, by post, to 400 Portuguese companies that perform activities in the building construction area. By the 30th December 2008, 61 were returned fully answered – these comprise the valid sample from which data on this chapter is based.

This chapter starts by detailing the sampling and application of the survey. The following section examines the analysis of data resulting from the statistical work done to each questionnaire question. This is the analysis of the statistical data in light of the research questions. The main findings are discussed in the last section of the chapter.

Survey: Knowledge and Use of existing Standards and Procedures and Classification Information Systems for Construction Projects in Portugal

4.1. Application of the Survey Questionnaire

In light of the literature review findings, it was thought that a survey by postal questionnaire would be the best way to address these issues as it enables a wider reach, i.e. a broader variety of stakeholders in the field covering a larger part of the Portuguese territory. Furthermore, it is more efficient both in time and financial regards, than interviewing, where the researcher would have to spend an enormous amount of time and financial resources to conduct and obtain such a professional and geographical variety. However, the survey approach setbacks – as explored in Chapter 3, such as low response rates and inability to actually see how respondents answer the questionnaire *in loco*, are acknowledged.

Also as detailed in Chapter 3, the survey analysis was descriptive as the idea was to grasp the actual panorama of knowledge and use of existing Standards and Procedures and Classification Information Systems for Construction Projects in Portugal. To conduct the survey analysis, a database in SPSS was created and survey data was inserted, cleaned, and compiled in a statistics report structured on a question-by-question basis[53].

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[53] In order to carry this through, training was attended both on statistics and on the use of SPSS, as the researcher's initial skills were insufficient to allow her to make the best use of the survey data. Such training was not initially envisaged and it revealed to be more time-consuming than expected thus delaying considerably the research progress.

The survey was considered the best way to gather this data since on the one hand it allows questioning a higher number of companies in the field and on the other the required information adapts well to a questionnaire structure. The questionnaire structure is thus three-fold:

A. Norms and Standards applicable to building construction projects.

B. Information Classification Systems.

C. Production, storage and management of information systems in offices/companies in the civil construction field.

4.2. Survey Sample Selection

In May 2008, a total of 400 surveys were posted to Portuguese companies that perform activities in the building construction area: 161 to Architects, 116 to Engineers, 120 to Construction specialists and 3 to local municipal authorities. By the 30th December 2008, 61 out of the 400 sent were returned fully answered – these comprise the valid sample that was then statistically analysed using SPSS[54].

When carrying out a questionnaire, one of the main issues is how to identify and access possible respondents and how to ensure that the sample is valid, diverse within its parameters and as little biased as possible. This survey was designed to be sent by post to 4 different types of respondents by random sampling: architects' offices, engineers' offices, construction offices and Municipal Authorities.

When it came to the first two groups it became clear that the only place where the researcher could access addresses of a variety of architecture and engineering offices would be through the Yellow Pages. It is of course understood that not all offices are registered in the Yellow Pages and that as such the survey sample would be biased towards offices that invest in their marketing and promotion, but as there is

[54] Please see Appendix 2 Survey questionnaire and Cover Letter sent to the 400 companies and Section 4.4 for details the data resulting from the statistical work done to each questionnaire question.

no other comprehensive listing of such offices, this was the only option available. There were 1610 architecture offices and 1160 engineering offices registered in the Yellow Pages in Portugal in 2008[55]. Choosing random sampling, the survey was sent to every 10th architect and engineer office registered in the national Yellow Pages. However, in order to ensure that the sample included at least a few offices involved in international projects or working with international teams, 60 surveys were sent to such offices/construction companies. This was important in order to test the prevalent assumption in the field that Portuguese offices involved in international projects have a better understanding of Standards and Classifications and make better use of them.

Construction offices, on the other hand, were identified through AECOPS,[56] an institution where all active construction companies have to be registered and which totalled 100.090 registrations in 2004[57]. Although for consistency purposes this sample could have been also identified through the Yellow Pages, it was thought pointless as AECOPS offers a more reliable and comprehensive listing, broken by business volume and number of workers, and the researcher was able to access it. This broken down list presented the researcher with another decision: should the sample of this group be restricted to those companies with a higher business volume, as they are considered to be ahead regarding information classification, storage and management, or go ahead regardless of business volume? After careful and attentive reflection it became clear that taking business volume as a way to restrict this sample would not be productive for the purpose of this study as Portugal is a country where small and medium companies prevail well above those with higher business

[55] To note however that some of these offices entail professionals from both areas, i.e. architecture and engineering.

[56] AECOPS - Associação de Empresas de Construção e Obras Públicas e Serviços; is one of the largest Portuguese sector association, and the principle structure representing companies operating in the construction sector. (Association of Construction Companies, Public and Services).

[57] This data is compiled in reports published by the InCI, the last of which dates from 2004, thus representing the most updated data. The report can be accessed at http://www.ine.pt/bddXplorer/htdocs/printable.jsp?id=c1c0071b30d86f1

volumes. As such, a total of 120 surveys were sent to every 50th company registered with AECOPS.

Regarding Local Municipal Authorities, from the existing 308[58], three only were chosen: Lisbon, Porto and Braga. These were chosen due to the higher population numbers[59] of their constituencies. Here the sample is clearly very limited but the rationale behind this decision justified the choice. Not all Municipal Authorities have a Projects Department and when they do, these tend to be used for projects related to public equipment and public services, which are not part of this research project. Further, it was thought that cities presenting higher population rates might also be the ones with more projects to approve and to build, and therefore would not only be able to answer the survey, but their insights would be more relevant to the study.

It is not the case that it is unimportant to include more Municipal Authorities in the sample. However, given time and budget constraints[60] it seemed logical to prioritise those working on the ground. From a legal and institutionalised point of view, if the Local Municipal Authorities were to know and use standards and classification information systems this would imply that the practitioners would have to use them too. Yet, the researcher's own experience as a practitioner in the field meant that it was understood this is not the case so, questioning practitioners working in the project design process was thought to produce better outcomes. To note, that of the three, only Greater Lisbon Municipal Authority reacted to the survey, contacting the researcher by phone and answering the survey.

Receiving 61 out of 400 questionnaires may seem a small number. Whereas one never knows why people do not answer a survey, one can speculate. In this particular case it is possible that the high number of absent surveys reflects not necessarily a lack of interest in the matter but a lack of knowledge and use of Standards and Classification Systems. If this is so, the sample of 61 valid surveys is

[58] URL: accessed on 01.2008

[59] URL:http://censos.ine.pt.

[60] Sending the postal questionnaire cost about 600.00euros

by default biased reflecting the reality of companies with at least some interest, knowledge and/or application of Standards and Classification Systems. There is little one can do to overcome this limitation, and special care was taken when analysing the data bearing that in mind, particularly when inferring conclusions and generalisations.

A positive remark has to be made as to respondents' interest on the subject. About 20 respondents sent their names and contact details with the completed survey, which was not asked for - nor did the survey structure motivate it as there was no spot to complete this information. Some went even further and contacted the researcher showing interest and availability in participating in further stages of the project if needed. This was most gratifying to the researcher as it proved the importance that practitioners attach to classification of information in this field.

4.3. Survey Structure

The survey objectives were sustained in 3 major questions, each with some specific sub-questions:

A) Which Standards, methods and procedures for construction projects are known and applied in Portugal?

A1. Who knows and applies the Standards, how do they know about them and why do they apply them?

A2. Who knows the Standards yet does not apply them, and why?

A3. Is the lack of application of Standards related to difficulties in understanding them?

B) Which of the existing information on production, storage and management systems for construction project processes are applied in Portugal?

B1. Who is familiar with these Systems and applies them, how do they know about them and why do they apply them?

B2. Who knows about the systems but does not apply them, and why?

B3. Is the lack of application of Systems related to difficulties in understanding them?

C) What is the most common procedure of storage and management of information systems in offices/companies in the civil construction business in Portugal?

After presenting the context of this survey, a thorough statistical analysis was carried out. The goal here was to check results relating to social demographic information collected in the same survey. The aims were to verify if there is any relation between knowledge and application of the Standards and Information Systems and:

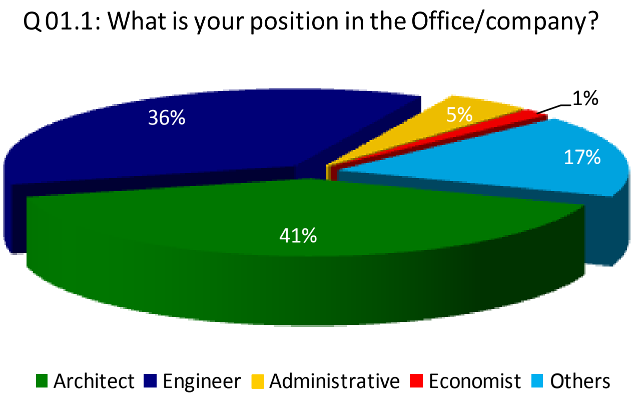
- academic qualifications
- position in the company
- type of projects performed by the company
- company's main activity
- involvement in international projects
- cooperation with international companies
- company's business volume

These questions stand on theoretical bases of other investigations and research lines. At this stage, the focus went to the understanding of Portuguese reality by a validated survey and approved methodology as an efficient measuring instrument for the survey questions. In the following section, the descriptive statistical analysis is presented.

4.4. Survey Analysis

4.4.1. Demographic description of the Sample

As stated, 400 questionnaires were posted to 400 Portuguese companies, of which 61 were returned fully answered (valid questionnaires). To obtain a global description of the valid survey sample, one needs to know better its respondents. As such, this section starts with a chart related to question Q 01.1 "What is your position in the office/company". A 100% response to these questions was obtained. The majority of the sample occupies an Architect (40%) or Engineer (36%) position, both representing 76% of respondents. A minority is positioned as Administrative (5%) or Economist (2%).



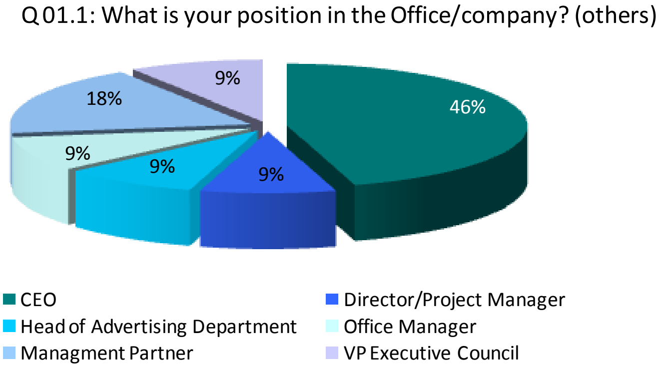


Figure 9- Respondents positioning in their working company (%): 2008, Portugal

However, 17% of respondents answered “Other”, and of these 11 identify themselves as “Administrator” (40%). These are followed by two respondents answering “Management Partner” (18% of Other), and four as “Head of Advertising Department”, “Director/Project Manager”, “Office Manager” and “Vice-President Executive Council”. There was not any identification for “Lawyer”, and so that category was removed from the analyses. Two respondents gave each two answers to this question, one identifying a double position as “Architect” and “Administrative”, and the other as “Architect” and “Engineer” suggesting that at least two respondents carry out more than one task in the company.

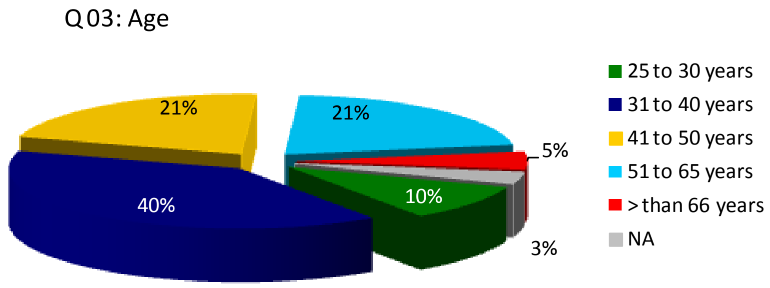


Figure 10- Respondents Age (%): 2008, Portugal.

Regarding age, data indicates that half of the respondents are less than 40 years old. For a better description of the respondents’ ages, it was decided to build age groups[61]. The majority of respondents is thus between 31 and 40 years old (41%)[62], followed by those who are between 41 and 50 years old, and between 51 and 65 years old. The younger respondents, between 25 and 30 years old represent 10% of the sample and the most senior, with more than 65 years, represent 5%.

[61] The categories definition was made to get homogeneous groups.

[62] Modal Class = 31 to 40 years

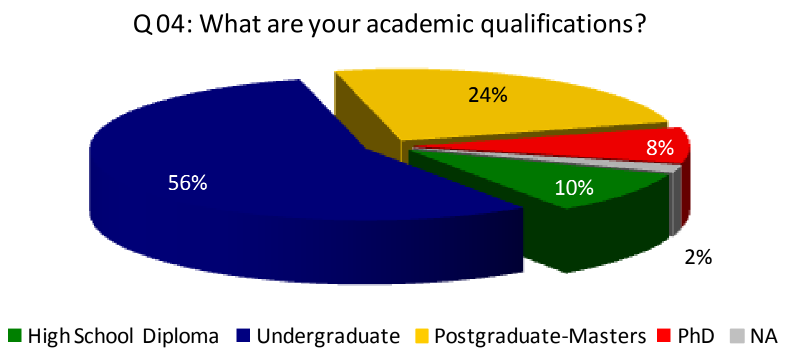


Figure 11- Respondents Academic Qualifications (%): 2008, Portugal.

Data suggests that the bigger part of the sample has a higher education qualification, of which the most common are Undergraduates (55%), followed by “Postgraduate-Masters” (22%), and PhD (8%). Two per cent of respondents chose not to divulge their qualifications and 10% held a High School Diploma (10%).

Relating academic qualification with age, it can be concluded that the younger are Post-Graduate-Masters ($X_{(Age\_PostGraduate-Masters)} = 38$ years old), followed by those who have the “High School Diploma” ($X_{(Age\_HighSchoolDiploma)} = 42$ years old), and the “Undergraduates” ($X_{(Age\_Undergraduate)} = 44$ years old). The senior classes are the PhD ($X_{(Age\_PhD)} = 61$ years old).

Another relevant variable for the study was the Professional Experience of the respondent. Regarding this variable, the average is of 19 years of Professional Experience with a minimum of 2 years and a maximum of 54 years. Since there is a large range between the minimum and the maximum years of professional experience, it is worth mentioning that half of the valid sample has less than 15 years of professional experience[63].

[63] $X_{(years\_of\_workexperience)} = 19$; Minimum = 2; Maximum =54; Median = 15

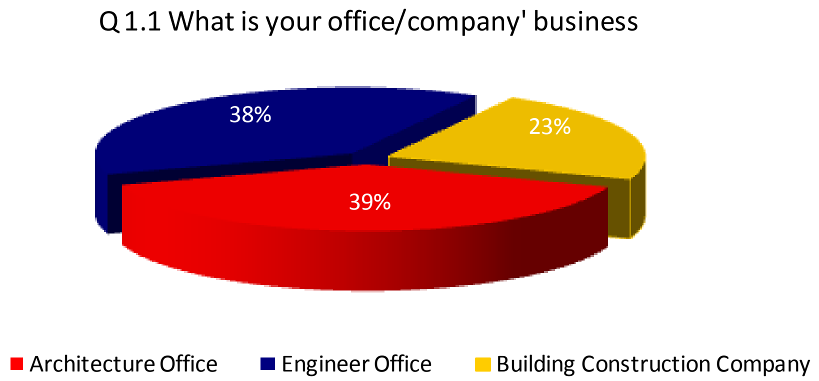


Figure 12- Distribution of respondents according to their company´s line of business (%): 2008, Portugal.

39% of respondents work in an Architect business, followed by those working in an Engineering one (38%). A lesser but still representative percentage is that of those working in the Construction business (23%). This question was taken as a multiple response set, where each respondent selected as many options as appropriate: five companies identified themselves as Architecture and Engineer, two as Engineer and Building Construction, and one as Architecture and Civil Construction.

		Q1.8.1 Has your office/company collaborated with international companies in projects in Portugal?			
		Yes	No	DK	NA
Q1.7.1 Has your office/company been involved in International projects?	Yes	31%	20%	2%	
	No	8%	33%	2%	3%
	DK	-	-	2%	-
	NA	-	-	-	-

Table 5- Crosstab between Offices that have been involved in International Projects and Offices that collaborated with International Companies in Portugal (%): 2008, Portugal.

Although it cannot be concluded for the population level (statistically saying), data reveals that 33% of respondents say they have not participated in International Projects nor cooperated with International Companies. There is a similar proportion regarding those who have both participated in international projects and cooperated with international companies at Portugal (31%). A significant part reports having participated in international projects but never collaborated with international companies (20%).

Looking at the sample by company, there seems to be a strong dispersion in the company's time of existence. In fact, in average respondents' companies have been active for 16 years, ranging from 1 year to 76 years. By group, the following graphic illustrates the distribution of the companies:

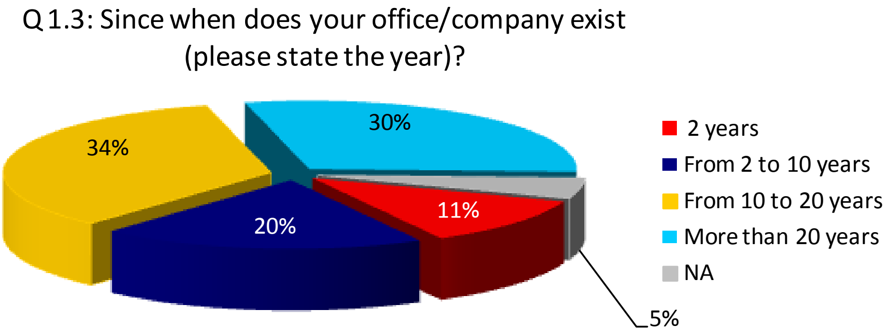


Figure 13- Respondents companies time of existence in the field (%): 2008, Portugal.

The most frequent in the sample were companies with more than 10 or less than 20 years in the market (34%), followed by those that have been in the market for more than 20 years (30%). In last came the younger companies.

Crossing companies' longevity with its line of business reveals that the engineering companies are the most persistent in the market. With younger companies, Architecture and Construction offices are most common. These results are presented in Figure 14 (pag.130):

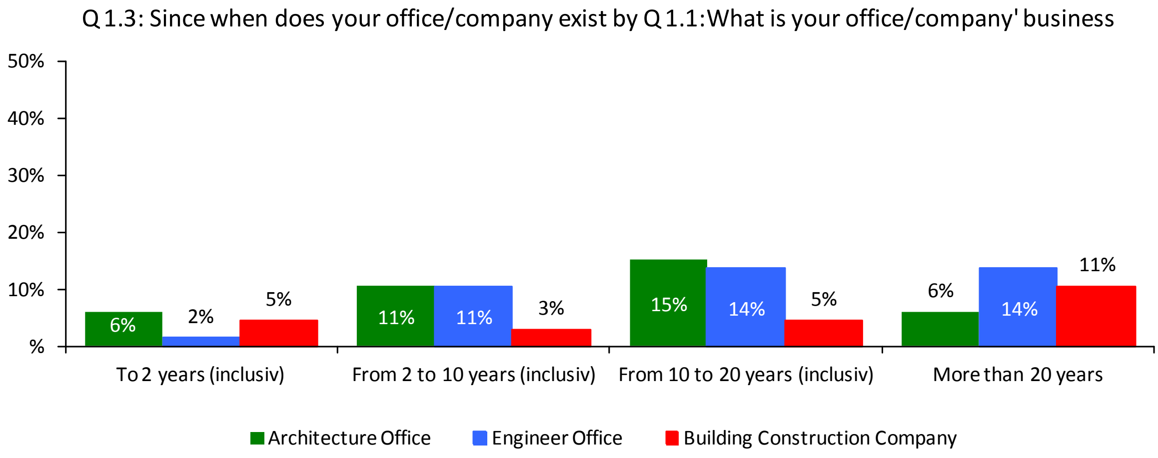


Figure 14- Companies longevity with its line of business (%): 2008, Portugal.

After identifying the main characteristics about the respondents and their companies, company business volume and co-workers academic qualifications are examined in the next Figures:

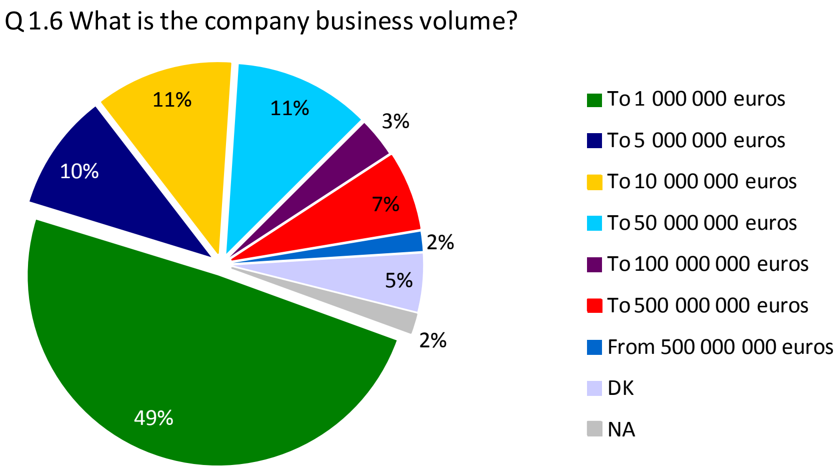


Figure 15- Companies business volume (%): 2008, Portugal.

Nearly half the sample has a business volume under 1.000.000 Euros (49%), followed by those who have a volume of 5.000.000 and 10.000.000 Euros (representing 10% and 11% of the sample, respectively). With less presence, are those who have a business volume over 100.000.000 Euros (12% of the sample). These results are compatible to those acquired among AECOPS.

Analysing these companies by number of employees, the average is of 64 employees per company. However, as the sample presents extreme values (such as 2000 employees), the outliers were excluded from the calculation resulting in an average of 21 co-workers per company. By median measure, we see that half of the sample has up to eight employees. As there is a severe dispersion within the sample, companies were aggregated by number of employees[64], which resulted in Figure 16:

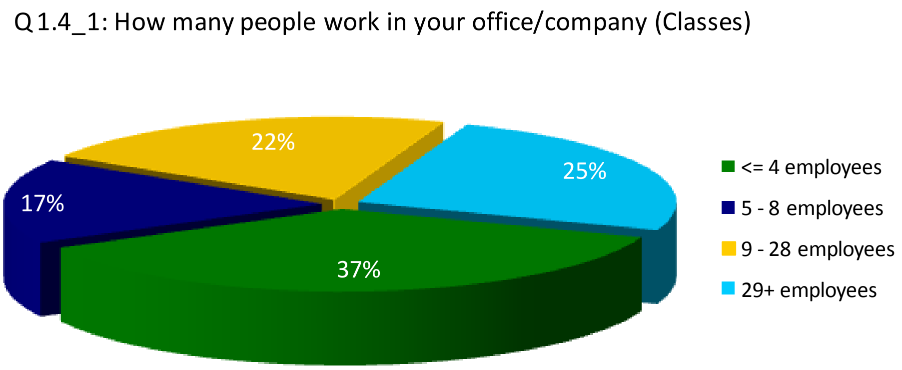


Figure 16- Companies number of employees (%): 2008, Portugal.

The most frequent are companies with less than 4 employees (37%), followed by those with more than 29 employees (25%). The aggregation revealed a relative balance on the distribution of companies by number of employees.

[64] The aggregation method was applied with the perspective of balance to the sample data and conciliate the interpretation with very small companies to major companies – recoded in SPSS Statistics v.16.

The following figure detailing co-workers' academic qualifications, revealing that the majority are Undergraduates (49%), followed by those who have High School qualifications (18%), Postgraduate-Masters (18%), and PhDs (5%).

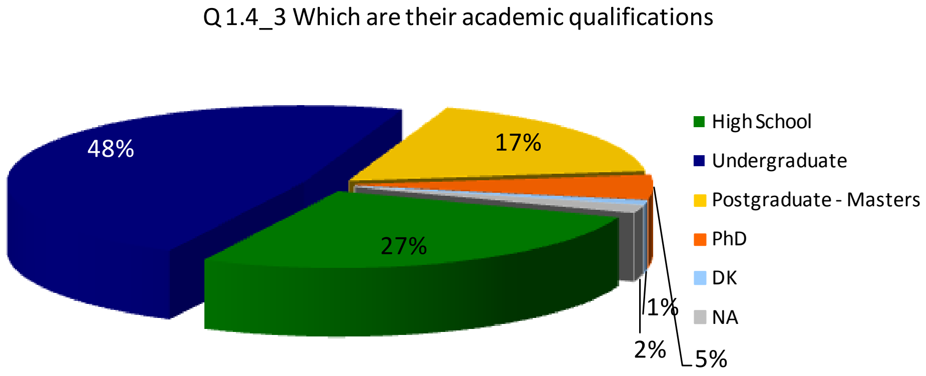


Figure 17- Companies employees academic qualifications (%): 2008, Portugal.

4.4.2. Starting Questions

In this project, some questions have been posed in order to trace the orientation for some conclusions on national level regarding the relation of Portuguese companies with construction standards. These were organized as follows:

A. Norms and Standards applicable to building construction projects.

B. Information Classification Systems

C. Production, storage and management information systems in offices/companies in civil construction.

These three major groups of questions will be analysed from the descriptive results from the applied questionnaire, generating some crosstabs relevant for the project at hand. At this stage, these questions were about the degree of familiarity with Norms and Standards for building construction projects, and their application in Portuguese companies.

A. Standards, methods and procedures for construction projects

A1. Which standards, methods and procedures for construction projects are known and applied in Portugal?

For this starting question, it was decided to follow two sections; one on knowledge of existing Standards, and another on their application. Starting with the "core" question Q 2.1.1: "Which standards, methods and procedures for construction projects from the list below do you know about?" The results are presented in Figure 18. For better reading, the green was chosen to highlight the most mentioned, and red for the least mentioned. Note that this is a multiple response set, so the percentages are referring to the total inquiries that responded to this question[65].

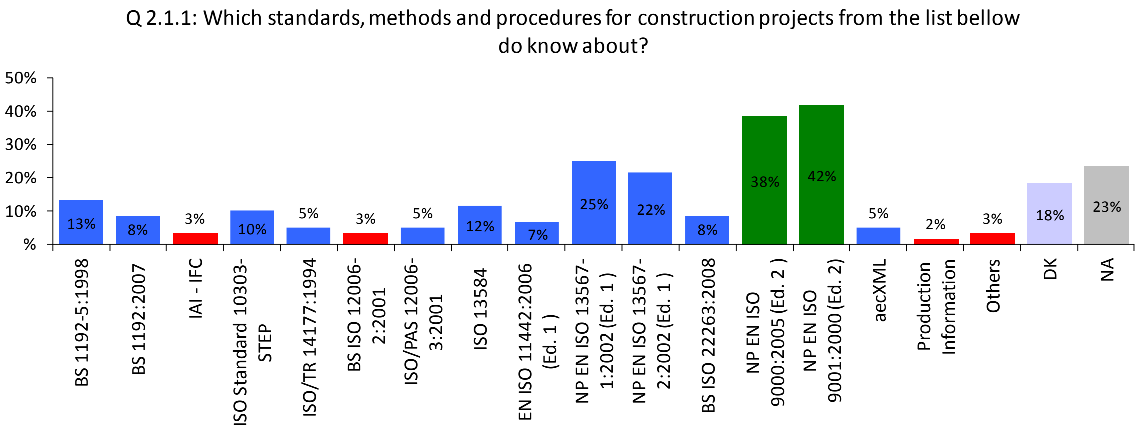


Figure 18- Known Standards, methods and procedures for construction projects (%): 2008, Portugal.

[65] This question is a Multiple Response Set. However, since we achieved a small sample of valid questionnaires, the decision of presenting the percentage of the answers related with the total respondents was made. In this case, 60 persons responded at least at one question (1 Missing answer).

The most mentioned Standards were the ***NP EN ISO 9000:2005 (Ed. 2)*** and ***NP EN ISO 9001:2000 (Ed. 2)*** with 38% and 42% valid responses. These were followed by **NP EN ISO 13567-1:2002 (Ed. 1)** and **NP EN ISO 13567-2:2002 (Ed. 1).** The less mentioned were the ***IAI - IFC***; ***BS ISO 12006-2:2001.*** In option ***Others***, **Company Internal Standards and Norms** and ***NCS4.0*** were detailed.

At this stage it is possible to analyse who knows the ***Standards, methods and procedures for construction projects.*** For this, a cross tabulation has been made between the respondents position in the company[66] and their knowledge of Standards. On this analytical procedure, the first step was to compare each Standard with the profession of respondents. Importance was given to professionals engaged in the first stages of the design process as exposed in Table 6 regarding the architects' age (%) and their knowledge on standards:

		Q1.3: Age bin by Q01: What is your position in the Office/company? Architects							
		25 - 30 years	31 - 40 years	41 - 50 years	51 - 65 years	>66 years	N	Age Mean	SD
Q2.1.1: Known Standards	BS 1192-51998	-	20,0%	25,0%	-	-	3	38,7	2,5
	BS 11922007	-	10,0%	-	-	-	1	36,0	-
	IAI - IFC	-	-	25,0%	-	-	1	41,0	-
	ISO Standard 10303-STEP	-	-	25,0%	-	-	1	41,0	-
	ISO/TR 141771994	-	-	-	-	-	-	-	-
	BS ISO 12006-22001	-	-	-	-	-	-	-	-
	ISO/PAS 12006-32001	-	-	-	-	-	-	-	-
	ISO 13584	50,0%	30,0%	-	16,7%	-	5	38,2	12,2
	EN ISO 114422006 (Ed.1)	-	-	25,0%	-	-	1	41,0	-
	NP EN ISO 13567-12002 (Ed.1)	50,0%	30,0%	25,0%	33,3%	-	7	41,4	12,4
	NP EN ISO 13567-22002 (Ed. 1)	50,0%	30,0%	25,0%	16,7%	-	6	38,7	11,0
	BS ISO 222632008	50,0%	-	-	-	-	1	25,0	-
	NP EN ISO 90002005 (Ed.2)	100,0%	20,0%	25,0%	16,7%	-	6	38,2	10,6
	NP EN ISO 90012000 (Ed. 2)	100,0%	30,0%	25,0%	16,7%	-	7	37,9	9,7
	aecXML	-	-	25,0%	-	-	1	41,0	-
	Production Information	-	-	-	-	-	-	-	-
	Others	-	10,0%	25,0%	-	-	2	37,5	4,9
	I Dont Know	-	40,0%	50,0%	-	66,7%	8	47,8	17,6
	No answer	-	20,0%	-	50,0%	33,3%	6	52,5	14,6

Table 6- Age bin by Position occupied – Architects by Known Standard (Column %): 2008, Portugal.

[66] Question Q01: What is your position in the Office/company?

Reading Table 6 (pag.134), it reveals that no Architect mentions **ISO/TR 14177:1994**, **BS ISO 12006-2:2001**, **ISO/PAS 12006-3:2001** and Production Information. None of the Engineers also mentioned the **IAI -IFC**, **BS ISO 12006-2:2001**, **aecXML**, **Production Information** (and neither do they mention Other Standards beside the ones listed in the questionnaire as can be seen in Figure 19 (pag.136). Overall, the Architects do not refer to the **ISO/TR 14177:1994** and **ISO/PAS 12006-3:2001**, which are mentioned by Engineers, who in turn do not mention the **IAI - IFC** and **aecXML** (which have been referred to by Architects).

Architects, not only mentioned more Standards than Engineers, but also reveal a better distribution of the same ones. Within the Standards mentioned by Architects, the most referred to are the Portuguese ones: **NP EN ISO 9001:2000 (Ed. 2)** (14%), **NP EN ISO 13567-1:2002 (Ed. 1)** and **NP EN ISO 9000:2005 (Ed. 2)** (both with 12%), **NP EN ISO 13567-2:2002 (Ed. 1)** (10.3%) and the **ISO 13584** (9%). The less mentioned are the **BS 1192-5:1998** (5%), **BS 1192:2007, IAI - IFC, ISO Standard 10303-STEP, EN ISO 11442:2006 (Ed. 1), BS ISO 22263:2008** and **aecXML** (2%).

On the other hand, among the Standards mentioned by Engineers, the most referred to are coincident with the ones mentioned by the "Architects", although there is more concentration of answers on the **NP EN ISO 9001:2000 (Ed. 2)** (24%) and **NP EN ISO 9000:2005** (Ed. 2) (20%), and less on the **NP EN ISO 13567-1:2002 (Ed. 1)** (9%) and **NP EN ISO 13567-2:2002 (Ed. 1)** (7%). The lesser mentioned are coincident with the less mentioned by the Architects. These are the **BS 1192-5:1998** (6%), I**SO/TR 14177:1994, EN ISO 11442:2006 (Ed. 1)** and **BS ISO 22263:2008** (4%), followed by the **BS 1192:2007, ISO/PAS 12006-3:2001** and **ISO 13584** (2%).

The Economists showed a less variety of Standards' acknowledgement. The referred to ones are the **NP EN ISO 13567-1:2002 (Ed.1)**, **NP EN ISO 13567-2:2002 (Ed. 1)**, **BS ISO 22263:2008**, **NP EN ISO 9000:2005 (Ed.2)**, and **NP EN ISO 9001:2000 (Ed. 2)**. In this sample, the respondent identified as Administrative only mentioned the **BS 1192:2007** and the **BS ISO 22263:2008**.

According to the analysis procedure, this can be compared using the known Standards against the position in the company (Architects and Engineers), using percentages by most mentioned norm. From this cross tabulation the results are presented in Figure 19:

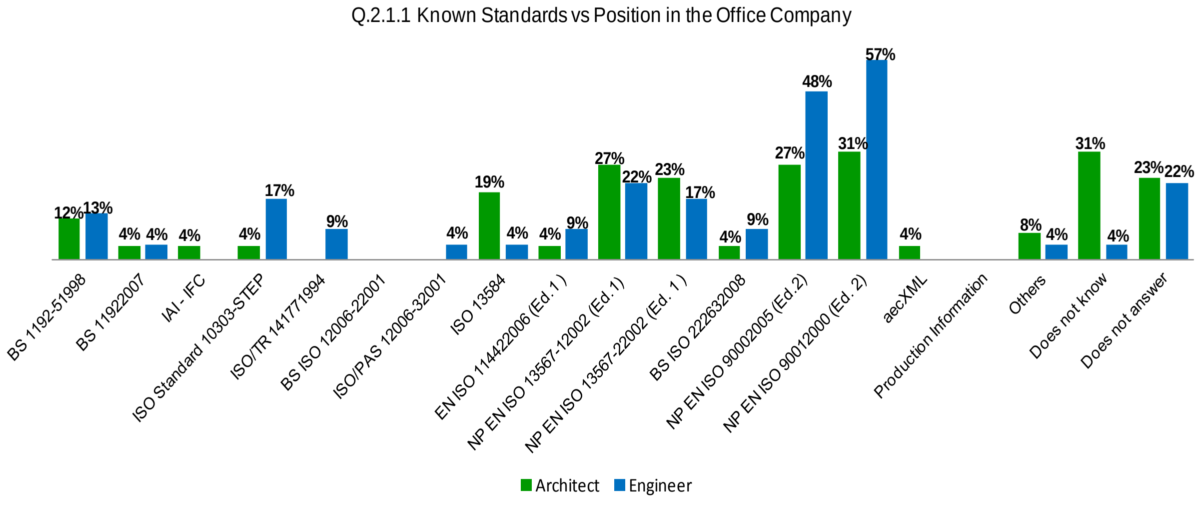


Figure 19- Known Standard vs Company Position (Architects and Engineers): 2008, Portugal.

Bearing in mind that the most mentioned Standards were the **NP EN ISO 9000:2005 (Ed. 2), NP EN ISO 9001:2000 (Ed. 2), NP EN ISO 13567-1:2002 (Ed. 1)** and **NP EN ISO 13567-2:2002,** the first conclusion is that more Architects referred to the **NP EN ISO 13567-1:2002 (Ed. 1)** and the **NP EN ISO 13567-2:2002** (46,7% and 46,2%), than Engineers (33,3% and 30,8%). The converse conclusion can be taken regarding those who mentioned **NP EN ISO 9000:2005 (Ed. 2)** and **NP EN ISO 9001:2000 (Ed. 2) -** with Engineers presenting most answers (48% and 52%) compared to the other major group, the Architects (30% and 32%). Of the four most mentioned norms, it was evident that there is a lesser presence of the Economists.

As for the Standards least mentioned, **IAI – IFC** is mentioned by the Architects. A possible and relevant conclusion is that the Norms **BS ISO 12006-2:2001** and **Product Information** were only mentioned by respondents with management positions (one Managing Partner and one Vice-President of Executive

Council). Data also reveals that the **ISO 13584** is mostly mentioned by Architects as opposed to the **EN ISO 11442:2006 (Ed.1)** which is more mentioned by the Engineers.

Error! Reference source not found. relates to question Q 2.3.1: "Which nes do you use?" The most applied Standards are shown in green, and the lesser ones in red:

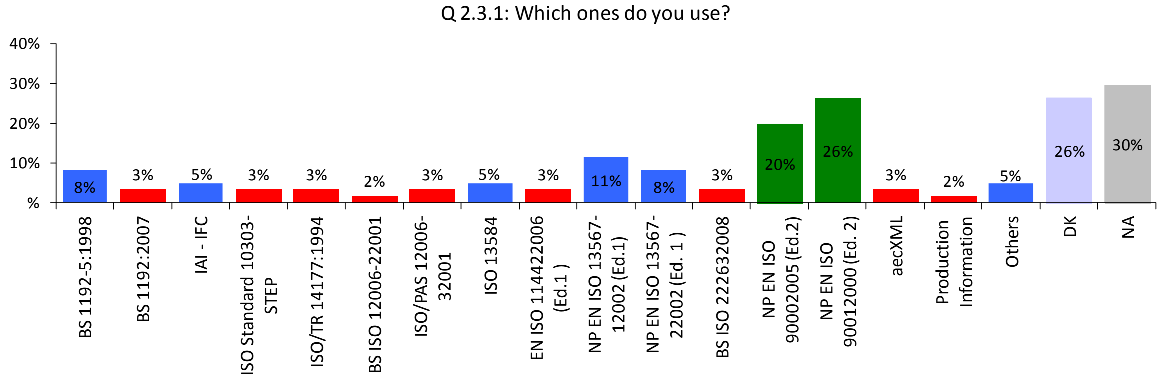


Figure 20- Applied standards (%): 2008, Portugal.

The first conclusion is that the better known Standards, are also the most applied. It is also clear that the "I don´t know" and the "No answer" answers increased on the application matter, suggesting that respondents may know of the existence of these standards, but are not aware of their applications within the companies in which they work. Overall there seems to be a lack of Standards application compared to the knowledge practitioners have on them.

The next table presents similar results as the ones obtained regarding knowledge of the Standard, now in relation to the applied Standards by respondent's position within their companies (column %):

		Q01: What is your position in the Office/company?				
		Architect	Engineer	Economist	Administrative	Others
Q2.3.1: Which Standards do you use?	BS 1192-51998	3%	3%	-	33%	7%
	BS 11922007	-	3%	-	-	4%
	IAI - IFC	3%	-	-	-	7%
	ISO Standard 10303-STEP	-	3%	-	-	4%
	ISO/TR 141771994	-	3%	-	-	4%
	BS ISO 12006-22001	-	-	-	-	4%
	ISO/PAS 12006-32001	-	3%	-	-	4%
	ISO 13584	3%	3%	-	-	4%
	EN ISO 114422006 (Ed.1)	3%	-	-	-	4%
	NP EN ISO 13567-12002 (Ed.1)	9%	8%	-	-	4%
	NP EN ISO 13567-22002 (Ed.1)	3%	8%	-	-	4%
	BS ISO 222632008	-	3%	-	-	4%
	NP EN ISO 90002005 (Ed.2)	6%	13%	50%	-	15%
	NP EN ISO 90012000 (Ed. 2)	9%	24%	50%	-	11%
	aecXML	-	-	-	-	7%
	Production Information	-	-	-	-	4%
	Others	6%	3%	-	-	-
	I Don´t Know	21%	18%	-	33%	4%
	No answer	35%	8%	-	33%	7%
	Total	100%	100%	100%	100%	100%

Table 7- Position by Applied Standard (Column %): 2008, Portugal.

When answering about the Application of the Standards, only Architects mentioned the application of the Standard ***IAI – IFC***, and **EN ISO 11442:2006 (Ed. 1)**. On the other hand, only Engineers mentioned the application of **ISO Standard 10303-STEP**, **ISO/TR 14177:1994**, **ISO/PAS 12006-3:2001** and **BS ISO 22263:2008**.

Architects mention Standards application less frequently than Engineers. This can be motivated by the amount of the “I don´t know” and “No answer” answers among Architects (more than 50%). From this group, there are more frequent answers on the Portuguese Standards **NP EN ISO 13567-1:2002 (Ed. 1)** and **NP EN ISO 9001:2000 (Ed. 2)** (9%), and less frequent on the **BS 1192-5:1998**, ***IAI – IFC***, **ISO 13584, BS 1192-5:1998** and the **NP EN ISO 13567-2:2002 (Ed. 1)**. Among Engineers, there is more variety of applied norms than among Architects, with a more relevant proportion on the same national Standards - **NP EN ISO 9001:2000 (Ed. 2)** (24%) and **NP EN ISO 9000:2005 (Ed. 2)** (13,2%). This group, in contrast to the Architects, do not mention the application of eight of the presented Standards, and mentions 11 Standards of the same 16. The Economists group, apart from knowing about the existence of four norms, only mention the application of the national Standards - **NP EN ISO 13567-1:2002 (Ed. 1)** and **NP EN ISO 9001:2000 (Ed. 2)**. Administrative staff only mention the **BS 1192-5:1998**.

When changing the perspective and comparing the applied Standards between positions, the following results were obtained:

		Q01: What is your position in the Office/company?					
		Architect	Engineer	Economist	Administrative	Others	Total
Q2.3.1: Which Standards do you use?	BS 1192-51998	20%	20%	-	20%	40%	100%
	BS 11922007	-	50%	-	-	50%	100%
	IAI - IFC	33%	-	-	-	67%	100%
	ISO Standard 10303-STEP	-	50%	-	-	50%	100%
	ISO/TR 141771994	-	50%	-	-	50%	100%
	BS ISO 12006-22001	-	-	-	-	100%	100%
	ISO/PAS 12006-32001	-	50%	-	-	50%	100%
	ISO 13584	33%	33%	-	-	33%	100%
	EN ISO 114422006 (Ed.1)	50%	-	-	-	50%	100%
	NP EN ISO 13567-12002 (Ed.1)	43%	43%	-	-	14%	100%
	NP EN ISO 13567-22002 (Ed.1)	20%	60%	-	-	20%	100%
	BS ISO 222632008	-	50%	-	-	50%	100%
	NP EN ISO 90002005 (Ed.2)	17%	42%	8%	-	33%	100%
	NP EN ISO 90012000 (Ed. 2)	19%	56%	6%	-	19%	100%
	aecXML	-	-	-	-	100%	100%
	Production Information	-	-	-	-	100%	100%
	Others	67%	33%	-	-	-	100%
	I Don´t Know	44%	44%	-	6%	6%	100%
	No Answer	67%	17%		6%	11%	100%

Table 8- Applied Standards by Position (Line %): 2008, Portugal.

Comparing the positions proportions in each Standard, it becomes clear that Engineers apply more Standards than Architects, all national – for example the **NP EN ISO 13567-2:2002 (Ed. 1)**, **NP EN ISO 9000:2005 (Ed. 2)** and the **NP EN ISO 9001:2000 (Ed. 2)**.

When analysing the applicability of the Standards, the data reveals that the norms **BS 1192:2007**, and **BS ISO 12006-2:2001**, **aecXML** and **Production**

Information are the ones less known. These are also the less mentioned as applied by these positions. In fact, it is hardly unexpected that the less known Standards are coincident with the less applied.

Who knows and applies the Standards, how do they know about them and why do they apply them?

Respondents have been using Standards for an average time of seven years, ranging between 1 and 34 years[67]. As non-responses predominated among almost half of the respondents, the sample for this question was reduced to 32 respondents.

According to the results in the next graph, the main source of learning about these is through the professional world, followed by university. However, it is still worth mentioning that some respondents have learnt from colleagues in the same or other fields, suggesting that academic teaching has its presence in this reality.

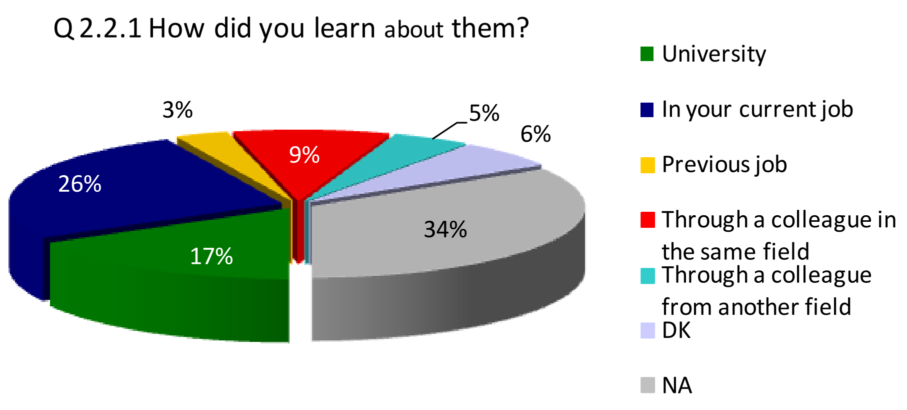


Figure 21- How the respondents learnt about standards (%): 2008, Portugal

[67] Q.2.3.3: When did you begin to use them? (please state the year).

Looking at Q.2.3.2ª: "Why do you use them", reveals again a strong presence of non-responses:

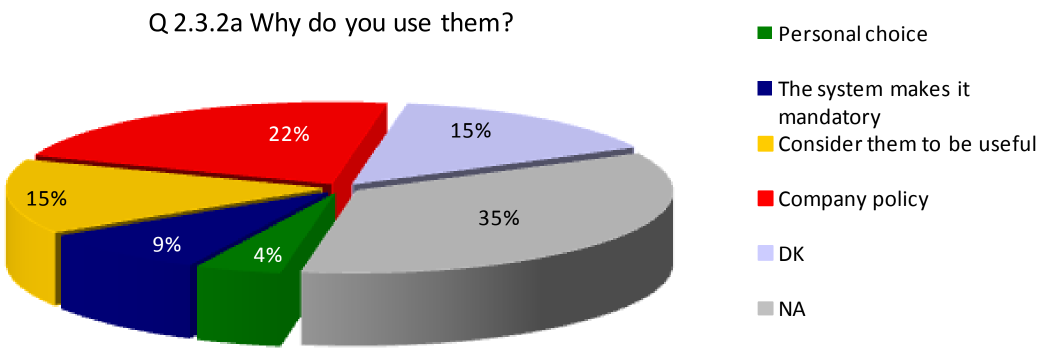


Figure 22- Reasons for respondents' use of standards (%): 2008, Portugal.

The major reasons behind the use of the Standards were "Company Policy" (22%), followed by "Consider them to be useful" (15%), "System makes it mandatory" (9%) and "Personal Choice" (4%). This suggests that technicians use the Standards as it is mandatory through company policies.

Q.2.3.4 asks "Why did you start to use them?", and the results are similar. The most cited is "Office/Company Policy" (21%), followed by "Obligated by the system" (12%), and "Personal Choice" (7%). We assume consistency between the answers. As other motives, two respondents referred to reasons as "Teaching" and "Because they are important for organizational processes".

It is appropriate to check what the data says regarding a possible relation between standards knowledge and application and the number of employees, business volume of the company and the academic qualifications of respondents.

Regarding the number of co-workers[68], only companies with more than 29 employees identified the **ISO/TR 14177:1994** and **Production Information**. Companies with less than eight employees do not seem to mention the **ISO/TR 14177:1994**, the **BS ISO 12006-2:2001**, **ISO/PAS 12006-3:2001** and the

[68] Table 21 exposed on APPENDIX 3 (read in line %).

Production Information. Companies with five to eight employees mentioned only the **NP EN ISO 9000:2005 (Ed. 2)** and **NP EN ISO 9001:2000 (Ed. 2)**.

Using the same procedure for business volume[69], no distinction was detected. This fact can be justified by the sample's dimension (it is mostly constituted by companies of small dimension). Overall, these two variables reinforce the suggestion that the **NP EN ISO 9000:2005 (Ed. 2)** and **NP EN ISO 9001:2000 (Ed. 2)** are the most known in general.

On the application field[70], it is interesting to state that although these are the better known Standards, that does not mean that they are the most applied. By number of employees, only those companies who have more than 29 workers mentioned the application of every Standard. However the expectation that companies with bigger business volume applied more is not supported by this sample. The bigger volume companies did not mention any Standard, which makes it inconclusive on this study.

Prospecting the role of academic qualifications[71], some patterns of known Standards and their application were expected. Respondents with "High School" qualifications only mentioned the **BS 1192:2007** and **BS ISO 22263:2008**, and a few, the **NP EN ISO 9000:2005 (Ed. 2)** and **NP EN ISO 9001:2000 (Ed. 2)**. Those with "Undergraduate" and "Post-Graduate" qualifications mention all the listed Standards with the exception of the last one, **Production Information**. Analysing the proportions between groups and the knowledge of Standards reveals a balance. Exceptions are made with **ISO/PAS 12006-3:2001**, **EN ISO 11442:2006 (Ed. 1)** and **BS ISO 22263:2008**, which are mostly mentioned by those with Post-Graduate qualifications, yet this may be justified by the proportion of Graduate (34) and Post-graduate respondents (15). Finally, those holding PhDs mention fewer norms than the others (less two Standards than the other groups). When it comes to the application, all groups mention the most popular Standards - **NP EN ISO 9000:2005**

[69] Table 22 exposed on APPENDIX 3 (read in line %).

[70] Table 23 and Table 24 exposed on APPENDIX 3 (read in line%).

[71] Table 25 and Table 26 exposed on APPENDIX 3 (read in line%).

(Ed.2) and **NP EN ISO 9001:2000 (Ed. 2)**. From all these groups, only the Post-Graduates always mention at least one applied Standard.

Looking at business activity[72], lead to similar conclusions to those taken from the professional groups. However, there is one more area – the building construction where there are similar results to the Engineers. The exception comes in that the Building Construction activity does not refer **the EN ISO 11442:2006 (Ed. 1)**.

Standards' application reflects the latter conclusions too. However, in Building Construction Activity **BS 1192-5:1998**, **IAI – IFC**, **ISO Standard 10303-STEP**, **NP EN ISO 9000:2005 (Ed. 2)**, **NP EN ISO 9001:2000 (Ed. 2)** and **aecXML** are mentioned – there is a bigger proportion of answers on the Architecture activity, and smaller than the Engineering. The exception is on the **IAI – IFC**, which is more often mentioned by Architects.

Further, cross tabulation of the known Standards with the Company's Activity reveals that the "Other" are present in all options. This happens because one of the "Other" is the Teaching area. In general, the most frequent indications are about the **NP EN ISO 9000:2005 (Ed.2)** and the **NP EN ISO 9001:2000 (Ed. 2)**.

[72]Table 27 exposed on APPENDIX 3 (read in line%).

Who Knows the Standards and doesn't apply them, for what reasons aren't they applied?

Figure 23 displays results for the question Q.2.3.2b "Why don't you use them?":

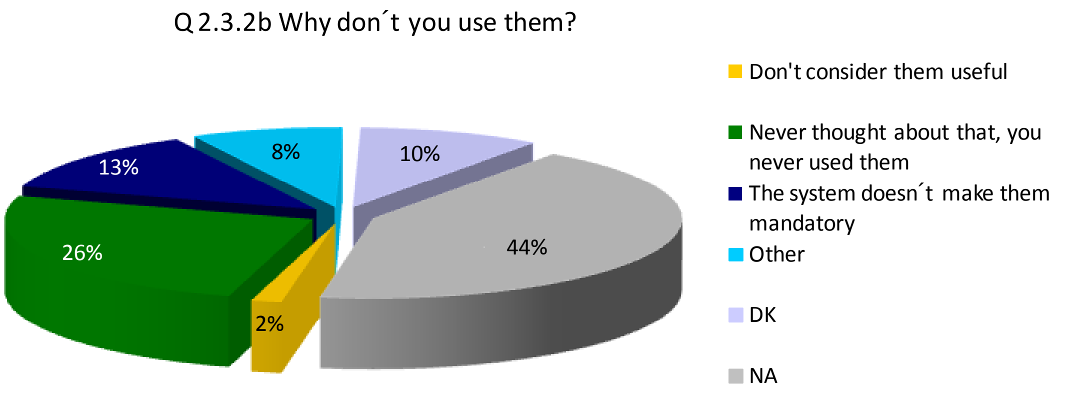
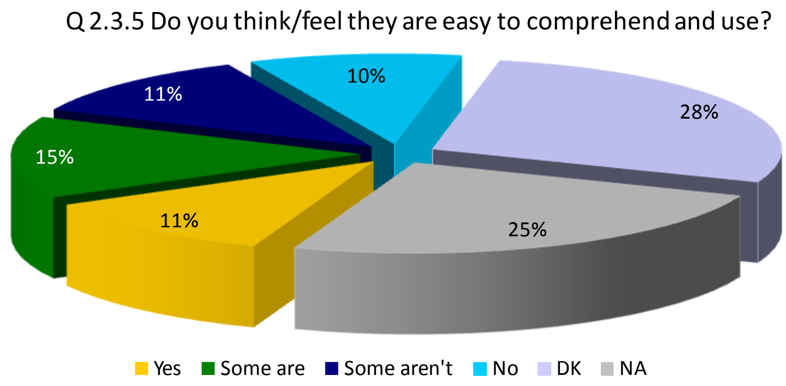


Figure 23- Reasons for not using standards (%): 2008, Portugal.

The major of answers is "Never thought about that, you never used them" (26%), followed by "The system doesn't make them mandatory" (13%), and "Don´t consider them useful" (2%). In "Other", there were 5 answers: "Had internal implement", "Lack of Knowledge", "Not relevant for my daily work", "Don't work with CAD" and "Limited practice".

Is the non applicability of the Standards related with the difficulty to comprehend them?

The next Figures present results for this question:



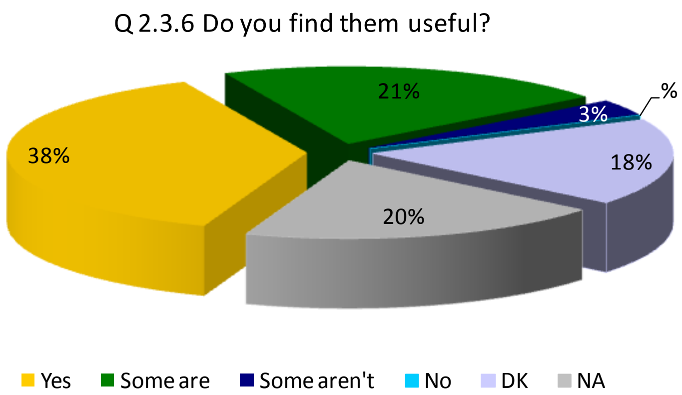


Figure 24 and Figure 25- Respondents perception of standards (%): 2008, Portugal.

On the perception of easiness to understand and apply the Standards, there is little consensus, with 11% agreeing that Standards are easy to use and understand and 10% disagreeing, and a similar proportion stating that some are easy (15%) or that some are not (11%) Yet, when it comes to respondent's own perception of the usefulness of standards, the bigger part attached definite importance to them (38%), followed by those who agree with the usefulness of only some Standards (21%). It is worth noting that most respondents regard them as useful which reveals that there is no effective relation between the perception of easiness of use and Standards usefulness:

Q2.3.5: Do you think/feel they are easy to comprehend and use?		Q2.3.6: Do you find them useful?						
		Yes	Some are	Some aren't	No	DK	NA	Total
	Yes	11%	-	-	-	-	-	11%
	Some are	8%	7%	-	-	-	-	15%
	Some aren't	7%	5%	-	-	-	-	11%
	No	3%	3%	3%	-	-	-	10%
	DK	7%	3%	-	-	18%	-	28%
	NA	2%	3%	-	-	-	20%	25%
	Total	38%	21%	3%	0%	18%	20%	100%

Table 9- Perceived usefulness of the Standards by Ease of understanding and use (%): 2008, Portugal.

This cross tabulation reveals that the bigger part of answers went to the useful and easy to understand.

Q2.3.1: Which Standards do you use?		Q2.3.2a: Why do you use them?						
		The system makes it mandatory	Company policy	Personal choice	Consider them to be useful	DK	NA	Total
	BS 1192-51998	-	2%	1%	3%	-	1%	6%
	BS 11922007	-	-	-	2%	-	-	2%
	IAI - IFC	-	-	-	3%	-	-	3%
	ISO Standard 10303-STEP	-	-	1%	1%	-	-	2%
	ISO/TR 141771994	-	1%	-	1%	-	-	2%
	BS ISO 12006-22001	-	-	-	1%	-	-	1%
	ISO/PAS 12006-32001	-	1%	-	1%	-	-	2%
	ISO 13584	-	2%	-	1%	-	-	3%
	EN ISO 114422006 (Ed.1)	-	1%	-	1%	-	-	2%
	NP EN ISO 13567-12002 (Ed.1)	2%	3%	-	3%	-	1%	8%
	NP EN ISO 13567-22002 (Ed.1)	2%	2%	-	3%	-	-	6%
	BS ISO 222632008	-	-	-	2%	-	-	2%
	NP EN ISO 90002005 (Ed.2)	3%	7%	-	3%	-	-	12%
	NP EN ISO 90012000 (Ed. 2)	3%	9%	-	3%	-	-	16%
	aecXML	-	1%	1%	2%	-	-	3%
	Production Information	-	-	-	1%	-	-	1%
	Others	1%	1%	-	3%	-	-	4%
	I Don´t Know	-	-	1%	-	6%	7%	13%
	No Answer	1%	-	-	-	3%	12%	15%
	Total	11%	28%	3%	29%	9%	20%	100%

Table 10- Standards and reasons for their use (%Total n=61): 2008, Portugal.

The reason most gave for the use of Standards was that they are useful. However, the **NP EN ISO 9000:2005 (Ed.2)** and **NP EN ISO 9001:2000 (Ed.2)** aggregate the “Company Policy” and “The system makes it mandatory”.

Regarding ease of understanding and use of the Standards:

Q2.3.1: Which Standards do you use?	Q2.3.5: Do you think/feel they are easy to comprehend and use?						
	Yes	Some are	Some aren´t	No	DK	NA	Total
BS 1192-51998	3%	5%	-	-	-	-	8%
BS 11922007	-	2%	-	2%	-	-	3%
IAI - IFC	2%	2%	-	-	2%	-	5%
ISO Standard 10303-STEP	2%	2%	-	-	-	-	3%
ISO/TR 141771994	-	2%	2%	2%	10%	15%	30%
BS ISO 12006-22001	-	-	2%	2%	15%	-	26%
ISO/PAS 12006-32001	-	3%	-	-	-	-	3%
ISO 13584	-	2%	-	-	-	-	2%
EN ISO 114422006 (Ed.1)	-	3%	-	-	-	-	3%
NP EN ISO 13567-12002 (Ed.1)	-	3%	2%	-	-	-	5%
NP EN ISO 13567-22002 (Ed.1)	-	2%	2%	-	-	-	3%
BS ISO 222632008	-	5%	3%	2%	2%	-	11%
NP EN ISO 90002005 (Ed.2)	-	5%	2%	2%	-	-	8%
NP EN ISO 90012000 (Ed. 2)	-	2%	-	2%	-	-	3%
aecXML	2%	8%	3%	3%	2%	2%	20%
Production Information	5%	8%	7%	5%	-	2%	26%
Others	-	3%	-	-	-	-	3%
I Don´t Know	3%	2%	-	-	-	-	2%
No Answer	11%	-	2%	-	-	-	5%
Total	11%	15%	11%	10%	28%	25%	100%

Table 11- Cross tabulation on standards considered easy to use and standards applied by respondents (%Total n=61): 2008, Portugal.

The Standards referred to as not easy to comprehend or use are the **ISO/TR 14177:1994, BS ISO 12006-2:2001**, **BS ISO 22263:2008**, **NP EN ISO 9000:2005 (Ed. 2)**, **NP EN ISO 9001:2005 (Ed. 2)**, **aecXML** and **Production Information**.

B. Information Classification Systems

B1. Which of the Information Classification Systems applicable to building construction projects are most known and applied in Portugal?

Similar to the former question, answers to this question have been organized into two sections. One refers to the knowledge of Classification Information Systems, the other to their application. The next graph illustrates which ones are most mentioned by the 61 respondents:

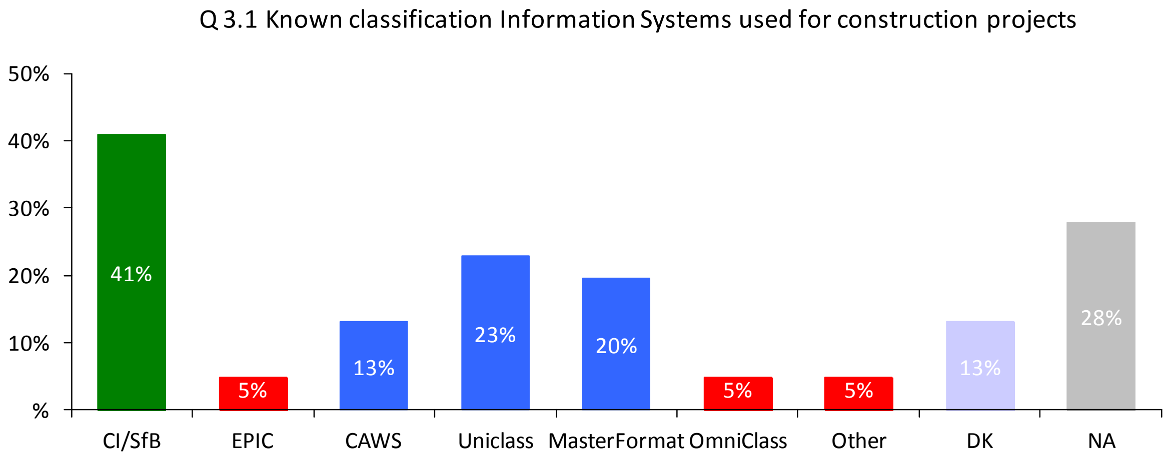


Figure 26- Respondents' knowledge on existing classification systems (%): 2008, Portugal.

From the Information Systems listed, the most mentioned are **CI/SfB, Construction Indexing Manual** (41%), **Uniclass** (23%), **MasterFormat** (20%) and, less predominant **CAWS** (13%). Lesser used are **EPIC - Electronic Product Information Co-ordination** and **OmniClass – The Overall Construction Classification System** (5% each).

As with the former group of questions, knowledge of Information Systems is now examined, analysed by group:

		Q01: What is your position in the Office/company?				
		Architect	Engineer	Economist	Administrative	Others
Q.3.1 Known classification Information Systems used for construction projects	CI/SfB	40%	15%	100%	-	15%
	EPIC	-	6%	-	-	8%
	CAWS	2%	18%	-	-	8%
	Uniclass	23%	9%	-	-	8%
	MasterFormat	12%	18%	-	-	8%
	OmniClass	5%	-	-	-	8%
	Other	-	9%	-	-	-
	DK	7%	6%	-	67%	8%
	NA	12%	18%	-	33%	38%
	Total	100%	100%	100%	100%	100%

Table 12- Position in the company by known Information System (Column %): 2008, Portugal.

The results reveal that those in Administrative positions do not know any System, and that Economists only mentioned the ***CI/SfB - Construction Indexing Manual***. This was hardly surprising. Architects make no reference to ***EPIC - Electronic Product Information Co-ordination***, and the lesser mentioned were ***CAWS - Common Arrangement Work Sections*** (2,3%) and ***OmniClass – The Overall Construction Classification System*** (4,7%). The most mentioned by Architects were the ***CI/SfB - Construction Indexing Manual*** (39,5%), ***Uniclass – Unified Classification for the Construction Industry*** (23,3%) and ***MasterFormat*** (11,6%). Engineers, mentioned ***CAWS - Common Arrangement Work Sections*** and ***MasterFormat*** most (18,2%), followed by ***CI/SfB - Construction Indexing Manual*** (15,2%). This group does not mention ***OmniClass – The Overall Construction Classification System***, and the lesser mentioned were ***EPIC - Electronic Product Information Co-ordination*** (6,1%). Respondents in 'Other positions' also mentioned ***CI/SfB - Construction Indexing Manual*** the most (15,4%).

Comparing groups, the following results emerge:

		Q01: What is your position in the Office/company?					
		Architect	Engineer	Economist	Administrative	Others	Total
Q.3.1 Known classification Information Systems used for construction projects	CI/SfB	68%	20%	4%	-	8%	100%
	EPIC		67%	-	-	33%	100%
	CAWS	13%	75%	-	-	13%	100%
	Uniclass	71%	21%	-	-	7%	100%
	MasterFormat	42%	50%	-	-	8%	100%
	OmniClass	67%	-	-	-	33%	100%
	Other	-	100%	-	-	-	100%
	DK	38%	25%	-	25%	13%	100%
	NA	29%	35%	-	6%	29%	100%

Table 13- Position in company by Information System (Line %): 2008, Portugal.

Compared to Architects, Engineers more frequently mention ***CAWS***, ***Masterformat*** and “Other” (no specification). Architects, compared to the Engineers, more often mention the ***CI/SfB*** and ***Uniclass***.

When analysed by business activities, the same trends emerge as those in professional positions, added that those in Civil Construction, more often mention ***CI/SfB*** (30%), followed by ***Uniclass, Masterformat***, and ***CAWS***.

Regarding their application, **Error! Reference source not found.** details esults:

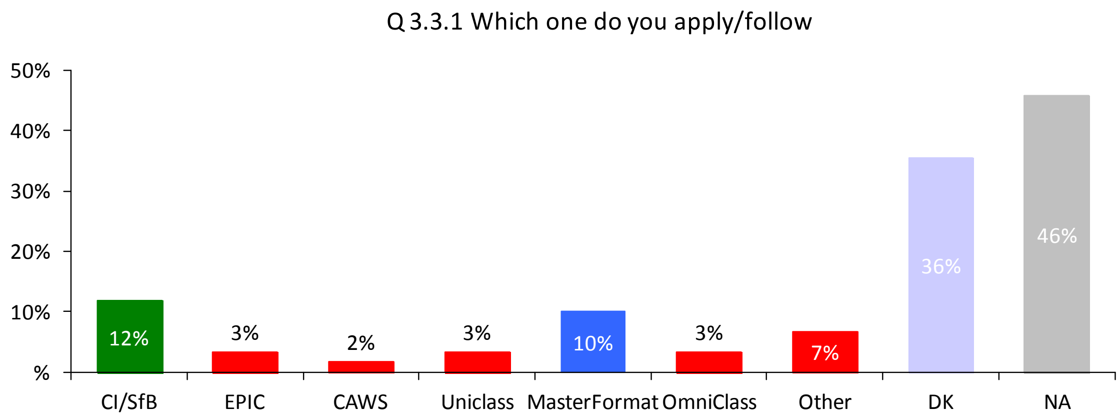


Figure 27- Applied classification information systems (%): 2008, Portugal.

The most mentioned is ***CI/SfB, Construction Indexing Manual*** (12%) followed by ***Masterformat*** (10%). In "Others", Information Systems reference was made to ***PRONIC***[73] and ***UNIFORMAT***.

Analysing Information Systems by professional group reveals that even though respondents know of many existing systems that does not mean that they apply them all. The results of application by position are detailed below:

		Q01: What is your position in the Office/company?				
		Architect	Engineer	Economist	Administrative	Others
Q3.3.1: Which do you apply/follow	CI/SfB	14%	7%	-	-	8%
	EPIC	-	4%	-	-	8%
	CAWS	-	-	-	-	8%
	Uniclass	-	4%	-	-	8%
	MasterFormat	7%	11%	-	-	8%
	OmniClass	4%	-	-	-	8%
	Other	4%	11%	-	-	-
	DK	36%	25%	-	100%	8%
	NA	36%	39%	100%	-	42%
	Total	100%	100%	100%	100%	100%

Table 14- Position in company by Information System (Column %): 2008. Portugal.

In this domain, there are some differences between Architects and Engineers. Further, ***CAWS*** is only mentioned by the "Others" group, corresponding to two company's CEO´s.

Among Architects, there is more reference to ***CI/SfB - Construction Indexing Manual*** (14%), followed by ***MasterFormat*** (7%), ***OmniClass*** (4%) and "Others" (4%), without specification. Engineers, mostly mentioned ***MasterFormat*** (11%), followed by "Others" (11%) where ***PRONIC*** and ***UNIFORMAT*** were specified.

[73] ProNIC (2008) project, a Protocol for the Normalization of Technical Information for Portuguese construction. An investigation project sponsored by the Portuguese Government to improve information in the construction industry. Literature found relates to this project investigation from 2005 until 2008, from 2008 until the present date (2012) few developments are reported.

Crossing these positions with the information classification systems:

Q3.3.1: Which do you apply/follow	Q01: What is your position in the Office/company? Architect	Engineer	Economist	Administrative	Others	Total
CI/SfB	57%	29%	-	-	14%	100%
EPIC	-	50%	-	-	50%	100%
CAWS	-	-	-	-	100%	100%
Uniclass	-	50%	-	-	50%	100%
MasterFormat	33%	50%	-	-	17%	100%
OmniClass	50%	-	-	-	50%	100%
Other	25%	75%	-	-	-	100%
DK	48%	33%	-	14%	5%	100%
NA	37%	41%	4%	-	19%	100%

Table 15- Position in the company by Information System (Line %): 2008, Portugal.

Comparing groups reveals that only ***CI/SfB*** is more applied by Architects than Engineers. The latter apply ***MasterFormat*** more, and neither applies ***CAWS***.

When looking at the type of office respondents work in, it becomes clear that results are identical to what was expected by profession. In this case, the only difference is that those in civil construction businesses only apply ***CI/SfB*** and ***Masterform***at. The next table supports these findings:

Q3.3.1: Which do you apply/follow	Q1.1: What is your office/company Business Arquitecture Office	Engineer Office	Building Construction Company
CI/SfB	13%	9%	6%
EPIC	-	3%	-
CAWS	-	-	-
Uniclass	-	3%	-
MasterFormat	7%	12%	6%
OmniClass	3%	-	-
Other	3%	9%	-
DK	33%	21%	44%
NA	40%	42%	44%
Total	100%	100%	100%

Table 16- Business company by Information Systems (Line %): 2008, Portugal.

B1.1 Who knows and applies Information Systems, how do they know about them and why do they apply them?

There were only 10 answers in 61 inquiries to the question related to the source of knowledge of Information Management Systems. On average respondents had known about the systems for seven years, ranging from a minimum of 1 and a maximum of 34 years.[74] It is to note that half of respondents have learned about them in the past 3 years. The interesting point here is to check the way they had learned about them:

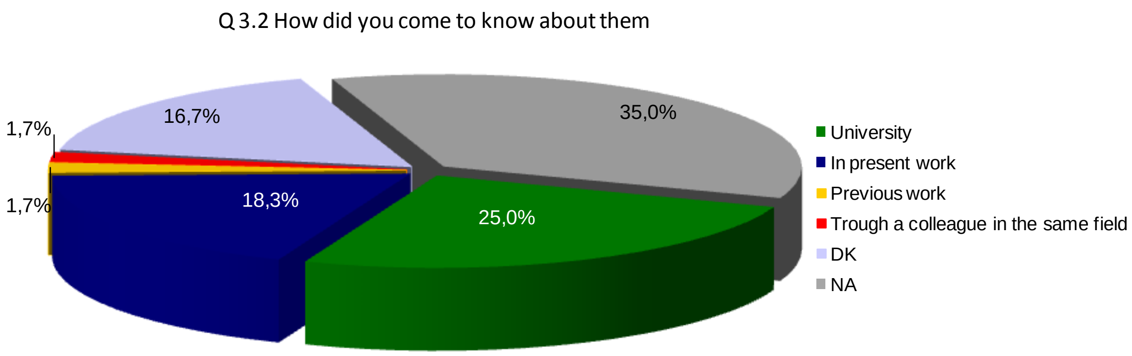


Figure 28- Font of knowledge on Information Systems (%): 2008, Portugal.

Knowledge about Information Systems is mostly associated with University (25%), and professional reality (18%).

When analysing reasons for using them, results are similar to those regarding the former question:

[74] Q.3.3.3: When did you begin to use them? (please state the year).

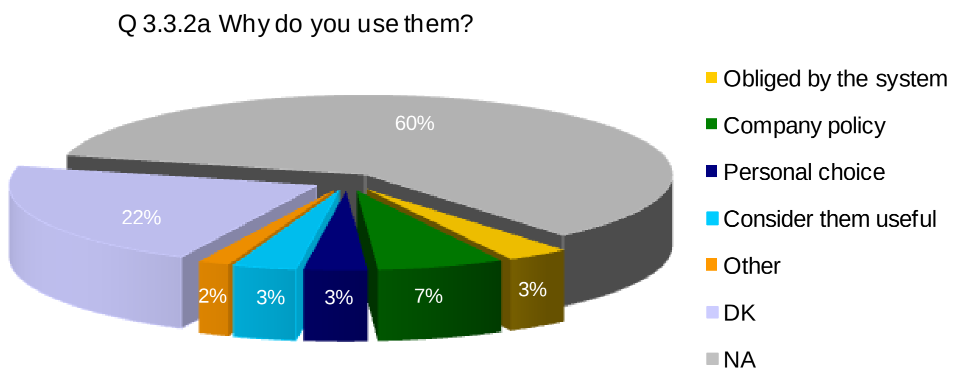


Figure 29- Reasons given for using Information Systems (%): 2008, Portugal.

The most cited reason was “Company Policy” (7%), followed by “Consider them to useful” (3%), “Obliged by the system” (3%) and “Personal choice” (3%).

To the question Q.3.3.4 “Why did you start to use them?”:

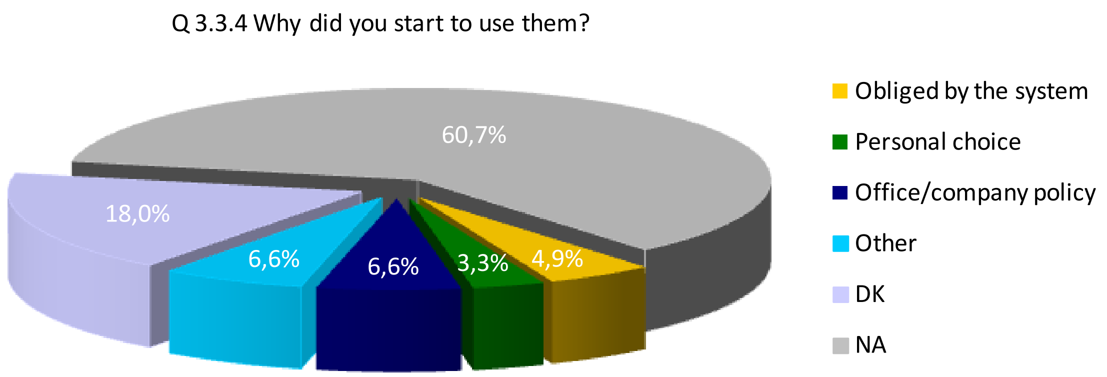


Figure 30- Reasons for starting using Information Systems (%): 2008, Portugal.

We can see that the most cited were the “Office/Company Policy” (7%), followed by “Obliged by the system” (5%), and at the end “Personal Choice” (3%), assuming the same coherence between the answers. The category “Others” was also well cited (7%).

As with the Standards, Information Management Systems were analysed by number of employees, business volume and academic qualifications.

Regarding number of employees, data reveals that ***CI/SfB*** and ***Masterformat*** are the most applied ones. It is to note that companies with more than 29 co-workers know and apply all systems options. This group is also the only one that mentions ***CAWS***. Offices with less than four employees mentioned more options, except ***CAWS***. Companies with 9 to 29 employees also mention ***CI/SfB*** and ***Masterformat***. This cross tabulation suggests that the bigger and smaller companies are those who apply a wider variety of Information Management Systems.

Analysis by business volume does not reveal major differences between companies. This may be due to the fact that the sample is mostly composed by companies with a business volume lower than 1 000 000€.

When analysing Academic Qualifications, a trend is revealed at the high school level, where more Systems are mentioned. Postgraduate/Masters mention all the systems of the questionnaire on their knowledge and applicability. PhDs do not mention ***CAWS*** and ***OmniClass***, and so do not apply them either. Regarding applicability we can see a distinction between school levels – those with "High School Diploma" do not mention any application of these systems. Those with Undergraduate qualifications do not mention ***EPIC***, ***CAWS*** and ***UniClass***. Those with Postgraduate-Masters are thus the only ones that mention all systems. PhDs present similar results about known systems in this area, but don't know about their application in their companies.

Concluding, this section has analysed results about which systems are known and their applicability without success. There aren't relevant results that can answer this question, except the existence of a discrepancy at the High School Diploma and Undergraduate groups between the acknowledgement and applicability of these Information Management Systems.

B1.2 Who knows them and doesn't apply them, for what reasons aren't they applied?

The most cited reasons for not applying the Information Systems are "Never thought about that, never used them" (15%), followed by "Not obliged by the system" (8%) and "Don´t consider them useful" (5%). The category "Others" has also been cited but without any specification.

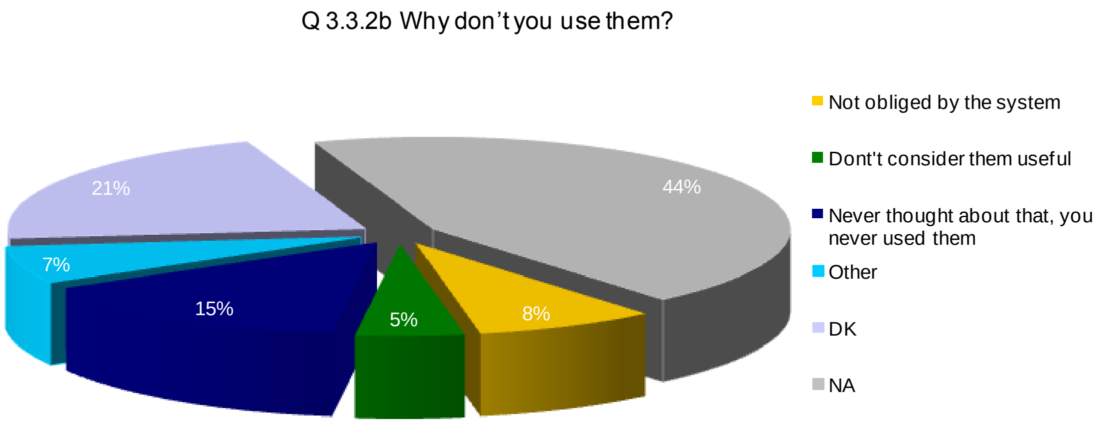
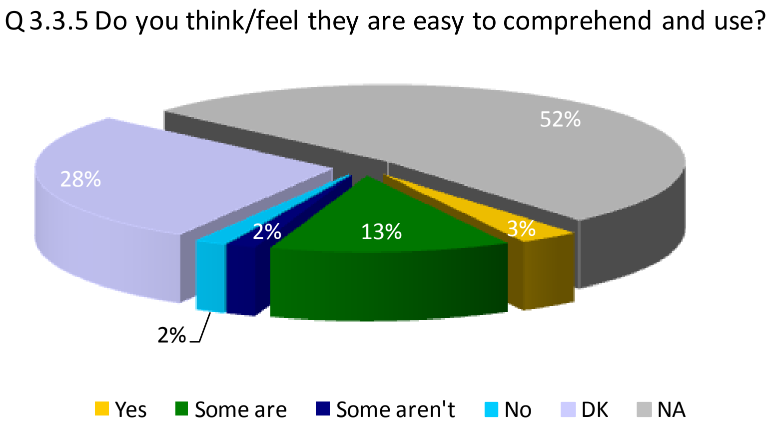


Figure 31- Reasons given for not using Information Systems (%): 2008, Portugal.

B1.3 Is the non applicability of the Systems related with the difficulty to understand them?



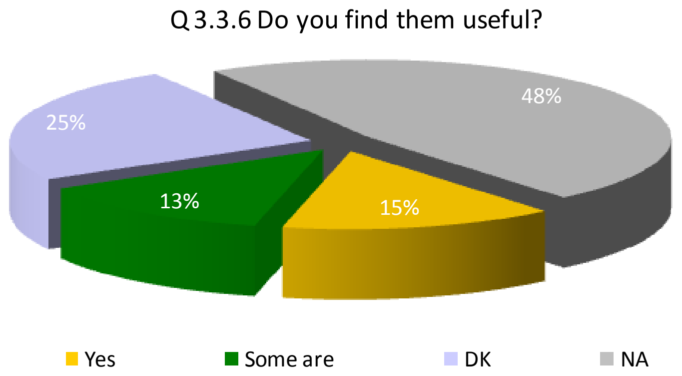


Figure 32 and Figure 33- Respondents perception of Information Systems (%): 2008, Portugal.

The systems are in general not perceived to be easy to understand, as the "Some are" answer (13%) reveals. In fact only 3% of respondents consider Systems in general to be easy to understand and use. Regarding their perceived value, 15% consider them useful and 13% agree that some are indeed useful. It is significant that there is no answer supporting that the systems are not useful.

C. Ways of storing and managing applied information

C1. Which is the most frequent way to organize information related to construction projects in Portugal? Does it works for all professionals involved?

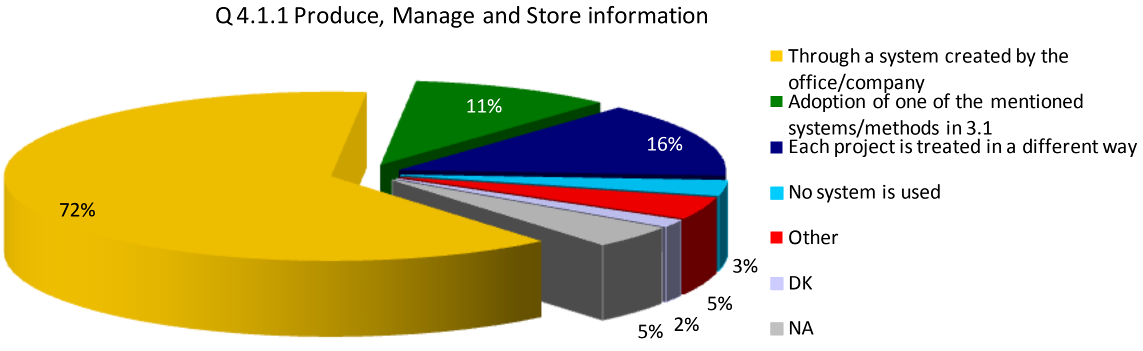


Figure 34- Ways of producing, managing and storing information related to construction projects (%): 2008, Portugal.

Most respondents referred to information management systems being created by themselves internally (72%), whereas some state that each project is treated differently in that matter (16%). Only 12% adopted of one of the systems listed in question Q.3.1. An important point is that 3% of respondents state to have no system at all. Despite 3% being a small proportion, the fact some companies do not have any system to store and manage information is of concern. Some respondents mentioned “Others” (5%), and specified ***LNEC (CI/SfB)***, ***MASTERFORMAT*** and ***UNIFORMAT***, some tables from ***OMNICLASS***, or ***WPROC – Working Project***, and ***WORD|EXCEL|CAD***.

On the perspective of academic background, most respondents mentioned that the technicians involved in the process of information management are mainly “Civil Engineers” (56%) and “Architects” (51%), followed by “Administrative” (28%) and “Informatics Engineer” (12%).

Here it is relevant to note that the category of Others (18%), include six respondents that mentioned “Draughtsman”, and others answered “Environmental Engineer”, “Electrical Engineer”, “Quantity surveyor”, “Manager” and “Quality Officer”.

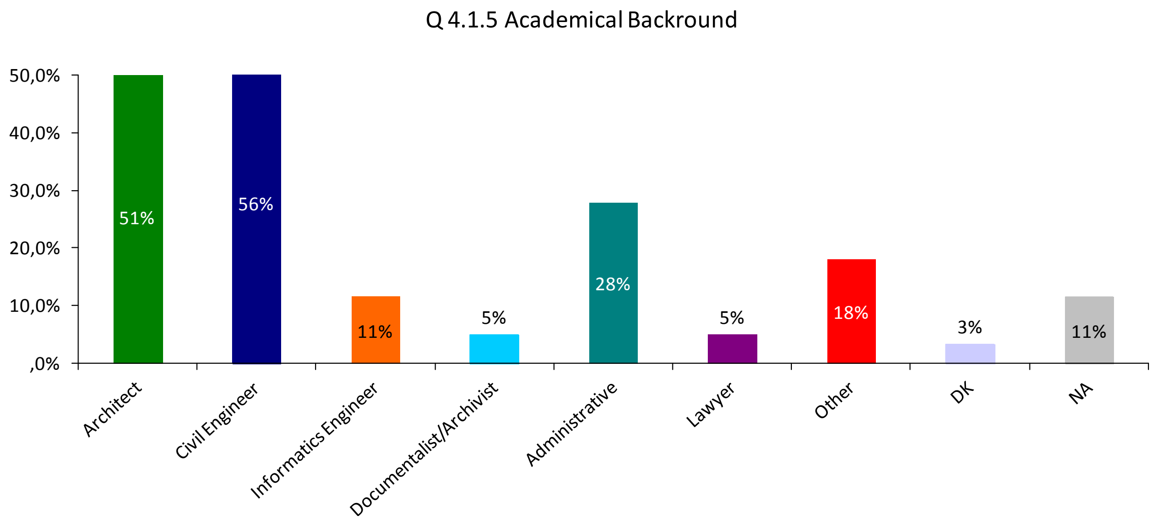


Figure 35- Academic background of practitioners involved in the process of information management (%): 2008, Portugal.

When questioned about the way respondents exchange information with other teams involved in the process:

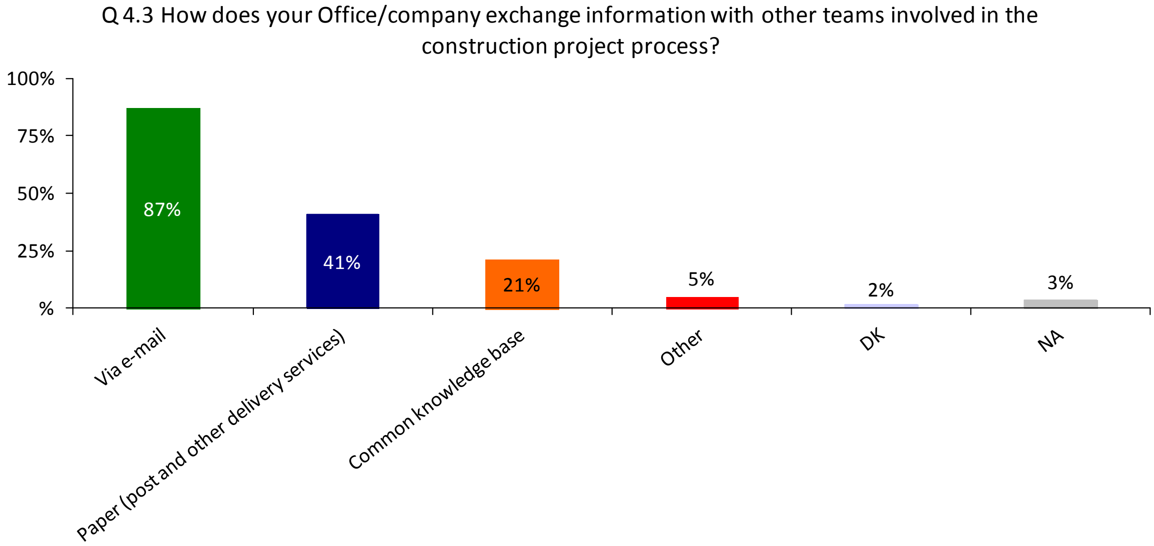


Figure 36- Methods used for exchanging information concerning construction projects (%): 2008, Portugal.

“E-mail” (87%) is by far the most common way, “Paper” (41%), and “Common Knowledge Base” (21%). “Others” (5%), were specified as “Briefing”, “Digital format”, “Coordination meetings” and lastly “Phone/in person”.

4.5. Discussion of Main Findings

This section will draw on some of the most considerable findings from the survey, and examine how these impact the development of the FCI. Some findings were as expected, others were surprising. Overall, most listed Standards and Classification systems on the survey were identified by respondents, and even some mentioned Standards and Classification systems that were not listed. Of direct impact to the research project was the realisation that offices in this field do not tend to have a systematic use of Standards and Classification Systems. Other findings considered to be important are outlined below.

The most known and applied standards are the Portuguese quality certification related, NP EN ISO 9000:2005(Ed.2) and NP En ISO 9001:2000 (Ed.2). This might be proof that translated standards are more likely to be used in Portugal than the original ones since they are easier to understand (language barrier). On the other hand it could just be the case that certification has become a part of any EU company and in which case it is necessary to follow the applicable standards to the process.

It was interesting to note that the only people identifying BS ISO 12006-2:2001 and Product Information were in management positions. In fact, that and IFC were the two lesser mentioned standards by respondents. This was not expected as they were considered important to the framework being developed here. Yet this could possibly be justified as they are both considered difficult to understand and use. This is rather important for the framework development because one wants it to be user friendly - it would be pointless to create yet another complex and obscure system as its ease of use is imperative for spreading the application wider afield. In this field, as in many others, people tend to apply what they find is simpler and effective so positive word of mouth is preferable. It seems that architects are more aware of these two than engineers and this has also to be considered.

Architects' knowledge on BS 1192:5-1998 and IFC is surprisingly low. Better understanding of these was expected since they are standards directly related to classifying and organising drawing project information. In the case of BS 1192:5-1998 it is seems obvious that respondents relate most to NP EN ISO 13567-1:2002 and NP EN ISO 13567-2:2002 as they entail an updated and developed version of CAD layering standards and are in the Portuguese language. Further, IFCs are already part of some computer programmes for design construction projects. So why are they not using them and what are the alternatives?

The classification systems mostly known are CI/SfB and Uniclass. In terms of applicability CI/SfB and Masterformat are the most used ones. The first is predominantly used by architects and the second by engineers. This makes perfect sense as the first has more application in cataloguing information from procurement to drawing elaboration and the latter is specific for construction parts.

Knowledge and application of CI/SfB might be explained by the fact that this is one of the oldest systems - it has been used long before computers were mainstream and it is reported to be easy to understand and use. It was updated when CAD was introduced but not fully developed, bearing mind all recent advances in the field.

CAWS is identified only by engineers but not referred to in terms of application. This was not expected as its characteristics are, in theory, most useful to engineers.

On the matter of applicability of standards and classification systems, the findings were also surprising. There is a lack of application of standards and classification systems, in particular when compared to the knowledge respondents have of their existence - practitioners are aware of most standards yet they do not apply them in the work place. Architects seem to know more standards than engineers but mention their application less than them. One reason might be their relatively recent appearance - standards and classification systems have been used in Portugal for an average of 7 years. This is an issue further explored in the semi-structured interviews as it is important to understand what is preventing or discouraging architects from applying these standards.

Related here is the source of knowledge – how do people learn of the existence and usefulness of standards and classification systems? The main source of knowledge of standards is the professional world followed by university training. In the case of classification systems, the source of knowledge is mostly through university training.

If standards and classification systems are introduced in academia or in the work place how are they accepted and adopted? Is it because they are considered useful or made mandatory by office policy? Mostly, respondents started to use them because of company policy or because they are mandatory, even if many also stated they considered them useful in the organization of processes. The main reasons stated for not using standards and classification systems were that it never occurred to them or that it was not company policy. So, if respondents find these standards useful and easy to understand and use in general, why are there not more reports of their applicability? In terms of classification systems, users find them useful but somehow difficult to learn and understand.

It was thought that if construction teams were to work outside Portugal in international projects, then a common framework and language for information classification would be imperative and thus these teams would be the ones more often using Standards and Classification systems. However, survey data indicates that this is not the case. This does not mean that these tools are not important, but it suggests that countries in partnership with Portuguese construction teams are also not using Standards and Classification systems systematically. If neither are using Standards and Classification systems how do the teams communicate with and amongst each other? In an era of globalisation, with more and more construction teams cooperating with their international colleagues in transnational projects, these tools are but the more important and it is time to act accordingly for the future.

When asked about the method used to produce and store information related to construction projects the answer more often given was “through a system created by the office/company” followed by “adoption of one of the mentioned system/methods”. This might ultimately create a *modus operandi* in the field since the professional world is stated to be the main source of dissemination regarding standards and project procedures. Further it is unlikely that there is currently a possibility to cross-reference to other systems and/or standards to allow for exchange of information between different companies and even within the same company, between different departments.

The fact that most prefer to use a system created by their office/company to manage information can also be perceived as a good path to the research idea as long as that system is based on something that is known and recognized by more than one company (e.g. ISO, NP or CI/SfB). But, when a relevant percentage of practitioners state that each project is treated in a different way as far as information management and storage is concerned, the problem that this research project seeks to address is confirmed, compounded by the fact that some mentioned not using any system at all.

Different teams of experts working on a given project exchange information mainly by e-mail and paper and some stated they use a shared database. What do these databases entail? Their existence is promising: if there are some practitioners in Portugal thinking ahead and using a common database, these might entail principles discussed in this project such as common used system/methods with specific language for exchanging information.

Another premise was that the more workers a company has, the more standards and classification systems would be known and possibly applied. A possible explanation for this is knowledge transfer. If practitioners come across standards and classification systems through the professional world than it is only natural that when changing companies they disseminate that knowledge.

When designing a framework that entails classification information throughout a project's lifecycle it is important to consider the literature review and the survey analysis as they bring light to practitioners' behaviour and to their awareness on the subject. Some considerations must be taken regarding the study of BS ISO 12006-2:2001 and IFC seeing that they are the least cited, as well as CI/SfB and Masterformat, for being the most mentioned by respondents. The reasons given for this are very important as they show that some existing standards and classification systems in theory might have what it takes to be effective, however, in the field, practitioners are not able to use them. Although technicians relate to CI/SfB and MasterFormat the most, these systems do not comprise all that needs to be taken into account when developing a framework, but might provide some light regarding use and application.

From the literature review one can also conclude that the most developed countries in this field are the ones that represent a small case study and where systems can be applied and tested and afterwards used, developed and upgraded in an effective way (e.g. Sweden, Norway, see literature review chapter for detailed information). Portugal is also a small country where the construction industry represents a big part of the GDP and that needs to develop their work methods not only in the name of progress but also in order to be able to compete in the globalized world. Since practitioners that produce and classify information are mainly architects and engineers, the framework has to be understood by them in order to be applied and not by informatics technicians or retrievers. The exchange of information amongst practitioners in the different fields of construction through a common knowledge base could also be of interest to consider.

4.6. Conclusions

This chapter detailed the data resulting from the statistical work done to each questionnaire question and a proper analysis of the statistical data in light of the research questions and its findings.

The data gathered through the survey by postal questionnaire has shed some light on some issues that were raised during the initial literature review but further insights were needed to develop the conceptual framework for classification of information in the construction design process. Taking into consideration the results of the survey analysis, semi-structured interviews were designed in order to explore further conclusions and suggestions raised by the survey. In fact, at the same time as survey data was analysed, efforts were continuously made to identify respondents for the semi-structured interviews. It was thus based on data and insights from the statistical analysis of data collected through this survey that the semi-structured interviews were designed and planned.

The next step, after the semi-structured interviews was to design the framework taking survey and interview data into consideration.

5. COLLECTION AND ANALYSIS OF QUALITATIVE DATA

The previous chapter introduced the research findings collected through quantitative data analysis. This chapter now presents the qualitative data gathered, its analysis and main findings. It is divided into two sections, the first devoted to semi-structured interviews and the second to validation through focus-group discussions. Each section will detail the sample, structure and main findings of its respective data gathering method.

5.1. Semi-structured interviews

Based on insights arising from the survey data analysis, semi-structured interviews were designed and conducted among practitioners and relevant authorities in order to identify the requirements involved in a construction project in Portugal and to find out if and how information is classified and standards are used. Interviewees were chosen from different standpoints in a project's life: Architects, Engineers, Construction Companies and Government Institutions. Interviews aimed at 1) enlightening a number of issues raised in the findings of the survey data and 2) inquiring about interviewees perspectives and thoughts on how such a framework should be designed in order to optimize its use in Portugal - hence the importance of choosing interviewees diversely positioned. This makes possible an analysis of the different contexts in which the framework for the classification of information for construction project design should be developed and implemented.

This first section of the chapter will detail the use of semi-structured interview techniques as part of the study at hand as well as examine its sample, design and content analysis. The main findings are summarised before the chapter moves on to discuss focus-groups and validation.

5.1.1. Content Analysis

Following the survey analysis, a set of questions for semi-structured interviews was developed and ten interviews were conducted among practitioners from different fields within the construction design industry. In light of survey findings, some questions remained unanswered while new ones were raised. For instance, there was also the need to clarify whether certified companies have a more in-depth knowledge on these issues, as the survey was not clear on this matter, and whether certified companies have already entailed standard procedures in their information classification system. It was thus thought that some questions needed clarification in order to proceed further with the research project.

The semi-structured interviews appeared as an effective method to gain an in depth understanding of the stakeholders' take on classification of information in the construction industry. Semi-structured interviews allowed for participants to give their insights on issues in a more private and intimate environment, enabling the researcher to obtain answers and ideas that the questionnaire did not clarify given its restrictive method of closed questions. One-to-one interviews facilitated a more up close and personal idea of the phenomena, based on the experience of the interviewee themself. Interviews proved to be a valuable tool in collecting different perspectives on the subject that helped to narrow down and clarify some issues raised during the previous stages of the study.

5.1.2. Interview design

The interviews were subsequent to the survey analysis and as so, questions were carefully designed as to gain a deeper understanding of issues raised by the survey.

A more free form of question layout was developed so as to steer the conversation without leading the interviewees – to ensure that the researcher would not lead the interviewees in answering what they thought she wished to hear or trying to get the correct answer to each question. The questions were mainly open-ended simple questions, as these are the most profitable way of obtaining richer information on the subject. The aim was to have an interview where conversation would flow in an environment as natural as possible under the circumstances with the researcher steering them.

The researcher conducted pilot interviews with two architects in the field to test for any issues that might be sensitive or contain wording problems as well as giving the researcher practise as an interviewer.

At the beginning of each interview, a brief description of the research study and work undertaken was given to interviewees. The structure of the interviews was simple: it started with questions related to methodology and/or systems applied to production and management of information throughout the design construction project in different construction areas in Portugal and inquired how stakeholders perceive the importance of those methodologies and systems in terms of use and workability. It then probed general procedures used by each company, if there is a standard procedure project work plan, even if only internally, and how important information management was for participants; benefits, setbacks, improvements that could be made (if there was already such a plan in place), and how they faced the implementation of a system for the classification of information for the design construction projects in Portugal. Some questions were related to drawing identification and existing standards application and also with the knowledge of standards entailed in popular software programmes for project design data in use in Portugal. Please see APPENDIX 4 for the interview script.

Interviews were recorded, with the interviewees consent. Recording interviews has its advantages and setbacks. For the interviewer it is the best method as it gives a digital recording of the interview to allow proper analysis, even if the transcribing process is often time-consuming. Recording also allows the interviewer to focus the whole attention on the interviewee (making the interview setting more relaxed) and on the interview's agenda, not having to worry about note taking. There is concern that some interviewees may feel uncomfortable with being recorded and this may constrain what they say and how open they are about their views. However, given the small size of current digital recorders and the more relaxed interview dynamic allowed by the recording (where the interviewer is talking with the interviewee and not taking notes) this uncomfortable feeling dissipates soon after the interview begins. To be clear, and as mentioned before, informed consent to record the interview was obtained from every interviewee.

Whereas the researcher wished for the interviews to take place in a public place that would free the interviewee from constraints of peer pressure, all companies contacted expressed the wish that they be conducted in their facilities in conference/meeting rooms. This was allegedly due to time constraints and comfort on the interviewee's part as well as a company requirement. As the subject was not sensitive, and the meeting rooms ensure privacy this did not compromise the validity of the interviews.

5.1.3. Sample

As mentioned in previous chapters, some survey respondents demonstrated will and availability to participate further in this project. A number of these were then selected as to be interviewed. However, to avoid sample bias, i.e. hearing only those who volunteered as interested, other interviewees were chosen from random companies. Interviewees within each company and institution were assigned by their institutions regarding the subject in question, meaning that the actual interviewee was appointed by company according to who it saw best fit to answer the researcher's questions on the matter of classification of information in the construction design industry. This ensured that all interviewees had clearance from their company management to participate in the study. From the ten interviewees, the researcher previously knew two of them.

Due to time constraints, most interviewees were located in Greater Lisbon – the researcher's residence and working area. Yet, to diversify the sample and again avoid bias, two interviewees based in the North were selected and included in the sample.

Regarding position in the construction industry, the sample is composed of two interviewees from construction companies, two from engineering companies (each of these from a different branch of engineering expertise in the construction field), and one each from an architecture office, a building management company, a urbanism and planning office, a software company, a construction inspection company and a government authority (the Portuguese Navy), thus totalling 10 participants.

The Portuguese economy is mainly composed of small to medium scale companies and the construction industry is no different. As such, and to get a broader view of stakeholders´ perceptions, interviewees were selected from companies of varying size and reach. Both construction companies have a considerable size and importance in the Portuguese panorama as well as outside the country; one of the engineering offices and the building management office are both medium size companies participating in international projects; the Portuguese Navy is a major institution responsible for much of the Portuguese coastal built environment and thus constantly refurbishing and developing new projects. The remaining five were small size companies.

Interviews were conducted in the interviewees' work places, in meeting rooms allowing privacy, and took around one and a half hours.

5.1.4. Data analysis

Following each interview, the researcher transcribed the sound files and any notes taken regarding that specific interview, the interviewee and the company. The researcher's perceptions of the interview were written immediately after it took place. The notes taken regarding each interview were then typed and attached to the respective transcript document. This information was then coded and organised in separate folders to enable analysis of interview contents.

The data gathered was subsequently thoroughly read - the main concepts and the ideas and issues discussed more often and in more detail were catalogued. Key words from each interview were also extracted and catalogued. This was done over and again as to narrow down and systematise the main concepts that could be then translated into key features in the development of requirements for the FCI.

The more prominent keywords in the interview's contents were: Classification, Information, System, Methodology, Practitioners, Client, Functions, Roles, Implementation, Experience, Team, Software, Windows' folders, Accountability, Security, User-Friendly, Uniformization/Standardization. Keywords were then divided into three main areas: **Project procedures, Classification of information and Storage**.

The main issues identified relating and influencing information production and management fell under the following categories:

- Political issues;
- Cultural issues;
- Behaviour issues;
- Legal issues;
- Technical issues;
- Educational issues;
- Economical and financial issues;
- Organizational issues

Three major factors were also identified as having a greater impact on the construction project design: **Corruption, Accountability and Timeline (deadline**

issues). These were emphasised by all interviewees in one way or another as having a major impact on all the others or as being influenced by some of the above mentioned categories, which in return influences others in the process.

The main concepts and their interrelations, as revealed by the semi-structured interviews, are outlined in the cognitive map (Figure 37, pag.173).

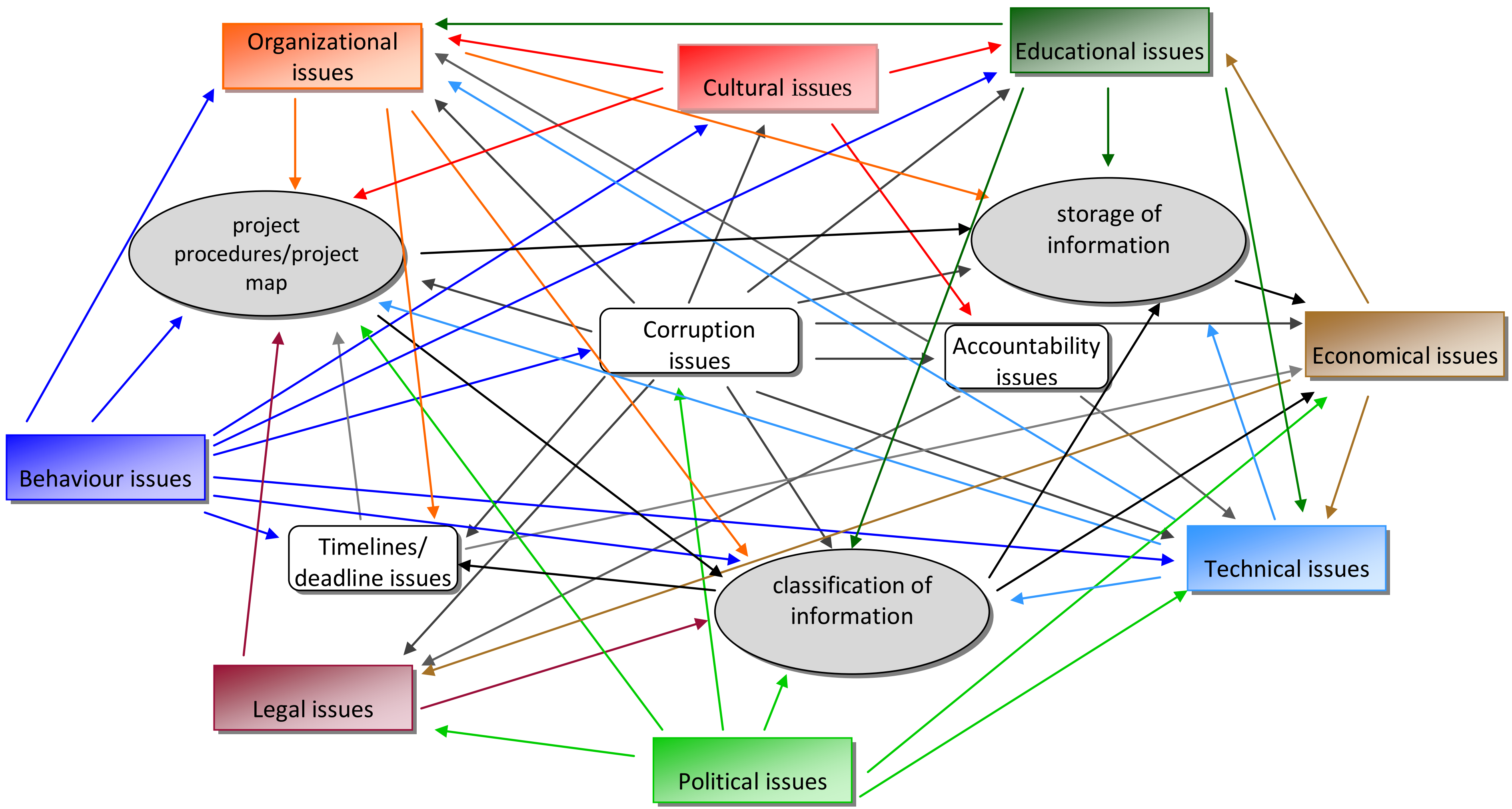


Figure 37- Cognitive map of most mentioned issues and their relations (mentioned by respondents).

As interviews were located in different filed areas within the construction industry, it was important to analyse how each one perceives the requirements for an information classification system. Table 19 (pag.177) shows interviewees with the main concepts[75] this was underlined to better identify the importance of each to the different interviewees. This said it is important to identify each interviewee field of expertise and background (Table 17 pag.175); 01 – Architect; 02- Civil engineer; 03- Mechanical Engineer; 04- quality certification Engineer; 05- Project designer and quality manager; 06- Engineer, responsible for quality environment and safety in construction and laboratory quality; 07- Civil Engineer, construction inspection expert; 08- Software Engineer in the construction field; 09-Civil engineer, 10- Architect and project manager in the Portuguese Navy.

The semi-structured interviews carried out confirmed some issues raised from the survey analysis and revealed some new ones. Some issues were raised more often than others within each interviewee (Table 18 pag.175) - this is of importance as it suggests links with the field of expertise of the interviewees.

Behaviour, Technical and Organizational issues were the ones mentioned by all respondents independently of field of expertise. Interviewees 5 and 10 are the ones that identified all issues, this is not by chance, both have to deal with almost all sorts of project demands: Maria, working for an urban and planning company experiences both sizes of field reality, private and public companies and Manuel´s work involves working alongside other teams from the private sector and developing projects within the Portuguese Navy.

[75] The main areas mentioned by interviewees; **project procedures, classification of information and storage** and some of the more often used keywords; classification, information, system, methodology, practitioners, functions/roles, implementation, experience, teams, software, Windows folders, accountability, security, user-friendly, uniformization are not outlined in this table. This last were entailed in the main concepts described above as to its context and the first are the ones that are affected by the last.

Interviewee	Field expertise	Qualifications background	Company size	Location	Approach
01-Nuno	Architecture	Architect	Small	Lisbon	Survey respondent
02-José	Owner Engineering company	Civil Engineer	Medium	Lisbon	Survey respondent
03-Ricardo	CEO- FM company	Mechanical Engineer	Medium	Lisbon	Survey respondent
04-Rita	Quality manager- Construction company	Engineer	Medium	Oporto	Random sampling
05- Maria	Project design and quality manager	Urban and planning	Small	Oeiras	Random sampling
06- Ana	Quality manager- Construction company	Engineer	Big	Lisbon	Random sampling
07-António	Owner of a inspections company	Civil Engineer /construction inspection expert	Small	Alenquer	Random sampling
08- Luis	Software developer	IT and software expert	Small	Lisbon	Random sampling
09- André	Civil Engineer	Civil engineer	Small	Torres Vedras	Random sampling
10- Manuel	Architecture Portuguese Navy	Architect	Big	Lisbon/ Portugal	Random sampling

Table 17- Brief chart on respondents' background

Interviewees / Issues	01	02	03	04	05	06	07	08	09	10
Political	■	■	■	■	■	■	■		■	■
Cultural		■	■		■				■	■
Behaviour	■	■	■	■	■	■	■	■	■	■
Legal	■		■	■	■	■	■			■
Technical	■	■	■	■	■	■	■	■	■	■
Educational	■	■			■		■	■	■	■
Economical	■	■	■	■	■		■	■	■	■
Organizational	■	■	■	■	■	■	■	■	■	■
Corruption	■	■		■	■		■		■	■
Accountability	■	■	■	■	■	■			■	■
Timelines/deadlines	■	■	■		■		■	■	■	■

Table 18- Main themes identified by each interviewee: 2011

Political and cultural issues were not raised at all by Luis, a software developer who placed emphasis on behaviour issues. A thin line was drawn between cultural and behaviour issues, which led the researcher to eventually group them into a single category.

What became obvious is that technical issues were given considerable weight by interviewees; again here one can conclude that behaviour and organizational issues are of importance. Political and economic issues stand out too. Practitioners perceived them to be influential in the construction process. Here it is obvious that the two issues are felt in both the private and the public sector.

It is interesting to see the different importance given to each subject according to the respondent's field of expertise. The ones that work in both private and public projects relate more with political and legal issues. Organizational issues are mentioned more by the ones positioning themselves after the first stage of project design - Engineering and FM. For FM mangers, management of information is one of the key factors of success for their work, as without a proper production and management system to retrieve information managing a building it is an extremely hard task. Matters of corruption, accountability and timelines/deadlines were mentioned by almost all, either explicitly or with linkages to other identified issues.

Issues \ Interviewees	01	02	03	04	05	06	07	08	09	10
Political	Mentioned the most	Mentioned some times	Mentioned	Mentioned some times	Mentioned some times	Mentioned	Mentioned some times	Not mentioned	Mentioned some times	Mentioned some times
Cultural	Not mentioned	Mentioned some times	Mentioned some times	Not mentioned	Mentioned some times	Not mentioned	Not mentioned	Not mentioned	Mentioned	Mentioned some times
Behaviour	Mentioned	Mentioned the most	Mentioned the most	Mentioned some times	Mentioned the most	Mentioned some times	Mentioned	Mentioned some times	Mentioned some times	Mentioned
Legal	Mentioned	Not mentioned	Mentioned	Mentioned	Mentioned some times	Mentioned	Mentioned some times	Not mentioned	Not mentioned	Mentioned the most
Technical	Mentioned the most	Mentioned the most	Mentioned the most	Mentioned the most	Mentioned the most	Mentioned the most	Mentioned the most	Mentioned the most	Mentioned the most	Mentioned the most
Educational	Mentioned	Mentioned	Not mentioned	Not mentioned	Mentioned	Not mentioned	Mentioned	Mentioned some times	Mentioned	Mentioned
Economical	Mentioned	Mentioned some times	Mentioned some times	Mentioned the most	Mentioned	Not mentioned	Mentioned some times	Mentioned the most	Mentioned the most	Mentioned the most
Organizational	Mentioned some times	Mentioned the most	Mentioned the most	Mentioned some times	Mentioned some times	Mentioned some times	Mentioned some times	Mentioned	Mentioned some times	Mentioned some times
Corruption	Mentioned some times	Mentioned	Not mentioned	Mentioned	Mentioned	Not mentioned	Mentioned	Not mentioned	Mentioned	Mentioned some times
Accountability	Mentioned some times	Mentioned	Mentioned	Mentioned some times	Mentioned	Mentioned	Not mentioned	Not mentioned	Mentioned some times	Mentioned some times
Timelines/deadlines	Mentioned	Mentioned some times	Mentioned	Not mentioned	Mentioned	Not mentioned	Mentioned some times	Mentioned	Mentioned some times	Mentioned the most

Table 19- Most frequently mentioned concepts by each interviewee: 2011

Mentioned the most

Mentioned some times

Mentioned

Not mentioned

The remainder of this section will address interviewees' inputs on the project process and on methodology applied to manage information concerning construction. Project process is reckoned by practitioners to be basically the same but the methodology applied in data management diverges.

Regarding project process, the steps to be followed are basically the same in each field of the construction project design; also the main core is similar within each field speciality. Nine out of ten interviewees mentioned always following the same methodology regarding project design data in their work place, each having its own, and that all projects start with client proposal, invitation or tender. All seem to have created their own methodology for information management applied to their field of speciality and to the specificities of their own company/office.

When asked if the procedure for entailing a project was always the same and knowing in advance that they have their own system in place, Nuno, who is an architect and business associate at a architectural firm, answered *“it is our own way of proceeding regarding projects (...), an exception is rare, I don´t remember any, it has always been done like this (...).”* Maria, working on an urbanism and planning company, stated *“Our methodology is always the same,”* as did André, working for an engineering company, *“from the moment we receive the architectural project the development is always the same, same methodology.”*

As mentioned above, all interviewees reported applying the same project process. Regarding the Government authority consulted, the Portuguese Navy, it was interesting to note that they have a methodology for data management for when they are the client and for when they develop projects at “home.” This is the current situation nowadays as Manuel, architect in the Navy, said:

> Here we do almost all kinds of ´ways of doing´ that are out there. We can do projects inside the Navy, we have experts in all fields of construction and do it a lot. Nowadays with the loss in the Ministry of Defence´s76 budget we have to do all projects internally because we don´t have the money to hire external teams to do it for us.

They have a standard procedure for when they develop construction design projects inside the Navy and they try to use and implement the same rules when hiring external teams.

Whereas some interviewees stated that they always follow the same process, six of them also stated that when the client is a government authority the process is more demanding and more guarantees are required. Take Ana´s words for instance: *“So far, the most demanding clients that we had were public authorities!”* All emphasised that the Government is the most demanding client. For Rita, like Ana, an

[76] The Portuguese Navy is under the supervision of the Ministério da Defesa (Ministry of Defence)

engineer at a construction company, this is obvious and she pointed to some of the differences:

> There is a higher level of requirements than with a private client (...) At the end of any construction they ask a compilation of the end version as well as all the process through the construction site duration, security plans, materials certification, all documentation (...). They have their own inspection system and there is nothing on site that hasn´t been previously approved by them in proper signed documents.

In the company that Ana works for, what started out as a hard task became an effective system:

> We had a case in 2007 with a project for Águas do Algarve[77]. They wanted the information management system throughout the construction project to be similar to theirs, so we had to implement a completely different system from our own for the environmental and security sectors of the company. At that time those sectors were not certified and that was eye opening for us. After that we saw that was relevant for us to be certified in those fields and started working on it. Ultimately we gained certification in those two areas and the drive to do it was definitely the demands of that particular project.

In fact, even if such dramatic results did not occur often, demands to conduct project process and information management in specific ways were emphasized by interviewees when it came to contracts involving public institutions:

> The process [project process and information management] changes when the client is the Government (...). We have to entail and obey their rules and most of the time they are not the same as ours, neither are they the same from one institution to another.
>
> Usually they require more information and more detail.
>
> We always have to comply with their rules if we want to work for them.

[77] Águas do Algarve- Algarve water supply company, a public company.

> Most of the time we have to change our *modus operandi* and establish theirs.
>
> They have a code of procedures and all teams working for them have to follow that code.

But the public sector is not the only one with special requirements regarding information in construction design projects

> We use some tools that clients provide and make us use. Some of them have software that allows them to control all information assembled during the project development and construction site.

This, however, happens only when the client has substantial financial resources, which is not often. Interviewees were then asked if they were aware of such systems/software why they did not apply them afterwards. Did they not see benefits in it?

> Yes. They serve also as stable common work environment between all teams engaged in the process. And the client is also more involved in the process which a good thing. (…) But these software's are very rigid in terms of information classification. Practitioners might not like them but for the client the control is higher.

Interviewees also argued it to be impossible for them to support the use of such systems or implement them in every project:

> The issue is that all clients that we work with are different and we have to adapt to each case and each software or classification system and that takes time as it entails different methodologies for each case. They don´t learn from each other! Different clients, different methodologies, different typology of information. All different from each other. It is almost as if each one had a little genius working on this by himself and thought "I am going to invent my own little management information system"!

The methodology in place to manage information is not based on any existing system; interviewees have no notion of existing classification information systems.

As such, each created its own methodology internally based on their own experience. Take Jose's case:

> We based it on our project´s development. If tomorrow we start doing projects in other fields, we will add more folders to the system. It is based on our experience.

For Nuno too, the system was developed instinctively, but there was input from colleagues who had worked elsewhere with different systems:

> [it began in an] intuitive way and afterwards we had one or two team members that worked here and had an idea of existing systems and we started to learn with each other and adapted it over the years.

Similarly to Nuno, Mary acknowledged the contribution of particular colleagues with specific knowledge:

> The colleague that developed the system [in place in her company], who is no longer working here, was very focused on SIG[78] systems so it was only natural that he had more information on the subject.

Mostly however, interviewees were not concerned or even aware of what other companies in the field do with their information. And yet, eight out of ten stated to have problems with systems in place, in particular with regards to retrieving information. The more often identified problems regarded over-storage, information misplacement, and erased documents and folders. Take the following statements regarding this matter:

> There have been some issues with copying or moving folders within folders and when we need to retrieve the information the folder is no longer where it was supposed to be. We believe this is the case because in those instances folders were never found. (Ricardo)

[78] SIG- Sistemas de Gestão de Informação (Information managemnet systems)

> There is the need to organize files, delete duplicated folders or unused and unnecessary files that are just pilling up without being need. (Nuno)
>
> Placing documents in the wrong file, classified under the wrong heading and afterwards someone goes looking for the file and it is missing…classified with different denominations than the ones previously established. (Jose)
>
> Sometimes without us wanting it to happen, we drag one project "inside" another (within the Windows folder systems) it´s not lost but it´s missing and we may be looking for it for quite some time in some other folders from different projects and that is a big flaw in the system (Maria).

The problems here related by interviewees are not a mere inconvenience but have important negative implications for the projects. It involves not only time wasted searching for information that should be readily accessible, but also a duplication of efforts when particular documents have to be redrafted. Further, it may result in important gaps in communication that can become disastrous:

> There have been some reports of issues like this: two teams involved in the same project working in different versions of the same documents because the one that received the information from the architect did not classify it well or did not share it with the rest of the teams. This situation lasted a couple of weeks until they´ve figure it out, and this is serious, this is really bad for us. (Jose)

Since each company interviewed has created its own classification system, it was important to understand how these systems were organized and establish if there are any trends or patterns among them. Two companies possessed suitable software for that purpose. Nor surprisingly these are two of the three companies in the interview sample that are certified. The remaining eight companies use a system based on Windows folders to classify the information gathered throughout the construction design project concerning their own expertise. All have developed their own folders' breakdown, not basing it in any existing previous idea developed or tested or seen in another place. The breakdown was designed according to their need and it is updated when necessary. Almost no folder is ever redrawn but some are added, as José explained,

> It was created on the grounds of the projects developed. Every time we need a little more, for example if we start doing other specialities projects we will add more folders to it.

These systems of classification and organization of information:

- Are based exclusively on each company´s perception of its needs. No background research, however small, was carried out to actually assess those needs or to check-out what might exist and being used in different companies or countries;
- Do not comprise international or national standards related with their field of application;
- Are reported to be user-friendly, even if during implementation most practitioners were reluctant to use them and some are still contesting them.
- Have severe limitations, in particular with regards to retrieval and sharing of information, resulting in time and effort spent in chasing information that should be readily accessible and in more severe cases, hindering the development of the project.

António, civil engineer and associated partner of a construction inspection company, made for a very interesting interview as far as this matter is concerned. The system in place in his own company, was developed by him and his team. He considers the system successful arguing that it was very easy to search for and access any sort of documentation and was eager to show it to the researcher. Yet, he failed to find any piece of document he set out to search throughout the duration of the interview which took over two hours. It was hardly a successful demonstration, which led Antonio to question the competence of his ‘wonder’ system and to consult with his team about it.

The failed demonstration attested both to the lack of efficiency of the system and to the fact that what people say cannot always be taken at face-value. In other interviews too the researcher asked interviewees to demonstrate their system in order to grasp if what is perceived as an effective system is actually working. These demonstrations proved useful to the researcher, as most practitioners took a considerable amount of time to find the documentation they were looking for.

File identification is of paramount importance in order make information easily accessible to all, and interviewees have stated it to be an issue. The two companies holding software adequate to classify and store information, code their projects data in an alphanumeric system. The main issues though, arise with those working with the folders system. Of these, two use a list of clients' names for file identification, and six a list of projects with numeric coding.

> The folders name….that´s another issue. The older system had certain filling coding rules but it was too complex for most practitioners and it was time consuming to try and file things but at least there was a coding file system. Now it is easier but sometimes it seems that everyone makes up their own way of filling!

Some presented somewhat unusual free form ways of classifying information:

> This system is not so participative. Each practitioner has its own documents and file system and when another practitioner needs his documents he just goes and asks him. Each one takes care of its own things.

Before looking into other issues arising from such filing systems a note is needed here on over-storage and back-up systems. As mentioned above, over-storage was also a problem. All interviewees agreed that it is necessary to store information for retrieval during and after project completion and usually this is the last version of the construction on paper and digital support. Eight companies store the documentation pertaining to all projects they have been involved with since their inception and intend to keep it ongoing. Two keep information for a maximum period of ten years only. Yet maintaining and organising such vast amounts of information demands time and systematised care if one wants to make access to information easy and intuitive, and as the above quotes reveal the systems in place leave much room for improvement in this regard. E-mail was also stated to be an informal storage method. Most importantly it was mentioned by most as back-up and a way to keep track of work being developed. As one interview said, "*we often use e-mail as a form of backup of information exchange and storage.*" This is not however an organised email system with any sort of structure or classification, rather email presents itself, by chance and lack of alternative, as an informal back-up system. Nuno and Jose explain:

> Eventually information that is lost, ends up by being in the e-mail account, which by itself ends up being a backup of information because attachments always remain up there. (Nuno)
>
> Sometimes I am looking for an important document and I cannot find it anywhere but I know that I have sent it to a client. Nowadays is even easier to find things in Outlook than in any other place. And look, there it is! Nowadays it´s very rare that an important document hasn´t been sent or received through e-mail so Outlook solves about any problem. *(Jose)*

Practitioners manage their e-mail accounts with Outlook or Microsoft Outlook software, where copies of e-mails exchanged with practitioners from the same field or between/within different field teams involved in the project are kept. Yet, if anything, this constant reliance on email to find and store information pertaining to projects attests to how unreliable the information systems implemented in these companies are. If information is being looked for in an e-mail account, surely something has gone wrong with the storage method in place. Whereas looking through e-mails to find information needed may save the day when the system fails, it is not sustainable in the long run.

The lack of systematised information management was stated to result in organizational and accountability problems, some of which have already been dealt with here: 1) vast amounts of folders, not necessary or in use, 2) misplacement of information and 3) breaches in security of information. Related here is the matter of accountability. Nine interviewees stated that practitioners' accountability regarding their own work, according to their job descriptions, is not easily detected or perceived. As most information can be accessed by all engaged in the process, problems are reported to arise regarding information management and practitioners' accountability for their work.

When talking about the need for a more organized structure in terms of information and practitioners responsibilities, roles and functions in the process, Rita states that "*the problem is that it is difficult to identify accountability and define roles."* Rita works for a certified construction company that has software designed to manage information and for her accountability issues were also behind the adoption of such a system:

> The objective was to organize the company by fields, establish work bounded areas, define responsibility for each one of those areas, assign functions to know exactly where each one stands, what they were doing, and what were their responsibilities.

Nuno and Jose also testified to problems faced when determining accountability:

> In theory, yes [it is easy to assign responsibility]. In practice, no. In the beginning of any process the person responsible for the information is accountable but sometimes another practitioner needs to make some sort of alteration to the project and that last change and person responsible for it is not easy to identify. (Nuno)

> Sometimes practitioners that produced some piece of information during a project process do not identify themselves in the proper way and when things don´t go so well and responsibility needs to be assigned for, we need to find out who did what, which is not easy. (Jose)

This is not just a matter of allocating responsibility. The lack of an efficient system for managing information, compounded with difficulties in determining who is responsible for specific tasks and documents not only compromises the quality of work as it may result in serious security issues. Manuel was very well aware of this,

> Accountability is never easy to identify and in most cases it´s not identified at all. As an end result quality is compromised.

The Navy is of course a special case in this regard. It is part of the Portuguese defence system and that raises high issues in managing information properly when it comes to security:

> We could have internet and even geographical reference but we don´t for security matters. We don't even have internet, only extranet. For security reasons there is no connection between our computers and the outside world. We only have e-mail and even those have to pass by a thorough scrutiny before being received in here.

This is of importance since the Portuguese Navy is responsible for a wide variety of the built environment along the Portuguese sea coast, which is constantly being refurbished or transformed for other purposes and with systems like SIG[79] information would be much easier to track and organize. But there is the security factor to consider. Manuel, architect in the Navy, explained that all information is classified and stored by a separate group of people and no contact is established between the different teams working on a project without passing through a properly identified higher hierarchical figure.

Even if private companies do not hold national security in their hands, data security issues were still of importance and were often raised. Nuno and José provided more detailed accounts of the problem:

> Now everybody can access almost everything! Put information in the wrong places and classifying it in the wrong way and afterwards someone goes looking for information and it is no longer there…I thought there was a folder to contain this and that and when I try to find it…it is no longer there. In theory practitioners do not "move" folders within the system, if they have access to them or not that is a different thing. In practice things are not exactly like this. (Nuno)

[79] SIG system- Sistemas de Georeferenciação (Georeference information systems)

> We had problem with this you know….the Windows folders system is very limited. The same people that insert the data can also remove it without further notice! (Jose)

For one thing, everyone seems to have access to all information throughout the process, misplacement of folders is common practice, either by lack of knowledge or distraction. For another, data was reported to be intentionally misplaced, deleted or 'stolen' by practitioners leaving the company as a means to jeopardise the company for a dismissal or to take clients with them. In fact, security issues were often mentioned with regards to employees that compromised projects' information upon leaving the company – at times with tremendous costs for the company and colleagues left behind.

All interviewees mentioned that information contents in the design process, both in architecture and engineering, are not uniform or even similar. All reported the main problem with the production of information to be in the early stages of the design process and most problems on site derive from it. In Rita, Ana, António and Manuel´s case this was evidently stated because they deal with projects reception to construction or inspection and that comprises all different specialities involved in a construction design project:

> Information within projects is not uniform at all. Some are really poor in terms of information content and representation (…). In the end the client is harmed in quality and money. (…) Some projects have materials description such as *"15 by 15 cm tile to be defined on site."* How do you work with this level of information on a construction site? How do you establish a real budget?
>
> The uniformization and parametrization of information should come within the different specialities of projects and that´s not the case. All projects have different content information not to mention basic representation.
>
> All represent different things in different ways so when we receive them we have to take some time to standardize the information.

For António, these issues are double-faced. At present he is an inspection engineer, but his academic background is in civil engineering and he did construction projects for about two decades:

> Things are worse than when I started. Project quality in terms of information is lower and makes the job harder. I have to inspect a construction site and I am responsible for all that happens on it but when I read a project and find that there are not basic specifications that it should contain I know the client is going to have to spend more money for things to be OK.

Manuel, deals with this issue every day from the perspective of public institutions:

> What lacks is information quality on project design stages which jeopardizes all that comes afterwards.

Different or similar types of projects have different approaches by practitioners as to their requirements for information content. Although some regulations were established by the Government, project information contents are far from uniform. Overall, some issues were raised as to figures, roles and responsibilities in the whole process: where does the responsibility of one team member end and that of the next one begin?

This was reported about the project manager figure and responsibility. The project manager appears as responsible for the whole process of information flow, from inception to storage, and retrieval of information after project construction completion. In the company where Maria works*:*

> Each project has a project manager (...). He has all information concerning the process (...), he defines roles and responsibilities and is assigned for each project (...). When engaged on a project the amount of information is such and the need to update and keep an eye on everything is so big that the project manager figure is somehow lost along the way.

Nine out of the ten interviewees stated issues with this figure and one of the major referred to issues was that the information and the human resources are too much for one person to manage alone. This role entails too much for just one person succeeding without some other form of support in keeping everything on track.

Certified companies, for which 3 interviewees worked, showed more knowledge of existing standards and have software for quality and certification management of document information. Companies that have worked with or for the government or governmental intuitions are more aware of standardization procedures and have already had to adapt their system or their “way” of producing and managing the data to the requirements of government institutions, as was seen for instance, by the company for which Ana works and their case with Águas do Algarve. This was also brought up by Manuel who explained that the Navy demands that teams of practitioners working for, or with, them have to follow their rules of information production, classification and storage. Within Government institutions, the rules applied concerning information are not always the same, although some standards such as layering remain the same. This was mentioned by all that have worked in, or with, different public authorities.

The need and usefulness of a system that can work from any place, maintain activity reports and ensure security of information, was stated by six of the respondents.

> Project managers and practitioners located on site cannot access all information because the internet coverage is not good enough and the storage and informatics systems don´t allow for them to open up folders on site. (Rita)

Ana was the only one reporting that her company has an extranet in place to overcome these issues. Although it may not always function at its best, it does keep activities reports on a file that, whenever possible, updates files on the main server.

Practitioners should be the ones producing, storing and managing information within any created system. That is why the system should be user-friendly, since their time and effort ought to be deployed in the actual projects at hand and on construction site, and not on a time-consuming, confusing organizational information system.

This was indicated as a problem that most face at present. When the information is not inserted by practitioners that work in the field, but rather by someone else after process completion or even after a days' work, there are reportedly issues with information misplacement. The three companies that are certified mentioned this but also mentioned that all activity and changes in the filing structure have to be monitored and authorized by a specific person, which is the quality manager engineer or another high ranking figure. Any change to the structure has to be justified.

Four companies mentioned that after implementing their own classification system, both they and their clients saw improvements in managing and retrieving information in a more efficient and speedy way. They also stated that classification information systems are of utmost importance when improving productivity by reducing time and enabling the monitoring of those responsible for the production of information.

Maria defends that information systems

> … brought organization to the company and it is much easier to establish deviations and to find out why some issues are recurrent from one construction site to the other and even if slowly making amendments that can be beneficial for all in the long run.

For Nuno, the system in place, even if far from perfect, brought benefits

> Yes, mostly in terms of organization (…). It takes us less time to find things mostly in large scale projects where it is now easier to retrieve information and folders are smaller with less duplication.

For Ana too, the classification system *"has room for perfection but it definitely brought visible improvements."* José, who showed genuine interest on the subject, explained that

> It was necessary and we always had an interest in the subject. We employ over 50 people and we need to store information in a way that it is accessible to all.

And Ricardo, working in a facilities management company:

> It is very important since we have to use all information gathered to do the buildings maintenance throughout the whole lifecycle of a building.

Others, such as André, were more pragmatically skeptical of classification systems:

> We used to have an information management system in place, very sophisticated, or at least more sophisticated than the one we have now. We had it for five years in place. Everyone respected and used it and it worked fine, but it was too expensive to keep and we had to stop using it about six years ago. All the information gathered during those five years was kept inside the system. Never to be used again. (…) We were trained to use it and after it was shut down, nobody used it anymore. (...) We only retrieved information from it maybe five to six times over the years.

As for the information it contained,

> It was never retrieved and we never saw it was necessary to do so. The system encrypted all documents and kept them super-safe and super I don´t know what and now it is super difficult to take them out of it!

Resistance to anything that is new was reported by nine of the interviewees - not for any particular reason but generally as novelty causes a change in the everyday established routine.

> It happens a lot, practitioners resist to anything new, they even resist when free educational training is given to them on a new software so when it is about a new implementation it is hard to convince them, most are only convinced when they are obliged to do it.

In fact, statements like *"there is always resistance"*, *"mainly resistance to the process and quality phase of implementation"* and *"there is always one or two who resist"* were recurrent during the interviews mostly when referring to anything that is new and has or is in the processes of being implemented. Even those who started by stating that it is easy to implement new things reveal the difficulties inherent to it:

> yes, perfectly, sometimes it's things that require more knowledge and if so either we don´t implement them or we try to understand how it works.

Luis, the software engineer, stated this to be a problem in every kind of change, but especially in his field of software implementation. He also mentioned that a classification system, to prevail, would have to be not only user-friendly but very well divulged through proper chains as this, he believes, is the only way to get practitioners to engage with it.

As to known and used software for design projects, the ones most identified were AutoCad, ArchiCAd, Revit. The latter two were taken as too expensive to be in place, not only in terms of software implementation but also skills development. Workshops are very expensive as is the software. Further, software's annual licenses are also expensive and often do not add much more to the original package – these are perceived as a means of exploitation by software companies. The software engineer developed further his thoughts on these issues and explained that if software licences were not as expensive as they are, practitioners would make more use of it. Instead, what happens today is that there are more practitioners, in a given company, working on software computer programmes than officially bought licences. Pirating has its own risks, not only in the quality of the software's pirated copy but also in eventual fines and the damage to the overall imagine of the company should this be publicly disclosed.

Almost all interviewees claimed to know, or have co-workers that know, how to work with these softwares but in fact did not have a clue how to do so. When asked questions concerning certain tools that the software entails for specific ends, their answers were either vague or silent. Technical issues were the most mentioned ones in almost all interviewee's fields as seen in Table 19 (pag.177).

Confirming survey results, ISO 9000 and 9001 were the standards more easily recognised, in fact mentioned by all ten interviewees. A curious fact was that interviewees who apply standards entailed in software, e.g. use IFC´s entailed in ArchiCAd for cataloguing materials were not aware that those are in fact standards and perceive them only to be *"(...) very useful in library managing materials(...)"* as Nuno and José mentioned. For Luis this is normal, as people do not know what software programmes are based on, nor do they know what they comprise.

Five companies, the ones with more employees, stated the need for a more organized information system as "*all it takes for a downfall of an organization is 10 practitioners working on the project at the same time, its chaotic."* But all interviewees revealed their concern that poor organization of information results in: poor specifications and mistakes and omissions in the quantity survey ultimately resulting in problems during construction.

Regarding the development of a system to be used nationwide, interviewees agreed that it has to be easy to implement and user-friendly and that it should:

- Enable control of information: what goes where;
- Enable control of responsibilities for production of information and alterations;
- Be simple and intuitive;
- Comprehend international standards that are relevant but not in a manner that compromises its ease of use;
- Enable uniformization of project information applied to the field area and project scale.

It was also suggested that for that to occur the system should comprise the development of a handbook, management procedures, work instructions and established guidelines through a work plan. Also, all agreed that uniformization and organization of information within the design process and specifications benefits the construction site, ultimately resulting in diminishing time and cost spillages.

5.1.5. Findings

The semi-structured interviews were undertaken to shed some light on issues raised by the survey by postal questionnaire analysis. Following the semi-structured interviews and their content analysis, the main findings are outlined below.

Project process diverges from each field area but the main core is similar and within each field speciality the process is more or less the same. Each company seems to have its own system installed or created and they diverge in terms of content and organization according to their analysed needs. The majority do not have software to classify and organize information and the ones that do have it relate to Primavera or systems that they have developed on their own with software technicians without any regard for any systems already in place elsewhere.

Companies always use the same system, mostly composed by windows folders - the breakdown of which is organized according to their needs and updated when necessary. Almost no folder is ever redrawn but some are added which generates confusion for practitioners.

The systems of classification and organization of information that interviewees reported to have are based exclusively on each company's perception of needs – no research, however small, was ever carried out to check what other companies, and countries, were using. None of them was thought to comprise international or national standards related to their field of application.

Most classification information systems in place are reported to be user friendly although at the launch of their implementation, most practitioners were reluctant to use them and some are still contested. The main reported problem when implementing a new classification information system is the reluctance of practitioners to new things in general. Also in spite of reportedly being considered user-friendly and allowing for a fast and easy retrieval of information, some interviewees were not able to open any documents they wanted to throughout the interview.

Companies from all the interviewed fields report having struggled with the issues of accountability and tried to resolve it by introducing responsibility reports and work sheets.

All companies believe in, and most have seen, improvements in implementing information classification systems. They all stated it to be of utmost importance when improving productivity by reducing time and monitoring those responsible for the production of information accountability.

Some practitioners do not believe that a common system is possible for Portugal but think that it would bring improvements in quality and best practice. Certified companies show more sensibility to these issues and already have developed efforts in terms of classification of information and state to see improvements, not only for them but also for the client.

Companies that have worked with or for public authorities are more aware of standardization and have already had to adapt their information management systems to the requirements of government institutions. Also between public institutions rules for construction project design information are not always the same although some standards such as layering remain the same.

Most believe that practitioners involved in the project process development should be the ones to produce and store the information within the created system. That is why the system should be user-friendly since their time and effort is to be deployed in the actual projects at hand and on the construction site, and not on organising information.

The main problem with the production of information is still at the early stages of the design process and most problems on site derive from it. Project information, such as architecture and engineering, is not uniform so each project has its own contents, which ultimately leads to problems in the chain.

5.2. Framework validation

Once the survey data analysis was completed and semi-structured interviews were carried out, the researcher had enough data to move on to pinpoint the main elements currently constraining and enabling the development and use of a system for classification of information in the construction industry, as well as establishing its requirements. The framework, as validated through focus groups, will be detailed in the next chapter. Yet it is useful here that the reader sees the drafted framework presented at focus-groups to better understand the issues discussed in the remainder of this chapter. Please consult APPENDIX 5, bearing in mind that this is the earlier version of the FCI and not the final one.

The researcher was able to develop the conceptual framework based on the findings from both the quantitative and qualitative data gathered. After developing the framework for the system, it was considered necessary to verify if the requirements identified, constraints and enablers, were accurate and comprehensive. For this purpose two focus-group discussions were set up aiming at validating the framework requirements - its key constraints and barrier enablers as identified by the researcher - and seeking to obtain further insights on the matter.

5.2.1. Focus groups composition

In order to validate the framework, two focus groups discussions were set up to obtain insights and ideas for further developments or corrections if that was to be the case. Gathering within each group, practitioners from different fields in the construction project design industry, would be the optimal way to validate the FCI, after careful consideration this did not prove to be a viable option. The researcher would not have been able to manage insights from different practitioners from different fields at the same time, and difficulties in moderating discussion in such a varied group would hinder the understanding of what practitioners think on the subject. Practitioners from different fields would probably refer to different meanings on the same subject and the conversations wouldn´t be valid for the purpose of framework validation. As such, each of the two groups comprised practitioners from the same or similar construction design project fields, even if holding distinct backgrounds and developing work in different areas within their field of expertise.

One group comprised five architects working on different areas of their field, both in the public and private sectors. Participants belonged to different age groups and had different professional experiences both in Portugal and abroad. The second group comprised four engineers working in different areas but all in the private sector: structural engineering and HVAC projects as well as IT and building management. All have been involved in public and private projects as well as with international teams and projects. Participants of this second group were all in the thirty to forty age group but their experience and hierarchical level differed substantially. Each session lasted over 4 hours and was successful both in validating the identified elements and in bringing to the fore new ones.

5.2.2. Focus Group: Structure of Discussion

After initial introductions, the researcher – that assumed the role of focus-group facilitator – gave participants a brief presentation on the overall aim of the research project and the specific aim of the focus-group. She then gave participants a list detailing the constraints she previously identified and elaborated briefly on the process of identification. Participants were then asked to take a moment to think about the constraints identified and discuss whether they echoed their experience and were adequately identified and if there were any left out. Afterwards, participants were asked to identify particular aspects of Portuguese reality that have the potential to help in overcoming those constraints (enablers) or to propose and identify mechanisms that can be implemented or put in place to actually overcome them (guidelines). Only after this discussion did the researcher present on an A1 board, for everyone to see, the framework guidelines she had previously developed. It was asked for participants to comment and if possible identify enablers and guidelines that were not considered. The framework was only presented in the second half of the discussions to participants in order to avoid preconceptions and bias. This sequence of events was done in the exact same way in both groups. After the presentation of constraints, enablers and of the framework scheme the discussions were much more active and richer insights on the subject were obtained.

5.2.3. Overall Outcomes

The first positive insight given by both groups was that the issue on the table was very prone to discussion. Practitioners think about classification of information in construction as being of utmost importance and were eager to participate and give their inputs to the research. As it was expected practitioners from different field areas have and gave different insights and interpretations of the constraints presented to them and identified different possible enablers. Also, when faced with the framework guidelines, practitioners reacted by adding or questioning proposed issues. This was considered to be very positive as far as the framework development is concerned.

Three of the architects engaged on the focus group have lived and worked abroad in Canada, Poland, Switzerland and Italy. Thus they based their opinions and insights on comparisons with other systems that in many ways were deemed more effective than the Portuguese current scenario. Those who worked in Canada and Switzerland were more aware of systems for classification of information and existing standard procedures to be applied in the field. They emphasised the need for methodologies and agents of change that might improve the design and construction work environment in Portugal. Further, they gave their contribution to enablers they saw that improved their work abroad. Three of the engineers have regular and ongoing working relations with countries in South America and Africa. They did not mention the existence of such systems in place in those countries neither their use of standard procedures.

In both, some issues were raised and some others were identified as being part of others previously identified. Perception on the overall requirements was positive and constructive criticisms were made to help this project development.

Constraints

It was confirmed that **corruption** is an issue in all classes of constraints; it is thought to be a key constraint to any process and progress in Portugal and all participants were keen to emphasise this point. This issue raised a lot of voices in the public and private sector in both groups. Practitioners stated this to be an important issue affecting almost all the others identified and the whole process. It was interesting to note that, for example, architects and engineers that worked in or with countries like Switzerland and Canada, were much more assertive and revolted about corruption than the ones with experience in Italy, Africa or South America.

Accountability, in its various facets and **time management** were also deemed by participants to be key overarching constraints as the researcher had identified. Both were also mentioned more strongly by the ones with experiences in Canada or North of Europe.

Within political factors, emphasis was given to: **public policies**, **decision making** and **lack of inefficient planning** as key constraints. Participants also suggested a very important one: lack of **public participation**. Motives given were absence of interest of individuals on public issues and omission of information to the general public by Government authorities. In the years of dictatorship that the country lived in the middle decades of the 20th century, only a few had access to education and information on political issues. With the end of the authoritarian regime in 1974, access to education was made available for all but the legacy endures – it is participants' perception that, even today, information required to make judgements and informed interventions with regards to the political field is restricted to a very few. This also applies to local authorities that are said to exclude its constituency from the political engagement and local decision-making. Related here is another factor identified by focus group participants: **lobbies**. These are stated to have a major impact on important political, legal, educational and economic decisions. The engineers' focus-group discussed that lobbies could also be seen both ways: as a constraint and as an enabler. If a construction lobby with political influence might see future profits to be gained from such a framework (e.g. if the framework developed a software or another form of IT tool that may have commercial value) it would then act as an enabler and not as a constraint. Lobbies are used for a variety of purposes and in different areas.

Concerning cultural and organizational factors, the engineers' group regarded these as strongly interlinked with the **technical and educational issues,** suggesting that solving the latter will result in great improvements to the former. This group put forward enablers too (see Table 20 pag.227) to the identified constraints.

Cultural factors were agreed by all. One very interesting insight was given, **absence of communication** amongst practitioners not only in the construction field but in all fields in general. Participants felt that there is a general lack of strategic communication of information. Professionals do not pass on information to colleagues or to others, be they students, apprentices or technicians from different areas within the same fields. This is a reality both in the academic and the professional world. Possible 'motivations' discussed were the 1) technicians' fear of being surpassed by colleagues, 2) elitism, 3) fear of losing their position and 4) jealousy.

Restraining the flow of information and knowledge is seen as a setback and a cultural problem. Another issue highly discussed was **poor professional ethics**, related with poor professionalization and education. Participants think that ethics is not perceived as a factor considered to enhance professional value and do not tend to have an appropriate behaviour in this matter.

Within legal factors, all identified constraints were discussed as the result of one factor alone: an **inefficient legal system**. This is not just so when it comes to the construction field, but in general: Portugal does not have an effective legal system. Further, lack of an effective legal system is compounded by corruption and lobbying. There is also a **constant change in legislation and regulations** for the field.

Practitioners are barely familiarized with the most recent regulation when yet another one is published, not allowing the time necessary to implement and see results from the previous one. These of course are factors that derive from political and corruption issues, creating instability and resulting in the lack of accountability. **Bureaucracy** was added to this category as an issue that is related to existing legislation.

Identified technical and educational factors were also agreed on. Further, one that had not been considered was put forward: **project illiteracy.** Some practitioners in the field, although very experienced on the construction site, do not know how to "read" projects.

The economic factors identified by the researcher were all agreed upon and there were no new ones to add. The discussion around economical factors in both groups centred on the **economical crises,** currently on everyone's mind. Whereas the crises is not a permanent factor, it that nevertheless impacts all others, not necessarily negatively, currently and for the years to come. Some participants referred to the present crisis as a **favourable time to develop and implement new ideas**, creating a window of opportunity. One issue of importance here was that some practitioners, within each group, did not see **elevated costs on software**, **lack of skills development** and **companies certification** as constraints that can be overcome in the short term.

In the organizational factors, a high rate of **absenteeism in the public sector** was added as an issue. Participants feel that there is no control over projects once they are submitted to public authorities and believe that this is so due to high rates of absenteeism in the public sector, although there is no available data to confirm this**.** It was also agreed that **bureaucracy** also falls short in this category. Participants in both focus groups did not perceive bureaucracy in itself as a constraint – the way they saw it, it is only a constraint if it is taken to extremes, which is the case in Portugal. Furthermore, participants emphasised its direct relation with political, legal and economical powers, bearing a negative impact on progress and competitiveness.

Overall, the constraints presented by the researcher were validated in both groups, and relevant new constraints were added. All are explained and introduced in the framework development chapter of this thesis.

Enablers/ Guidelines

The other issue that was posed for discussion during the focus groups was how practitioners thought that the identified constraints could be overcome. This meant discussing existing enablers and circumstances presented in the framework guidelines and how to create environments/circumstances that can act as **agents of change**. From the discussions of the two focus groups, some ideas were drawn out that are very helpful.

Regarding political constraints the architect group strongly agreed that **transparency** is the most effective way to deal with it. They believe that **Government processes** being more **transparent**, giving more **information to the public** and **engaging individuals in public participation** as well as **instating local power** would result in more effective democratic systems hence resolving the issue of corruption and lobbies. Engineers agreed with this but pointed out the **importance of lobbies** as enablers in some **existing implementations**.

In order to overcome cultural issues, and given their experiences abroad, some stated that the **emigration** factor is a great contribution to improvements and exchange within the work environment. Of course, this only acts as an enabler if practitioners that emigrate eventually return to Portugal while still professionally active, thus becoming **agents of change**. In that case, emigration enables dissemination of knowledge and better professionalism enriching the work environment in Portugal. Given the current economical crises participants feel that while this might be encouraging practitioners to emigrate it is hardly an incentive for returning in the short term.

Also **professionalization** starting with solid **professional education and professional schools**, would be an enabler to the framework. Currently certain work specialties such as carpentry, plumbing, and electrical work are learned on site, there are no technical courses and no formal apprenticeships. This brings problems when it comes to reading projects and coordinating with other construction stages and specialties. This presupposes a **change** in the current **educational structure**. As far as engineers are concerned, the cultural factors are not so difficult to overcome: they believe that when new things have to be implemented, practitioners do engage in the process with more, or less, enthusiasm.

Participants felt that legal constraints could only be overcome with an efficient legal system. The **legal justice system** would have to **be quick and effective**. For this to happen, it would be necessary to **educate practitioners within the legal system to have technical qualifications on specific areas/fields**. The system would also gain if **supervised** by a **suitable regulatory entity** that could **prevent corruption and lobbies** that slow and corrupt the system. **Less change in regulations and legislation** and implementation of the ones in place to be more effective would also be helpful. Ultimately, implementation of **effective legal penalties** would help establishing some awareness on accountability by practitioners, hence contributing to solve the issue.

Today Portuguese practitioners prefer to deal with certain constraints in project design and construction than halt a project at the construction site. The legal system in place does not encourage people to halt a construction in site, even when things are going wrong and extreme slippages occur, because they are aware that legal actions would not lead to any short-term conflict resolution between parties and would only amount to further expenses in legal representation.

Some participants mentioned that for the implementation of any system to exist, the example would have to come from above - **the Government**- or would have to be **imposed legally.** In fact, the engineers participating in the focus group believed that all legal constraints would be overcome should the system be **legally mandatory.** Also the fact that there is not such a classification information system in Portugal made them wonder if that is not the first issue to overcome - meaning that the system itself could be the agent of change that would establish all the different enablers to occur. A very encouraging thought for the researcher.

All the above are related with technical and educational factors that can be overcome with academic improvements and more technical education/schools, efficient methodology in place, skills development throughout the practitioners working life starting from academia/educational schools - these would ultimately result in more professionalism.

Engineers focused on the technical constraints to overcome most identified constraints, starting from an **early technical approach given in school** and afterwards not only in the university but also creating technical educational schools. Portugal has had them in the past but they were excluded from educational programmes to be substituted by the polytechnic institutions and by an increased number of universities. Medium professionalization is also necessary and much appreciated these days.

More **civic participation**, **accountability by practitioners**, establishing **interoperability** and **multidisciplinary** work amongst practitioners from different field areas, providing for different geographical relationships were also referred to as a way to solve the problem identified as a lack of knowledge transmission.

As to economical factors, all agreed that the periods of economical crises are fertile in terms of ideas to overcome problems and improve profitability and effectiveness of work. Although at this moment no one seems to know exactly how that can be sorted out.

Two things are clear: **software costs need to be revised**, they are not sustainable and allow for a parallel illegal market, and **companies' certification** could be a key factor for establishing a quality standard for the industry. This last one should be controlled by a supervisory authority, since it has been reported that the costs for this are immense and not regulated. Also if this could be established by the Government in their own construction works it would set the example. In terms of organization, all the presented factors are stated to be overcome when applying the same measures suggested to solving the cultural, technical and educational issues.

Throughout the discussion, all seem to agree that Government example, transparency and an effective legal system are key ingredients for implementing such a system. The outcomes of both sessions produced the results accessible in Chapter 6 concerning the framework conditions and guidelines.

5.3. Conclusions

The semi-structured interviews shed light on issues that were raised during the literature review and the survey by postal questionnaire analysis. Although ten interviews might seem a small sample, the interviews generated very rich data that enabled the researcher to gather convergent ideas about the subject. In specific regards interviewees' views varied but the core is the same. It was clear that information production and management is an important issue for all, that all faced problems with it and that resulting loss of time and money made some interviewees further develop their insights and volunteer ideas on how, from their point of view and experience, the problem can be addressed.

The semi-structured interviews contribution to the research study was of utmost importance in producing the conceptual framework guidelines, establishing its constraints and enablers. They provide for an in-depth understanding of why Portugal does not have a classification information system at the moment and what do practitioners in the construction field do with and to the information produced and gathered throughout a construction design project lifecycle.

Combining data gathered through the survey and the semi-structured interviews culminated in a first draft of the conceptual framework which was subsequently tested in two focus-group discussions. Through the focus group sessions, the researcher was thus able to test the guidelines that any system should comprise to be adopted and applied in Portugal as an answer to the identified constraints and enablers. The next chapter will detail the validated and final framework.

6. FRAMEWORK DEVELOPMENT

The objective of this research was to identify key guidelines of a conceptual **framework for the classification of information in the construction projects design data– FCI**, to be developed and implemented in Portugal.

Upon analyzing survey data and completing the content analysis of the semi-structured interviews, impact factors were identified to the FCI. To develop a common system for the production and management of information of process it was imperative to understand the reality of phenomena under study: Portugal's field reality, its stakeholders, government's influence on the process, methodology, knowledge of existing systems and standards, applied software and academic influence. As such, after developing the conceptual framework for the system it was necessary to validate key constraints identified and uncover possible barrier enablers, in short: to test the framework. To accomplish this, focus-group discussions were set up with stakeholders within the design construction industry, the input of which is incorporated here. The FCI key guidelines were identified regarding its content as well as the characteristics of an environment conducive to its successful development, implementation, use and dissemination. All guidelines are based on the data collected as well as the researcher's own experience in the field.

This chapter is divided into two interconnected sections. The first details the factors constraining the coordination and management of information in construction projects in Portugal and puts forward enablers to overcome them. This is done following the categories presented in the visual configurations of the framework constraints and enablers, which can be found in Table 20- Identified constraints and possible enablers' relations (pag.227). The reader should bear in mind, however, that such issues inter-relate to one another in ways that do not lend themselves to neat labelling, and often spread through different categories. In fact, some issues, like corruption and accountability, are overarching and as such are dealt with separately at the end of this first section.

The second section of the chapter is devoted to present the chart for the FCI content, a politico-legislative platform and guidelines for its dissemination and use. Some conditions are expected to be very difficult to obtain but they were thought to be of utmost importance and for that reason they are outlined here too. It is recommended that a classification information system to be developed has these guidelines taken into account to achieve successful implementation.

6.1. Constraints and Enablers

This section discusses in detail the constraints and enablers identified. All of them derive from the literature review undertaken, the survey by postal questionnaire analysis and also from the semi-structured interviews and focus groups conducted as part of this research project. These identified issues are thought to be of utmost importance when trying to develop and implement a classification information system as their influence is felt on a regular basis.

Figure 38 represents the key identified constraints to the development and implementation of the FCI and each one is subsequently detailed.

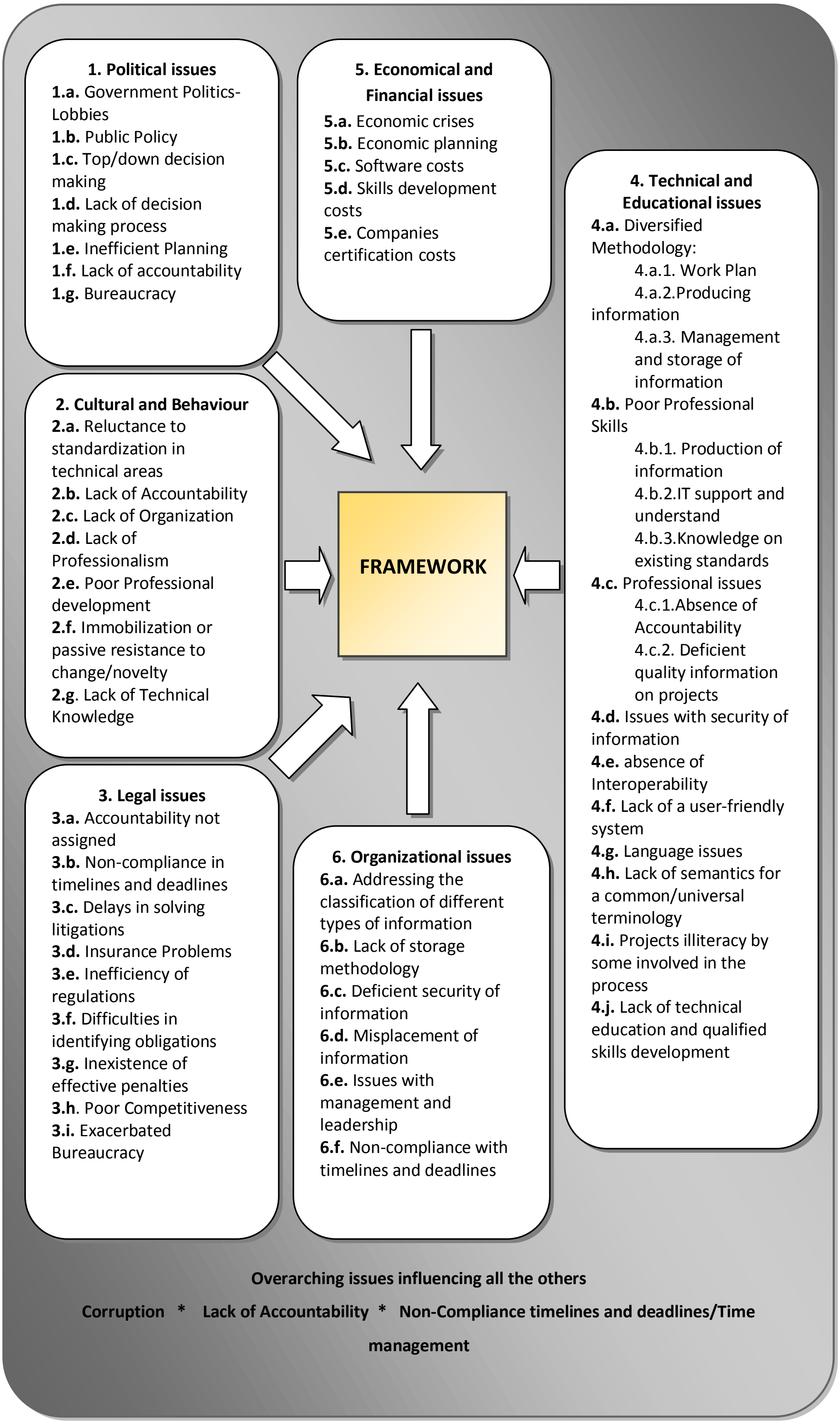


Figure 38- Identified constraints to the development and implementation of the FCI

6.1.1. Political issues

Political issues are of significance when addressing this matter. Mostly these regard issues of government politics, lobbies, public policy, decision-making, lack of or inefficient planning, lack of accountability and bureaucracy.

Both quantitative and qualitative data revealed how **public policy (1.b)** can bear an impact in the coordination and management of information in construction projects. Interviewees and respondents that work or have worked with public institutions have stated to do so under some form of uniformization of information that was imposed by these institutions.

Government authorities have developed a code – Codigo de Contratação Pública (CCP)[80] - to be used in all fields of public tenders. The CCP comprises rules and legislation for projects and construction works promoted by Government authorities and public institutions. Different Government authorities, whether local or national, apply the CCP the way they see fit and not necessarily the way it was designed to work. That a code allows for some flexibility is of course both positive and indispensable, but the CCP appears to be flexible to the point of jeopardizing standardization of process. The point here though is that public institutions do have set regulations for their own construction projects and these are the ones that Portuguese practitioners tend to apply the most. This is so because these regulations from public institutions are mandatory to all involved in their construction projects and there are associated penalties. This is not stated as occurring within the private sector, although some clients, the ones with more financial resources, are stated as having to establish their own rules concerning project design information, each in their own way.

[80] CCP- Codigo de Contratação Pública (Code for Public Tender) , Published in *Diário da Republica nº.18/2008* in 29th of January

Government politics and lobbies (1.a) are also perceived by respondents to bear an influence. Respondents reported that any change in politics (i.e. different political party taking over, whether at national or local level) results in major changes as previous policies are changed or not followed through thus hardly reaching their goal. Further it is said that a change in office leads to a change of the majority of decision makers in public authorities and institutions thus again interrupting ongoing processes. Even when there is no change of office, policies applied differ among government bodies and institutions.

Lobbies are stated to have a major impact on important political, legal, educational and economical decisions by the greater part of respondents but it was also mentioned in the focus groups discussions that it might go both ways, as a constraint and as an enabler. It can be seen as a constraint when lobbies control the system thus not allowing for its effective and suitable implementation or it can be an enabler in the way that lobbies with all they entail are sometimes the driving motion of changes. If a powerful lobby sees usefulness and of course profit to be made with such a system, its implementation can be faster and spread easier but this may also mean that it would probably be controlled by that lobby.

Moreover, informants felt that the existing system for financing public construction works is established in a way that does not allow the existence of adequate **planning (1.e)**, work scheduling and an effective financial management system. The attribution of funds is established by the State Budget which is approved and released by the end of the previous year. The funds are then transferred around May of the current year and have to be used until the end of that same year or returned to the Treasury. Funds not spent and returned to the Treasury result in the curtailing of the budget for the upcoming year. This means that in order to avoid a shorter budget the following year, funds are often spent hastily to the detriment of sound planning and construction.

Whenever an existing hierarchical structure is replaced or suffers changes it bears an influence on the **decision-making (1.c)** thus affecting the whole process. For instance, respondents detailed examples of projects that were already underway only to be deemed no longer a priority and put to the side when there was a change in the hierarchical structure of the public or private institution that commissioned it. Also most respondents state the **absence/lack of decision making (1.d)**, related with stakeholders **avoiding responsibility (1.f)**. This, combined with exacerbated **bureaucracy (1.g)** does not make Portugal competitive and attractive to investors. Mechanisms to regulate projects and construction as well as to submit projects to approval are neither effective nor fast: throughout the process there is too much paper-work, not enough accuracy, and a general lack of transparency. As such, any construction initiative demands considerable effort and time. This is stated as occurring in both private and public companies and institutions.

In short, what results from these insights is that an efficient framework to develop and use in Portugal will only be successful if it is **impervious to cabinet changes (E.1)**, **less bureaucratic (E.2)** and **becomes mandatory through government legislation and inspection (E.3)**. The establishment of European regulations and practitioners demonstrating will, in changing the state of affairs and turning public processes more transparent, thus come as enablers to the framework.

6.1.2. Cultural and behavioural issues

People are a major element to bear in mind when attempting to implement change. Portugal is no different in this regard. This sub-section details the cultural attitudes that informants considered more prominent and influential when devising a framework such as this.

After the survey analysis two major issues were identified as separate: Cultural and Behaviour. Yet there were some pinpoints that were established and interrelated between the two and more so after the focus-group sessions - it was thought that these two should be dealt with together as they influence each other and in the identified issues there is no clear and defined line between the two.

Portugal seems to suffer from an accentuated reluctance in **standardising procedures in technical areas (2.a)**. Specifically in the design process this is resulting in problems on the construction site, such as delays and lack of information. Interviewees, mostly in construction and inspection companies and government institutions, stated that the lack of standardised information in the first stages of a project make it difficult to calculate costs and often leads to omissions and poor specifications, which ultimately results in delay and cost slippage.

Related to this, is the difficulty in determining responsibility as there is a general **lack of accountability (2.b)** both during and after the process. When things go wrong or problems occur there is no clear way to understand what went wrong or identify who might be responsible for it. Everyone remains unaccountable. The issue here is not one of finger-pointing or assigning blame. Errors are bound to be made. The point is that people ought to be accountable for their errors and negligence in order to prevent future problems. Thus, the need for a more **organizational (2.c)** process that allows a better control of people and tools involved, as identified by informants, suggests that an established organizational structure is needed in order for projects to run smoothly. This necessarily entails accountability too.

An interrelated issue is that of **professionalism (2.d)**. A few informants mentioned that there should be improvements in the professional take of all involved - meaning that all stakeholders in the process, from the owner to the inspection team, should be more conscientious of their professional roles and act accordingly. Informants felt this lack of professionalism was ingrained in cultural factors, such a laid-back and smug take on things and, most importantly, a general resistance to change regarding not only technical skills development in education but also when it comes to new implementations, software or methodology, and of course in process uniformization and standardization. In fact, lack of standardization is not only visible between companies and between public authorities but also within each company and public authority. People tend to do things their own way, regardless of what others have done before them and oblivious to what is being done alongside them.

Interviewees also mentioned that practitioners display a lack of interest in their own **professional development (2.e)**, i.e. there is seldom a wish to seek further knowledge, education and experience. This is thought to be due in part to a lack of professional recognition, whether it takes the form of monetary compensation or mere acknowledgement of a person's professional worth.

During the focus-group discussions, some issues were raised as to Portuguese practitioners' **immobilization and passive resistance to change/novelty (2.f)** and **lack of knowledge (2.g)** transmission and communication. The first is probably not unique to Portugal and the last occurs out of a lack of strategic communication of information amongst practitioners within the academic and the professional world. Also during these discussions some defended that cultural and organizational factors are strongly related with the technical and educational issues presented below.

Cultural and behavioural issues are usually thought to be the ones more difficult to overcome because they are believed to be ingrained in people. But culture is ever-changing, and it is not impervious to outside influences and inner developments. **Globalisation (E.4)** is a factor here, as it allows the fast diffusion of not just commodities but also of ideas and ways of doing things, and the widespread use standards and classification systems is only testimony to it. Further, Portugal, as a member of the EU is also subject to the influences of its policies and motions towards standardisation **(European regulations E.5)**. As such, there is no reason to believe that the cultural practices and behaviours that currently hinder standardisation of the coordination and management information for construction projects in Portugal may not change, or adapt, to enable it. People will not resist change if they see it in their benefit, and in fact one of the main findings of both the survey and the interviews is that most practitioners are not aware of the importance and benefits of existing standards for production and management of information in the field.

6.1.3. Legal issues

In the design and construction field in Portugal, **litigation issues (3.c)** are reported to occur often but seldom are solved by the competent legal authorities and never without extreme delays in their resolution. This brings to the fore the already above-mentioned matter of **accountability not assigned (3.a)**. Interviewees state that there is an absence of a competent legal system concerning the responsibilities of all stakeholders, i.e. owner, practitioners, projects and contractors. In particular, issues often arise concerning the non-compliance with **timelines and deadlines (3.b)** regarding delivery of projects, specifications and construction. All this combined ultimately results on **insurance (3.d)** complications, because cause and responsibility are not easily identified and no one remains accountable. Because of this, when problems occur, they tend to amount to considerable sums of financial loss.

There is in place legislation regarding insurance, and insurance is mandatory to all those involved in the construction process. However, the mechanisms that are set to enforce these regulations are deemed inefficient.

The Government is also pointed out as responsible for this situation as there is reportedly an **inefficiency of regulations (3.e)** concerning projects delivery and information requirements for projects. This is ironic given that public authorities abide by the CCP which is not mandatory for private works. The CCP is of course a first step in regulation. Further, certain private projects need the added approval of particular public institutions, for instance, if the land where the construction will take place is under protected status the project must be approved not just by the local authorities, as any other project, but also with REN or RAN. These public institutions have made efforts to develop regulations that contemplate these instances and set out guidelines for submission of projects to their approval. Yet, much like the CCP, these guidelines are broad to the point that each institution ‘adapts’ it in such a way that there is no standardisation left. Further, practitioners feel that such legislation should be developed by jurists alongside with practitioners in order to ensure that it will adapt to field reality. Government legislations and regulations are reported to be in constant change. Practitioners do not have time to adapt to these changes since they occur in such short periods of time making for a very unsettling professional accuracy. Stakeholders involved need to be informed and updated and the constant change of legislation does not allow for it.

The development of a legal **identification of obligations (3.f)**, requirements and rights for each stakeholder in the process and **effective penalties (3.g)** are also factors that should be taken into account when developing the framework. The current lack of such legal tools leads to poor **competitiveness (3.h)**. Problems with regulations and **bureaucracy (3.i)** in place by the Government and the absence of an effective legal system redraw the confidence of private investors.

Revising Government regulations (E.6) concerning the matters mentioned above and having **effective and competent authorities (E.7)** enforcing them will bring benefits to the industry. **Regulations should be developed with practitioners from the field and not just by jurists (E.8)**. Established **European rules and legislation (E.5)** and developments towards **Globalization (E.4)** can also bear a positive influence on Portugal's legal system.

6.1.4. Technical and Educational issues

Many constraints identified through the survey analysis, semi-structured interviews and focus-group discussions concern technical and education issues. Some are directly related with economical and financial issues, others with cultural behaviour. Technical and educational issues were grouped together as its distinction was not clearly stated throughout the study - they are directly related with each other thus influencing in such a way that their identification regarding each was not possible.

What stood out most was the matter of **methodology (4.a);** each company and government authority has its own methodology in place and none seems particularly interested in what is being used or done by others. Although there are similarities between some processes and companies, the fact is that each one has its own **work plan (4.a.1)** or process map. The only guidelines that exist are the ones established by the CCP that only apply to public tender. Accurate **production of information (4.a.2)** from inception (design process) is also essential to continuing work on specifications, projects specialties, construction site and inspection. Project information is said to be in need of accuracy and scale compliance.

From the survey it was concluded that in terms of **management and storage of information (4.a.3)** practitioners treat each project in a different way and some claimed not to use any system at all. Interviewees said they change very little from one process to another or don't change anything at all, only doing so in times when there is less work at hand. In two cases the researcher was able to verify *in loco* that the system created and applied did not function at all: although the people who developed these systems did not admit it, in both cases not one item searched for was found, using what was called by Antonio, working for an inspection company, *"a perfect storage and management of information system."*

The survey suggested that standards are applied more by engineers than other stakeholders. But **standards should be applied right from the start of the design process, so efforts should be made in order to establish their use in the production of information at that stage (E.9)**.

Portuguese companies, as was also showed in the survey, have or produce their own *modus operandi*/methodology for the production and classification of information. Interviews revealed further that these methodologies do not differ much from each other except within the specific company field. A common **work plan guideline (E.10),** such as RIBA Plan of Work[81], could be suggested (some of its

[81] RIBA Plan of Work, (2008)- is a guide for project process organization that comprises all activities involved in the construction design projects as well as identified work stages. It is flexible and adapted to almost any project process by using only the required work stage and activities necessary. During the semi-structured interviews it was proven that project process does not diverge far from one office or specialty to another and that the main identified activities and work stages are described and organized in the work plan, for this reason it is recommended to be used here.

most important steps have been identified in Chapter 2). Needless to say that the framework/system will have to be based on the reality that practitioners from several companies and standpoints have identified, and not what on ideal notions of what reality ought to be but is not.

Interviewees felt that practitioners do not seek to further their **professional skills (4.b)** once they have completed their studies and entered the professional world, and this is said to prevent **accurate and thorough production of information (4.b.1)**. Related is the above-mention issue of methodology, as information on drawings, specifications, quantity bills should be more incisive, easy to read and thorough, not allowing for misunderstandings and omissions that lead to problems in construction. This is particularly relevant if we consider that survey data analysis revealed that the professional environment was the biggest source of dissemination of knowledge on existing standards. If university training is already deficient when it comes to information management, the lack of will in seeking further skills, whether formally or informally, when working is clearly an obstacle to a proper understanding of the importance of existing classification information systems and standards.

To note though, that while the **academic world** might not be a significant source of knowledge and dissemination on standards, it is concerning classification information systems, as presented by the survey. As such it **should be considered as a source of dissemination of the developed framework (E.11)**.

Skills development and also comprehension of **IT support and knowledge (4.b.2)** regarding software use: some field areas involved in the design and construction process are not completely engaged in IT tools, such as AutoCAD, ArchiCAD, BIM, and seem unaware of their potential. This constraint can also be overcome. Semi-structured interviews revealed that some **software for the industry already comprises some standards without practitioners noticing they are using it (E.12)**. This could be a good solution to implement the framework but software developers and sellers would have to come on board. Also this has to be balanced with the financial issue; most Portuguese companies cannot afford to invest in the development of such a project or even to buy it. But some form of partnership development could be arranged. The use of BIM (if not expensive) could be the answer to the above, since related uses are being thought of, in line with its development.

The survey and semi structured interviews also reveal that there is a lack of **knowledge and application of existing standards (4.b.3)** and protocols for the field. Practitioners only relate to certification standards.

Professional issues (4.c), **absence of accountability (4.c.1)**, and **deficient quality information on projects (4.c.2)** were mentioned in the semi-structured interviews as relating to technical issues, in other contexts. It was often stated that different stakeholders' functions in the process have to be made clearer or more defined in regulations or guidelines or at least stated at an early stage so that issues of responsibility and accountability will not arise later.

Different and low quality information on projects was also often identified as a constraint. Some projects are very meticulously developed but these are exceptions to the rule. 'Typos' and language errors, omissions and confusions with other projects were some given examples as well as information not appropriate for scale projects.

One of the constraints of existing systems in place in companies is the **security of information (4.d)**. This concerns effective documentation control as well as restricted access to information. Not all should be allowed to access and change information contained on the processes/stored.

Also, practitioners producing the information are the ones who store and manage it, which might seem to make sense but appears to create a problem in terms of security and regarding the hierarchical functions within companies.

Practitioners should not be allowed to change or move the structure of the system. This should only be done by a higher authority or at the very least with their informed consent. **Certified companies** did not present this issue, since their **system is run by a quality information technician (E.13)**, not directly involved in the production of information process, but trained in the area of storage of information management.

Different field stakeholders within the process should ideally work as a team and information crossed from inception to completion. Further, different teams of experts working on a given project exchange information mostly by e-mail and paper - this has to be overcome in order to obtain **interoperability (4.e)**. The idea of a **common shared database (E.14)** within companies, which a few respondents and interviewees stated to have, based on a common used system/method with specific language for structure would help to overcome the problem of interoperability. Also such a database, if allied with a common work environment between companies, practitioners and the construction site, will surely help to improve a highly reported issue of exchanging information inside and outside the office. All interviewees agreed that a classification information system to be used and widespread should allow consulting with just three or four keys to enable it to be **user friendly (4.f)**. Any framework development has to be in Portuguese, practitioners naturally relate to it more than any other **language (4.g)**.

Even so it **should have some base in existing and studied frameworks/systems** allowing for it to be adapted by other countries, most likely the ones with similar realities **(E.15).**

Not all terms and specifications used in the field have the same meaning for all engaged in the process so the framework development has to be aware of **semantic and interpretation issues (4.h)** that may arise. The issue of **project illiteracy (4.i)** by some engaged in the design and construction process was raised during the semi-structured interviews and much discussed in the focus group sessions. Project illiteracy is perceived by practitioners as an issue as it causes misinterpretations on construction site reportedly resulting in delays and budget slippages. Not all involved on a construction design project can know how to "read" a project. For example, on a specifications drawing it may explain that above the living room exists a mezzanine and the construction company builds a hole slab above the living room which afterwards had to be cut involving considerable costs.

This example and some others given, attest for the lack of technical knowledge by some engaging in the process which ultimately always results in problems on site and afterwards.

Economic and financial matters affect **technical education and qualified skills development (4.j)**. Technical skills like accurate and thorough production of information, IT support and knowledge, standards’ knowledge and application and state-of-the-art training, are indispensable to a standardised and efficient system of management of information, and yet, are systematically left out of key academic training fields, thus impacting any framework to be developed and implemented.

The majority of **practitioners working in the design and construction process agree that standards and classification systems are useful** - this is an advantage to their implementation **(E.16)**. There is, however, a gap between finding them useful and effectively applying them. The more difficult standards and classification systems to understand are the ones mandatory to use, so this has to be as **smooth and easy process (E.17)** as possible.

Existing and recognized classification systems should be considered when designing the framework. **CI/SfB and Uniclass** were more frequently recognized by respondents and these may be used right from the beginning of the design process, i.e. inception. Engineers tend to use **MasterFormat** that can be easily combined with Uniclass **allowing improved continued process (E.18**).

6.1.5. Economical and financial issues

The **economic crisis (5.a)** that has been felt increasingly in Portugal since 2008 was mentioned by all interviewees. The crises is said by the majority of informants to decrease work possibilities, leading to lower project fees which reportedly result in **poor project delivery** justified by less care for project information and ultimately standardization and technical, educational improvements.

Further, in times of hardship, project owners tend to choose the lowest construction budget presented to them, which may translate in **poorly qualified technical staff.** In fact, some proposals are impossible to carry out unless one cuts on qualified personal. Financial considerations also influence the equipment and building materials chosen and applied in the construction resulting in changes in its specifications on the construction site, eventually leading to costs spillages. Some focus-group participants believe that periods of crisis, as the present one, are favourable times to develop and implement new ideas in all fields, but mainly in the one that concerns us since with tight budgets practitioners have to develop other qualities such as creativity to overcome problems. Of course not all creativity is desirable and results in quality improvements but the fact that they have to think outside the box is perceived as a good thing, part of an evolutionary process.

Establishing unrealistic **deadlines and payment timetables** seems to be a reality in the field, which added to a general inefficient **cost control** throughout the process culminates, according to interviewees, in substantial cost slippages which otherwise could have been avoided. In fact, interviewees believe that should there be sound **economic planning (5.b)** and then slippages would be considerably less severe.

> There is no economic planning, what exists are political decisions! If there was an economic plan installed slippages wouldn´t happen, or if they did they wouldn´t be so big. (Manuel, architect in the Portuguese Navy)

Financial considerations also influence the use and development of **software (5.c).** Software is very expensive – it is not just the cost of the programmes themselves but the licenses and the yearly updates. This, combined with skill development is more than most companies can afford. It often results in legal issues as companies purchase licenses of a particular programme in a number lower than that of the employees who will be using it.

Developing and investing in qualified education is expensive. Most companies in the design and construction business in Portugal do not possess the financial means required for **skills development (5.d).**

Companies certification (5.c) guarantees that there is software in place to ensure quality and certification of documents. However, interviewees complained that certification is too expensive for the benefits it brings. Certification aims to establish a standardized qualification in construction in Portugal and it could be a means to elevate competitiveness. The idea being that certified companies would gain more clients, as quality was assured. Yet, it is so expensive that companies that were certified saw no financial benefits to it. Certified companies will charge higher fees because they have higher expenses with quality assurance, but project owners are not ready to pay more to ensure quality. So, ironically, instead of conferring companies with a competitive advantage over non-certified companies, certification actually resulted in less competitiveness for its companies. Quality assurance is clearly is second place to financial gain, both to companies and project owners, as explained by Rita, working in a construction company as quality manager engineer:

> If we saw that certification is a selection criterion, as it should be because certification brings quality, we would have continued doing it. (...) A certified company has costs but it also brings advantages. It has to have a quality plan, information management system control and it is test submitted during periods of time which means that has to keep everything in order. But in the Portuguese market it has to compete with some other companies that do not have any of this present and very low construction budgets that most of the time result in slippages or abandoning the construction work site and not finishing.

The survey analysis revealed that companies with higher business volumes do not apply more standards and classification systems than others. The decisive factor seemed to be the number of employees. **Companies** with more business volume (effective) **could eventually** be drawn to **invest in research for the industry and in its application.** However, **companies will not invest in research and development if they don't see benefits in it**. The **economical factor of the research should be taken into account (E.19)**.

Portugal's major project construction businesses are small, with up to one million Euros of business volume and an average of four employees. **These factors may be a helpful factor when implementing the framework (E.20)**.

6.1.6. Organizational issues

Organisational issues are also related to different aspects of the research, are problematic, and were part of the survey and also mentioned in the interviews. When speaking about a framework for information management and coordination, organizational issues cannot be overlooked.

The first organisational issue to mention is directly related to technical issues, as **different field areas need different types of classification of information (6.a)** and the academic environment, apart from CS/SfB, does not mention them. It is to note that **storage methodology (6.b)** is of importance not just for current projects but also with regards to projects previously developed. For instance, whenever an old facility or building needs refurbishing or any sort of substantial changes, practitioners are faced with two different storage systems – the old paper files of the building and the new digital files of the refurbishment – that are not necessarily compatible. This is particularly important if we consider that construction companies in Portugal are on average 20 years old. Technologies have since been improved, developed and created allowing for better storage methods. Yet, companies seldom update their systems.

As mentioned above, **security (6.c)** issues regarding organizational information were also identified, as different practitioners in the production and management of information have different ways to engage with whatever system is in place. This results often in **misplacement of information (6.d)**, inadvertently occurring, for instance, when one practitioner decides to move one digital folder into another or has a personal take on what information should go in each folder, making it difficult for others involved to find the information they need to proceed with the project.

A project's organisational chain also needs to be clear: **Management and leadership (6.e)** hierarchical structures must clearly establish stakeholders' roles, responsibilities, identification and requirements. The project manager/coordinator figure is stated to be responsible for the production of information of projects development, for the construction site and also for the storage of information in the aftermath of the project. This seems to be an unnecessary overloading of the manager's responsibilities. It also suggests that there is some resistance in delegating responsibilities. This is highly related to the issues of accountability already discussed. But of course, one person can only manage and supervise so much, and this often results in important elements of the project and construction being overlooked. For instance, all projects and constructions have a design coordinator and an inspector. These practitioners should be accountable for the specific project stages they are directly linked to, i.e. design and construction inspection respectively. Yet, in reality, the responsibility for these falls under the hands of the manager.[82]

Deadlines and timetables (6.f), already mentioned above, have also been identified as an organizational problem - if the organization was more effective, deadlines would not drag on and the slippages would be better controlled, thus impacting the final expenditure of the construction project.

The proposed enablers for all these constraints outlined are presented for the identified categories in Table 20 (pag.227).

[82] This is so in part because practitioners tend to overlook the different stages of a project – they take it as a whole and as such the manager is the one that is sought for everything.

Enablers \ Constraints	Political	Cultural behavioural	Legal	Technical and Educational	Economic and financial	Organization
E1 -Impervious to cabinet change	✓					✓
E2- Less bureaucracy	✓					✓
E3- Mandatory through Government legislation	✓					✓
E4- Globalization		✓	✓			✓
E5- European regulations		✓	✓			✓
E6- Revising Government legislations			✓			
E7- Effective and competent authorities			✓			✓
E8- Regulations development by practitioners from the field and jurists			✓			
E9- Standards application				✓		✓
E10- Work plan				✓		✓
E11- Academic world as font of dissemination				✓		✓
E12- Software entailing standards				✓		
E13- Quality information management				✓		✓
E14- Common shared database				✓		✓
E15- Consider existing classification systems				✓		
E16-Practitioners believe that standards are useful				✓		
E17- Smooth and easy process				✓		✓
E18- Combination of existing systems				✓		
E19- Industry investment in research					✓	
E20- Portugal is a country of small business companies					✓	✓

Table 20- Identified constraints and possible enablers' relations

6.1.7. Overarching Issues

As mentioned before, three issues influence all the above categories of constraints, some in a direct way and others by a chain of influence. These refer to corruption, accountability and timeline issues. Each now is examined is detail.

Corruption issues

Interviewees have identified corruption and nepotism as significant constraints to their work. Corruption and nepotism are found at the political, legal and economical levels. Interviewees complained of personal influences and preferences in what should be fair and transparent public tenders; of vested interests in the development of legislation; of double-standards when projects are submitted to local authorities for approval; of specifications for building materials and equipment in public and private tenders, to the sole advantage of a particular supplier, etc. It should be noted here again that interviewees believe that Portugal does not have an effective justice system, where complaints against such instances can be made and effective penalties applied.

Corruption issues influence the economy, in the sense that it leads to a lack of competitiveness in the field: interviewees complained that companies contracted following public tenders are always the same few. Investors are thus drawn away as the system reportedly protects and works to the advantage of these same few.

Accountability issues

Accountability was referred to by respondents in different contexts of the design and construction process: it overarches Cultural and Behavioural, Legal and Technical and Educational issues. The core of accountability is not about finger-pointing, as many might see it. Rather, it is a matter of preventing and identifying problems that may arise (and some do arise frequently). It is also a matter of finding a solution: if no one is accountable, no one will want to develop efforts in finding a solution. But in a legal system where justice cannot be depended on, and where penalties do not apply, there is no incentive for anyone to be accountable. Further, as we mentioned already, if there are no clearly established roles and responsibilities, accountability cannot be allocated. This suggests that if different practitioners can be made accountable for their work, fewer problems will occur in the design and construction of a project.

Timeline issues

Time has different expressions in different cultural contexts. In Portugal we believe Germans are always on time, by the second. This is of course a stereotype, but one that reflects that that is not our reality. In fact, in Portugal, in general, one is not late for a meeting if he/she arrives 20 minutes past the agreed time. With the risk of over generalising, deadlines are taken lightly in Portugal, to say the least. Timelines, deadlines and punctuality are far too flexible and elastic – they stretch till they burst. Our loss, as they do often burst – they end in severe cost slippages, but most importantly they reflect poorly on our competitiveness and professionalism, and of course, on how other markets perceive us.

This is a factor bound to change (or so one hopes). With highly attended European exchange programmes at university, and increasing numbers of Portuguese students and practitioners seeking to further their education and professional development abroad, it is likely that the coming generations will be more attentive to the importance of timelines. For the time being, and for the matter of this framework, it is suggested that with a proper penalty system in place, deadlines might be taken more seriously.

6.2. Guidelines - Framework

In the preceding section key constraints and possible enablers to the FCI development and implementation were identified and explained.

Bearing in mind the research question and following the analysis of all quantitative and qualitative data gathered in the exploratory phase as well as during the validation stage which resulted in the identification of key constraints and possible enablers, the guidelines for the FCI are presented in this section along with a relationship chart.

It is argued here that any efforts in developing and implementing a classification information system for the construction project designs in Portugal take these guidelines into account since they were devised in light of the inputs given by stakeholders in the field.

It was also considered and thought important to develop and present the characteristics of an environment conducive to the successful implementation of such a framework. The fact is that during the conducted work and analysis it became clear that not only was it necessary to understand the FCI requirements but also the favourable conditions in which such a chart can be implemented and disseminated in Portugal.

6.2.1. Guidelines: Framework Content

The framework content (Figure 39 pag.229) was established after the identification of possible constraints and enablers throughout the continuing literature review, the survey analysis, the semi-structured interviews and the focus group discussions. All guidelines were identified during that analysis and relations were identified between them. Others were drawn after thoughtful consideration on their impact and possible outcomes and solutions.

When developing a framework one should bear in mind the **methodology implementation** for construction projects design information which should obey the same basic rules being **public authorities** or **public and private companies, in all projects independently of their size and type**. It is important that the core of the methodology in place is the same although some deviations might occur in special cases but always based on or deriving from that same methodology. A recognized methodology enables stakeholders to identify stages and procedures no matter what the project or team they have to work with.

The established methodology is directly related with the implementation of a **classification information system** also applicable to public authorities and public and private companies in all projects and **operable by practitioners that produce the information: a user-friendly system that uses a common infrastructure for producing and manage information** directly linked with a **common shared data base and document control**, which necessarily implies a **uniformization of the information** concerning not only **general information** but also **projects information accuracy regarding projects type and scale**, not more nor less than what is necessary for them to comprise.

When speaking about classification of information, **standards knowledge and use** has to be considered so that each stakeholder is using tools available to all and that all are able to use the same.

A **plan of work** valid to all projects entailing **work stages requirements, procedures and instructions** should be considered as well as an accurate linked plan of **time, people, resources and costs**. If a plan of work is established and may be adopted in all project types, it is easier for practitioners to engage in a standardized methodology that is identifiable in all projects hence providing guidelines for overall accuracy of information. Also it might inhibit practitioners´ creativity when storing project information.

Also related to all the aforementioned issues are the **management procedures**, which should allow **identifying roles and responsibilities** of **all stakeholders** involved in the process and therefore attributing **accountability** and allowing **interoperability**. Management procedures ought to be thought of in terms of software use and development. Not all stakeholders should be allowed to access all information for consultation or alterations.

A **common shared database** is considered by all respondents to be a good idea. Some companies already have one but do not obey to the basic considerations mentioned above. It is preferable that stakeholders involved in the process are able to access information that is essential to their work and might be able to make the necessary changes if required. This does not mean that every stakeholder should be able to access every piece of information; **document control** should be restricted, **maintaining activity reports** as to whom has worked and accessed information **ensuring security of information**. This allows for **interoperability** amongst practitioners from different teams as well as effective **multidisciplinary management** keeping permanent contact with, and within, different teams and different environments. Also, it allows for a permanent information update by and to all. A common shared database is only possible if a **nationwide terminology** is set in place, so that all speak the same language and apply the same concepts.

The guidelines presented may be achieved with the help of a **handbook and a code of procedures**, both to be developed within the system created.

Throughout this study, communication and knowledge transfer issues were often mentioned, as was a **strategy for communicating and establishing knowledge transmission** and this should be implemented throughout all design construction projects in Portugal.

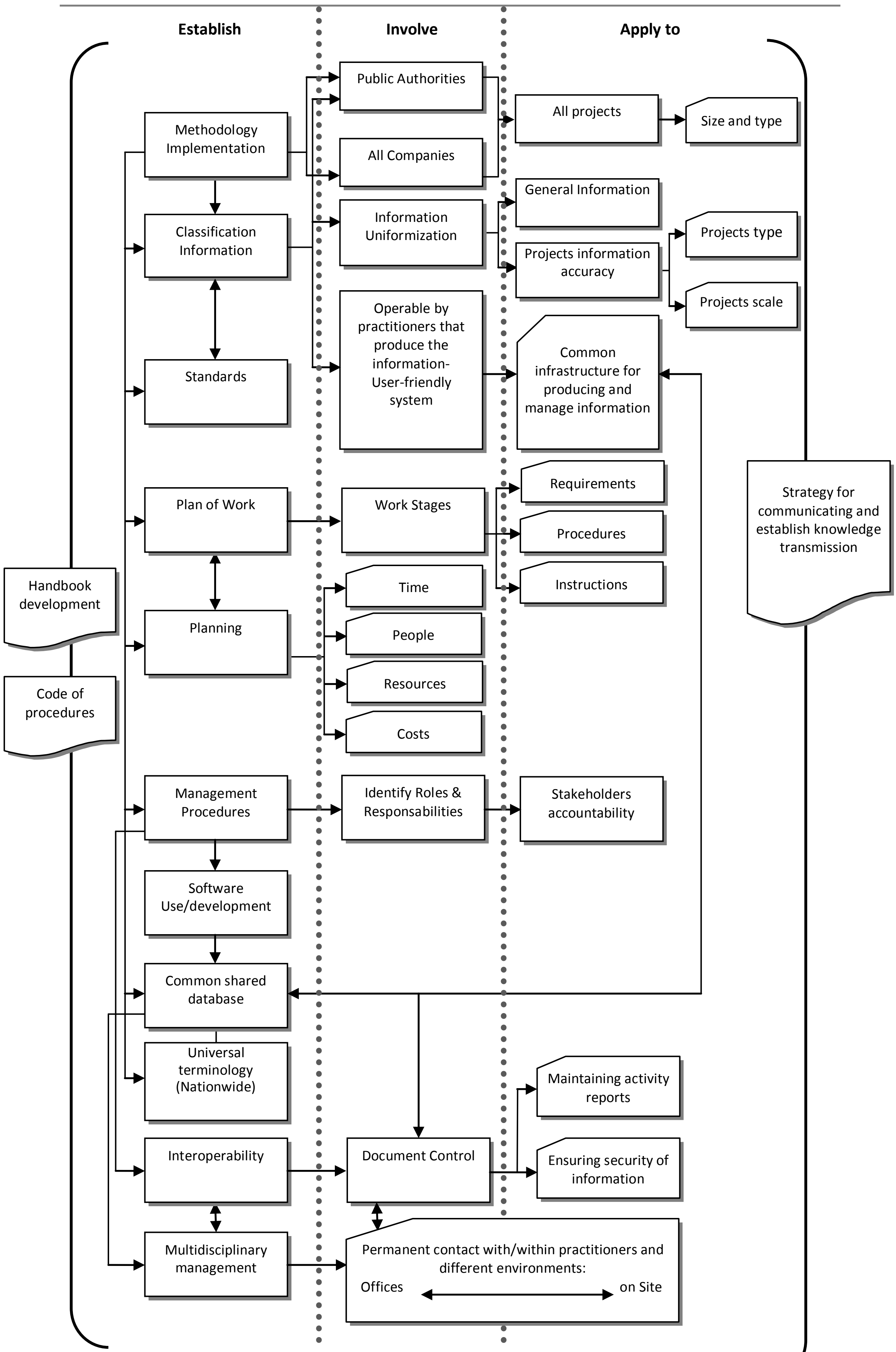


Figure 38- FCI- Framework content

6.2.2. Characteristics of an environment conducive to a successful development, implementation and use of the framework

Developing a framework for the classification of information for construction design projects in Portugal requires a proper environment for its successful implementation. During this research project, several constraints and enablers to the framework development and implementation were identified. From data collected and analyzed arose a **politico-legislative platform,** and a set of **dissemination and implementation** guidelines was established as shown in Figure 40 pag.235.

This does not mean that the framework will only be viable if this environment is in place but the improvements it would bring to the industry are asserted by the majority of respondents.

For the framework to be effective and adopted by all stakeholders, it should be **mandatory through Government legislation** as well as impervious to **cabinet changes.** This guarantees that it will be applied by all and that it will not change as often as Government changes occur enabling it to be established and implemented for as much time as necessary to allow for stakeholders to use it in a continuous way becoming a day-to-day routine.

Processes should be simplified by **reducing bureaucracy**. This was stated as inhibiting not only Portuguese investors but also foreign investors. Bureaucracy is necessary but when exacerbated it slows processes down and makes for a non competitive market. If processes take too long to be evaluated and approved, in today´s market that is not a valid investment, on the contrary. This might not be difficult to achieve if basic requirements are applied and effective professional responses to queries that may occur are put in place. This is evidently related to the need for **competent authorities** in the field. Authorities linked with the construction industry, being Government, local or any other kind, should be competent and swift in answering queries and analyzing processes and, if the case, in supervising them.

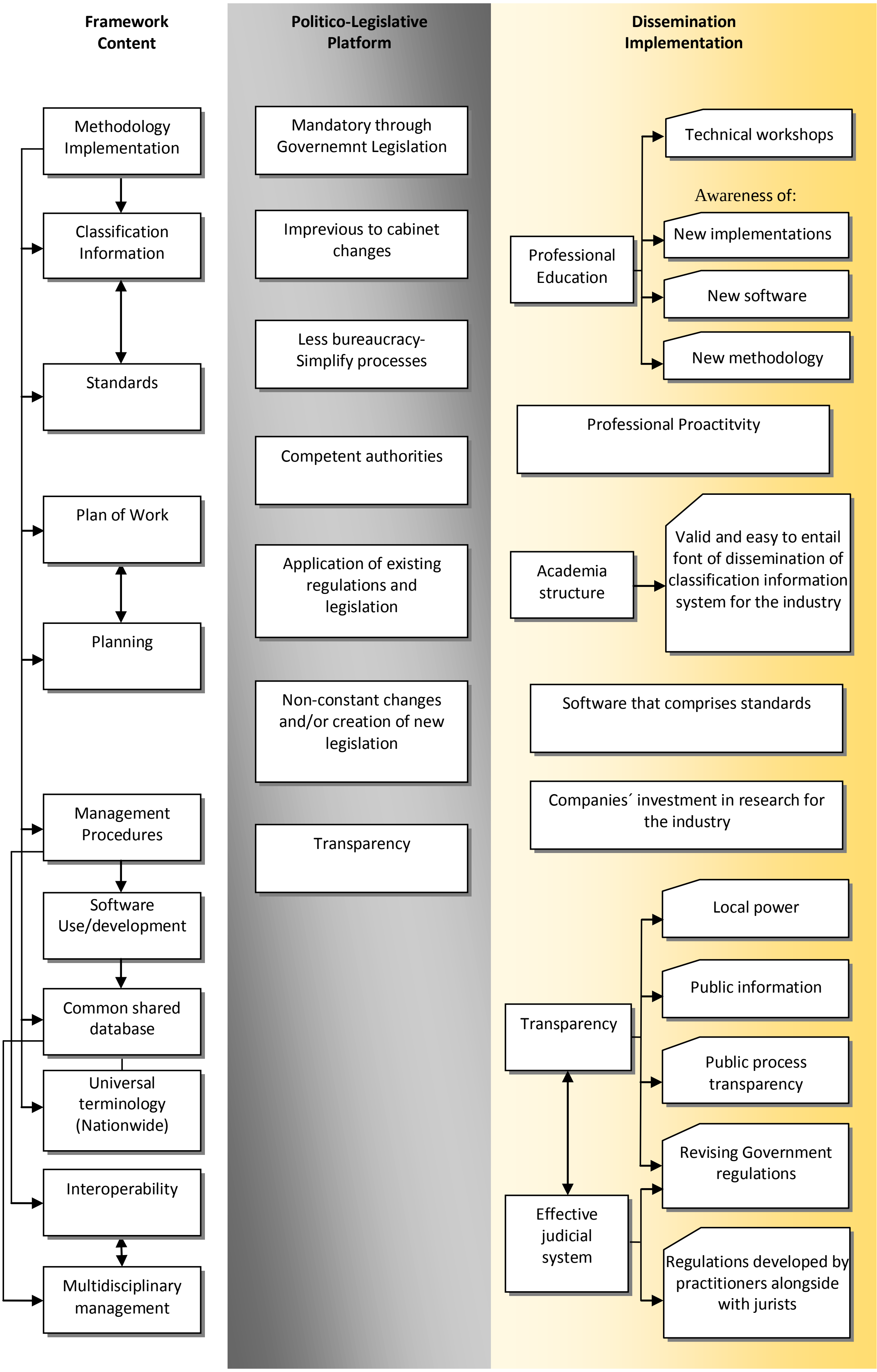


Figure 40- Conditions for the successful development, implementation and use of the FCI

Processes should be simplified by **reducing bureaucracy**. This was stated as inhibiting not only Portuguese investors but also foreign investors. Bureaucracy is necessary but when exacerbated it slows processes down and makes for a non competitive market. If processes take too long to be evaluated and approved, in today´s market that is not a valid investment, on the contrary. This might not be difficult to achieve if basic requirements are applied and effective professional responses to queries that may occur are put in place. This is evidently related to the need for **competent authorities** in the field. Authorities linked with the construction industry, being Government, local or any other kind, should be competent and swift in answering queries and analyzing processes and, if the case, in supervising them.

Existing regulations and legislation should be applied before any new ones are created/developed. Portugal´s **constant legislation** changes have not allowed for an effective use and test of existing ones. In the past few years Portugal has assisted to a crescent of legislation creation. It seems that new regulations are published by government authorities almost every year before stakeholders are familiar with older ones (e.g. from the previous year).

All the above is related with what the majority of respondents considered being the solution to many of Portugal's competitiveness problems: **transparency!** Government transparency, authorities' transparency, and process transparency, in short: transparent procedures in all matters related with construction design projects development, approval, implementation and maintenance.

When taking into consideration the framework dissemination and implementation**, professional education** with **technical workshops** regarding its use should be held as well as investment in practitioner's knowledge on **new implementations, new software and new methodologies** for the industry being developed and applied elsewhere and considered of importance. Professional development and skills education should be a major step when attempting to disseminate any framework.

This also translates in **professional proactivity**. When practitioners seek to improve their professional education and further knowledge in their field of expertise it results in better practices and improvement in the work field. More qualified and updated technicians result in enhanced work skills and higher standards in product delivery.

Academia is also to be considered a very important means to disseminate the framework for a classification information system for construction design projects. If awareness to the subject is brought during academic training, afterwards in the work environment dissemination will continue to professionals that have not heard or applied it before. Students in academia are also prone to novelty and embracing new ideas that might be useful to them in the future.

As was shown in the semi-structured interviews, some practitioners already use some of the mentioned standards available for the industry not knowing that they apply them since they are part of the **software** they use on a day to day basis. This might be an active way to incorporate standards in the industry. If practitioners use software on a day to day basis that already comprises standards in a user-friendly manner, there will be no resistance to its use.

Software and technological developments are very important for any industry and the construction industry is no different, but it would be more useful to companies to have or develop technology in field areas or in special projects they want to implement than having software vendors selling what they believe is profitable. For that purpose it might be interesting to have partnerships between companies and universities or software/technological vendors to develop those projects alongside each other. **Companies´ investment in research for the industry** would likely be more profitable in the long run and would also establish relations between field work and academia which possibly results in higher profits for both. Tax benefits for companies investing in Research & Development could be a further incentive to such investments.

As in the politico-legislative platform, **transparency** is considered an important factor for implementation and dissemination of the FCI. Transparency regarding **local power** procedures, in making **public information** available, in **public processes** transparency and also when **revising Government regulations**.

These **regulations** should be revised and **developed by practitioners alongside with jurists**. These measures are related with the resolution for an **effective judicial** system, stated by all respondents to be the solution for the Portuguese construction market.

The development and implementation of a framework aims to overcome the issues observed, identified and discussed with stakeholders from different field areas in the construction design projects but it touches other areas of Portuguese society. Some issues are perceived as easy to overcome while others will need more time and efficient tested strategies, but are, nevertheless surmountable. All can be achieved with the will of stakeholders and authorities.

6.3. Conclusions

The two sections that compose this chapter have presented the outcome of the overall research project. The constraints and enablers thus identified support the development of the FCI and the established guidelines in how to best address them. The constraints identified are not of course particular neither to the construction industry nor to Portugal. What is particular here is the specific combination of constraints and the ways they interlink.

The scenario described above looks rather dark, but it should be borne in mind that although constraints were identified, the fact is that Portugal also presents promising possibilities for any framework development and implementation: first, a major part of Portuguese business companies are small companies, not only in the number of employees but also in business volume. Second, the fact that Portuguese stakeholders recognized that standards and classification information systems benefit their work, even if they are not entirely sure about how that might occur, it is positive. Third, Portugal has pioneered some technology that improves daily life, such as the ATM machines and Via Verde, which signals that barriers to change are not all that resistant.

It is also important to mention that practitioners involved in the construction industry perceived this issue as important to establish a quality standard that allows them to become competitive, especially now that emergent economies are ruling the construction business and Portugal's companies are turning their heads to Europe and beyond.

This said, it might just be the case that as soon as stakeholders engaged in the process realize the benefits to be obtained with such a framework, its implementation will run quickly and smoothly.

7. CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER WORK

This research project set out to address one specific question:

WHAT SORT OF FRAMEWORK AND GUIDELINES ARE NEEDED FOR THE SUCCESSFUL IMPLEMENTATION OF A CLASSIFICATION INFORMATION SYSTEM FOR CONSTRUCTION PROJECT DESIGN DATA IN PORTUGAL, WHICH IS ACCESSIBLE TO ALL STAKEHOLDERS INVOLVED?

This final chapter summarizes the research conclusions from the literature review and from both quantitative and qualitative data collected and analysed in light of the investigations conducted by the researcher and presented in this thesis. Ergo the research methodology adopted and research innovation is reviewed and recommendations are made for further work. Moreover, the chapter highlights how the research objectives of this investigation, as identified in Chapter 1, were addressed:

i. To undertake a comprehensive **literature review** under the area of existing, known and applied classification information systems, standards and protocols for the construction project design data - achieved through a systematic literature review during the investigation process and presented in Chapter 2.

ii. To conduct a **survey** in Portugal on the knowledge and use of existing classification information systems and standards for the construction industry - achieved with the application of a survey by postal questionnaire sent to Portuguese architectural and engineering offices, construction companies and public authorities (Chapter 4).

iii. To **develop and validate a conceptual framework – FCI - and guidelines** for the implementation of a classification information system for construction project design data as presented in Chapter 6.

iv. To make **recommendations** for the implementation of the framework in Portugal and further work (Chapter 7).

v. The objectives identified would never been achieved without a carefully thought out and **planned methodology of the research**, as detailed in Chapter 3.

7.1. Conclusions from the Literature

In light of the research idea to develop a framework for the classification of information systems for construction project design data in Portugal (FCI) this project began by reviewing the literature surrounding existing classification systems; standards, taxonomy, terminology, ontology, nomenclature, thesaurus, catalogues and libraries databases, resource management, collaborative working and project process and IT tools. Generically, classification information systems involve all the issues mentioned and for that reason the researcher undertook a review on their relations, means and their implications for the development of the FCI for Portugal.

The literature was crucial to identify similar systems that exist or are being developed and applied throughout the world to respond to this recognised problem and identify existing gaps. The fact is that throughout the ongoing literature review it became clear that other countries are experiencing the same issue: the United Kingdom, the United States, Japan and Australia to name a few. The ones developing more efforts in this sense are the U.S.A and, in Europe, the UK and Scandinavian countries. Denmark, Sweden and Finland have developed efforts in overcoming classification of information and communication issues in the construction industry. The findings from these developments are outlined in Chapter 2 of this thesis but importance is given here to the most recognized system in place - CI/SfB initially developed under *SfB (Samorbetskommiteen for Byggnadsfrsgor*) from Sweden (in place for more than 50 years). The CI/SfB was the only effective mentioned approach to classification known in Portugal although no implications of its implementation were found.

Systems developed, whether or not already implemented, or that are in the early stage of application are OmniClass (U.S.A.) and Uniclass (UK), both based on *BS ISO 12006-2:2001, Building Construction – Organization of Information about construction works - Part 2: Framework for classification of information*, which identifies classes for the organization of information and indicates how they are related. This framework is considered to be of utmost importance when trying to develop any system for Portugal as not only it is comprehensible to most but also enables, if intended, a cross-referencing base with other systems since it is an International Standard.

Most problems found with the classification of information concerning project design was the fact that new improved IT tools, launched as the future by vendors, do not by themselves solve the issue of information, against the arguments of some (e.g. Autodesk Revit). When CI/SfB was initially instated and used, practitioners were all drawing on boards, not on computers. Documents were produced and filed by hand and repositories were already somewhat messy but classified. Today, and in general, practitioners use computer software for almost anything and the passage from drawing board to computerized technologies was done automatically. Software and expensive IT tools have yet to be developed and proved in a way that practitioners will not have to think twice about classifying an object, an attribute or a whole document.

The literature also showed the need for standards and protocols to be entailed in the process as part of the whole classification information approach. Without them there is no recognized methodology to develop construction project information. Thus with the increased need for interoperability between and amongst stakeholders involved in the process, standardization is the first weapon in thorough production of information.

Developments of important relations were found (Howard & Björk, 2008; Jung & Joo, 2010; Kehlmin 2007), in the integration of Industry Foundation Classes (IFC) and STEP Standard for the Exchange of Product Model Data (ISO 10303) standards with Building Information Modelling (BIM).[83]

An issue considered in the development of any attempt to improve the construction industry sector cannot rest alone on classification information systems or on BIM technologies (Holzer, 2007) as the support for any business is to be found in people, process and information systems (Bhargav et al 2008:796). As Egan (1998) also pointed out back in 1998 in his report, integrated processes and teams have been indicated as one of the five key drivers of change for the building industry.

This research aimed at identifying the conceptual dimensions of a system to be implemented in Portugal: practitioners' actions and methodology, classification systems and standards, plan of work, IT influence, terminology, management and interoperability amongst stakeholders. All this has its roots in identified political, behavioural, legal, technical, economical and organizational issues.

The developed FCI presents the identified requirements that can and should be used as a base for any classification system or procedure to address information problematic in project design data in Portugal.

7.2. Conclusions from the investigation

During the exploratory stage of this investigation a survey by postal questionnaire was conducted as a means to understand the problem at hand - the literature review was silent when it came to the Portuguese reality on this matter. The survey showed that although practitioners are aware of some existing initiatives, their actual implementation and knowledge on them is far from satisfactory.

[83] URL:http://bimserver.org/#

The survey raised some queries regarding practitioners' ideas of what classification systems and standards are for and how they should be applied. Of direct impact to the research project was the realisation that offices in this field do not tend to have a systematic use of standards and classification systems even if they consider them useful. From the survey, one could conclude that practitioners see these initiatives as important to their field but do not apply them because they believe they are difficult to understand and use and because their application is not mandatory. There is a lack of application of standards and classification systems, in particular when compared to the knowledge respondents have of their existence - practitioners are aware of most standards yet they do not apply them in the work place. This became an issue to explore further in the second stage of the exploratory phase of this research as it was important to understand what was preventing or discouraging practitioners from applying these standards – this was most surprising regarding architects, which are considered the first row of the design project phase and that compromises all information produced afterwards.

The survey analysis produced valuable data but also raised further issues. For that reason, ten semi-structured interviews were conducted amongst practitioners from different fields of the construction project design flow of information. The data collected from the literature review, the survey by postal questionnaire and from the semi-structured interviews, along with the researcher's own personal experience in the field, served as a basis for the construction of the FCI for Portugal.

The FCI, its constraints, enablers and guidelines, were afterwards tested in two focus-group discussions with practitioners from the field. Practitioners gave their insights on what the FCI should and should not comprise. Validation was successful because practitioners agreed with what it contained, added more factors and discussed it with enthusiasm remarking that it would be a valuable starting point for the effective existence of a classification information system to be developed and adopted by all engaged in the process.

7.3. Research methodology

The design of the research methodology applied in this project proved effective in finding the requirements that the FCI should entail. The literature review (Chapter 2) identified initiatives being held or existing initiatives to respond to the issue reported in Portugal; the survey by postal questionnaire (Chapter 3) informed the current state of affairs thus supporting the research need and; the semi-structured interviews (Chapter 4) gave the in-depth input from practitioners in the field. Together they were used to develop the framework and its requirements (Chapter 6). Two focus groups (Chapter 4) amongst different practitioners provided for its validation.

Both quantitative and qualitative data provided for the research development and end result in the exploratory phase and in the validation stage of the project. It is inevitable that the researcher´s own experience in the field will to a degree bias the results of this investigation, but all possible efforts were made to overcome this; testing the survey and changing the wording, not asking leading questions throughout the interviews and recording them. The same process was done with the focus group sessions.

7.4. Limitations of the work

The work undertaken is bound to have some limitations, as all do. A limitation of this project could be considered as the number of respondents of the survey by postal questionnaire: from the 400 sent, only 61 were returned with the survey fully answered. This could be interpreted as the result of a lack of familiarization on the subject or it could be interpreted that the wrong sample was chosen. Apart from sending it to architectural and engineering offices, construction companies and public authorities, the survey could have been sent to clients, suppliers or other parties involved in the process. Clients would be difficult to reach though since they are seen as not having a real input in the production of information (exceptions made to financially affluent clients, not the average in Portugal). These issues were thought through and a decision was made to send it to the core of the design project parties and this, it is recognised, has limitations. Even so, the survey served to inform the current state of affairs and shed light on the subject; some issues were confirmed and others were raised, which was its purpose. Also the semi-structured interviews were thought out to cover a more wide variety of field practitioners in the construction process.

Another issue considered was validation through two focus groups from practitioners in the field; one with architects and another with engineers. More focus group sessions could have been conducted to validate the FCI with different practitioners from the field in the same group as a means to diversify the discussions. It was thought that not all the profits from such a miscellaneous group would be grasped by the researcher thus losing the sense of their application in this study: to present the FCI constraints, enablers and requirements to validate them and gain inputs for further developments.

7.5. Research novelty

Despite the above limitations, the research project is novel. It addresses the problem of information classification for construction project design data in Portugal by providing a conceptual framework that can be used to develop and implement such a system. According to the research question, this project sets out to explore the possibility of developing a system that effectively manages the undertakings of a construction project design, from the moment the client initiates the project to the moment its construction is finished, while at the same time gathers the information necessary to design a construction project. This necessarily entails the establishment of standards too.

One could ask why such a system is needed for Portugal, but this project answered that too. It is needed because the different types and the vast amounts of data produced and stored need to be addressed in an effective way. Practitioners need to know what goes where and how and where can they find it when needed, and this is only possible by classifying information. The survey and the semi-structured interviews proved that stakeholders complain about the difficulties in producing and storing information, and afterwards, retrieving it. This was reported by a variety of practitioners from different areas in the field.

The idea was to explore the viability of one such system in Portugal, and develop not the software but the information that is needed to be in such a system, i.e. the content of the system and the issues regarding its management and implementation. The framework intends to be a base for such a system.

As mentioned above, information coordination in the construction industry has become of most importance, due to a variety of factors. These include the use of new and improved technologies (Rezgui et al., 2009), 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, and international trading. These factors combined together subsequently result in the need for information coordination and protocols for communicating information at an international level of representation and understanding.

The importance of using protocols and procedures is as immense as the importance of adopting an information coordination system, because it is only when information is produced 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.

Throughout the literature review several classification systems of considerable significance and implementation were identified, so why not just adopt one of those? The exploratory phase answered this question: there is probably no way in which a country can fully absorb and adopt another country's developed system apart from the case of the Commonwealth countries. The requirements might be similar, even overlap at some points but human behaviour and culture may not. Culture is, at an extreme, what defines a country. Existing systems found were developed and are in use in countries much different from Portugal - they are wealthier (not necessarily dotted with more resources than Portugal but exploring them in a different way) and their perception of management information is different from the Portuguese one.

There are cultural issues identified that make Portugal unique and the identification of those requirements is what is important to develop and implement such a system. This means that the FCI requirements can be extrapolated from, to be used by countries experiencing similar difficulties, but comprehending most of our culture, probably southern European countries.

This is not the same as saying that we need to produce a system that stands alone - it might, as it should (and it is intended to) allow cross-referencing and for that it needs to be based on something that already exists out there, but it has to respond to Portugal's requirements or otherwise it will not work.

The literature review was silent in the existence of such a system to Portugal and for that reason a survey was undertaken. The survey presented results that showed that a problem exists but it has not yet been addressed although stakeholders thought about it. The semi-structured interviews provided the reasoning behind Portugal's needs and the recognized importance of this issue by all involved in the process. The discussions taken in the focus groups were life proof that practitioners think and are trying to be involved in finding solutions for it. The FCI aims at providing exactly that: a future path to start from.

7.6. Recommendations for further work

So, what's next? The aim for further work is probably obvious to the reader: to develop the system to be implemented in Portugal. This is quite an endeavour, especially considering all the work undertaken with the development of the FCI.

The first step for future work will most likely be to divulge the FCI primarily amongst Government authorities and secondarily in academia. The fact that the UK Government is making efforts to implement the progressive use of BIM in its building programmes (BIS[84], 2012; CabinetOffice, 2011), allied to the fact that respondents engaged in this project often stated that if mandatory they would apply any sort of system, leads the researcher to believe that this should be the first step to be taken to disseminate it.

A strong presentation should be done in academia. University is a starting point for young practitioners, a stage when individuals are at their most explorative phase thus providing for the right mood to adopt alternative ways of thinking. This is also a crucial stage in terms of information dissemination. Young practitioners are expected to come out of university with the full determination that they are going to change the world, (or hopefully, if not the world then maybe just information management). Workshops and courses are to be considered also.

After engaging Government authorities and academia, efforts should be developed in overcoming the constraints found and drive possible enablers to the next stage of a system development. It is also important to engage professionals from earlier stages of the project design in discussions and experiments for information management and content. As identified, design projects need consistent information and steer to standardize processes. Furthermore, there is a need for a more proactive architects' association (Ordem do Arquitectos), when it comes to the issues this

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[84] BIS- Department for Business Innovation and Skills, UK,
site: [http://www.bis.gov.uk/]
accessed at: [http://www.bis.gov.uk/policies/business-sectors/construction/research-and-innovation/working-group-on-bimm];

thesis has addressed. Again workshops and informed sessions are useful strategies in accomplishing the above needs.

The framework implementation and the desire to transform it into a classification information system for the project design stages of construction works can only be possible after a more thorough comprehension of further research on project process in Portugal; identifying what it involves: work stages, practitioners engaged in each and all stages, their inter-links, what information needs to be addressed in each stage, the entire work flow and existing relations between them. Only a small part of it was identified in this project, mostly with the semi-structured interviews and the focus group discussions. This is thought to be an important part of any system to be implemented in Portugal but it is a full project in itself. To accomplish this, both financial and human resources should be obtained, whether in the private or the public sector (or both combined) to develop further research.

The network of contacts that the researcher established during this project, have already provided for some interest on behalf of companies in the private sector (facilities management companies and software companies) to join efforts in developing the system– a promising venture.

The work undertaken to develop a system for structuring and representing information for proper coordination and management in the Portuguese construction industry, should be 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 and management end users. Any efforts in this direction should necessarily be ISO based or compatible, and should comprehend the use of BIM processes and technologies and standards related to it. To accomplish this, again further research needs to be set in motion. Since standards and BIM cost money, efforts should be made to diminish the costs as much as possible and for that to be a reality one needs to know to what extent this will be profitable, not in financial terms, but in classification information implementation.

Following submission of the thesis, the researcher plans to submit papers for publications both in academic journals and national newspapers, in order to disseminate the FCI and, hopefully, to generate constructive discussion over the issues it addresses and hence bring them to the public agenda.

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APPENDIX 1

COMPARATIVE TABLE

Summarized comparative analysis table of the seven Classification Information Systems studied

Acronym/ Name	CI/SfB Construction Indexing Manual	EPIC Electronic Product Information Co-operation	CAWS Common Arrangement Work Sections	Uniclass Unified Classification for the Construction Industry	MasterFormat	OMNICLASS The Overall Construction Classification System	BS ISO 12006-2_2001, Part 2: Framework for Classification Information
Developed by	Alan Ray-Jones, RIBA, Royal Institute of British Architects Davis Clegg, ALA	Elements of WTCB/CSTC, Brussels RIBA, UK NBS Services Newcastle upon Tyne, UK Swedish Building Centre, Sweden CSTB, France STABU, Ede, Netherlands	CPI – Coordinated Project Information	CPI – Coordinated Project Information	CSI – Constructions Specifications Institute CSC – Construction Specification Canada	CSI – Construction Specifications Institute CSC – Construction Specification Canada IAI – International Alliance for Interoperability Since 2000 more than 50 AEC organizations have joined in its development	Technical Committee ISO/TC 59, building Construction, Subcommittee SC 13, Organization information about construction works
Country of origin	U.K.	Belgium, UK, Sweden, France, Netherlands	U.K.	U.K.	U.S.and Canada	U.S and Canada	U.K
Legacy systems	SfB from Sweden	Framework ISO 12006-2: 2001	CI/SfB	CI/SfB, CAWS, CSEMM3, EPIC, Framework ISO 12006-2: 2001		Frameworks ISO 12006-2: 2001; ISO/PAS 12006-3, UNICLASS, MasterFormat, Uniformat, EPIC, ASTM International	It is based on ISO Technical Report 14177, July 1994 and embraces many existing classification systems that were established since SfB.
Countries where its applied/Used	Most countries in Europe and the Commonwealths	Europe	Europe	Europe	North America, Canada	U.S.A. and Canada	All countries interested in developing classification systems and tables
Language	English	English	English	English	English	English	English
Information Classified	Design Drawings Working drawings Specifications	Product attributes	Bills of quantities Specifications	Technical Drawings Technical information regarding a structure's life cycle	Construction product information Specifications Written information for commercial and institutional building projects	Construction and project information, communication exchange information, cost and specification information and other information related to the project generate	Construction works Design production, maintenance and demolition

Acronym/ Name	CI/SfB Construction Indexing Manual	EPIC Electronic Product Information Co-operation	CAWS Common Arrangement Work Sections	Uniclass Unified Classification for the Construction Industry	MasterFormat	OMNICLASS The Overall Construction Classification System	BS ISO 12006-2_2001, Part 2: Framework for Classification Information
						throughout its lifecycle	
Use and Purpose	Office libraries Checklist for collecting and storage of information Outline technical specifications	Common reference system to the European construction industry for access to product information across national boundaries Define qualitative aspects of construction products	Arranging building project specifications and bills of quantities	Organize library materials and structure product literature and project information	Classify and organize product information by based on work results	Preparing project information Organizing different forms of information, electronic and hard copy, libraries and archives Organizing library materials, product literature, project information Providing classification structure for electronic databases Sorting and retrieving information and deriving rational computer applications	Intended to be used as a framework to develop the actual classification system
Used by	Architects Quantity surveys Engineers Contractors	Architects Quantity surveys Engineers	Architects Quantity Surveys Engineers Contractors	Architects Quantity Surveys Engineers Contractors	Architects Quantity Surveys Engineers Contractors	The AEC (architectural, engineering and construction) Industry	All involved in the development of classification systems compatible with international classification systems standards
Involved actions and people	Stakeholders/firms involved in the building industry	Professionals involved in the building industry	Preparation of building project documents. Professionals involved in the building and construction industry	Professionals involved in the building and construction industry	Organizing information about a facility's construction requirements and associated activities. All parties involved in construction projects	Is to be used by all involved in the AEC industry throughout a facility's life cycle, from conception, design and creation to its eventual demolition,	Organizations that which to develop and publish classification systems and tables for the construction industry

Acronym/ Name	CI/SfB Construction Indexing Manual	EPIC Electronic Product Information Co-operation	CAWS Common Arrangement Work Sections	Uniclass Unified Classification for the Construction Industry	MasterFormat	OMNICLASS The Overall Construction Classification System	BS ISO 12006-2_2001, Part 2: Framework for Classification Information
						deconstruction and re-proposing	
Range of application	Classification Filling Indexing Re-use of information	Classification of product groups and relevant attributes Product specification	Classification of work section for building work	Classification of product and work section and activities Filling Indexing Re-use of information Computer databases	Organizing project information specifications for commercial and institutional building projects	Classification, organization and preparation of information throughout a facility's lifecycle Address all aspects of information collection, record keeping and biding and contract requirements	It identifies classes for the organization of information and indicates how these classes are related
Representation of events/ occurrences	Physical Environment Elements Construction forms Materials Activities	Construction products Construction products attributes	Resources Activities involving skill and responsibility Parts of the work being constructed	Form of information Discipline Project management Space Elements Work section Construction products Construction aids Properties Materials	Facility's construction requirements and associated events	Construction entities Space Elements Work results Products Phases Services Disciplines Organizational roles Tools Information Materials Properties	It recommends the representation of: Construction entity, entity part, complex, product, aid, agent and information Space Elements Designed element Work element Management process Work process Project stage Property/ characteristic
Classification Notation/code	Alphanumeric	Alphanumeric	Alphanumeric	Alphanumeric	Numeric Six-digit numbering system	Numeric	Alphanumeric
Correlation compatibility		UNICLASS OMINICLASS	CI/SfB Is to be used with UNICLASS	CI/SfB CAWS CSEMM3	It advised to be used with the National CAD Standard v3.1(U.S) and	It is intended to be ISO compatible	UNICLASS, EPIC and OMNICLASS are based on it

Acronym/ Name	CI/SfB Construction Indexing Manual	EPIC Electronic Product Information Co-operation	CAWS Common Arrangement Work Sections	Uniclass Unified Classification for the Construction Industry	MasterFormat	OMNICLASS The Overall Construction Classification System	BS ISO 12006-2_2001, Part 2: Framework for Classification Information
				EPIC It is advised to be used with CAWS	is compatible with OMNICLASS		
Work practice	37 years in operation Most widely used	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	Flexibility User friendliness (introducing more practical terms rather than abstract functional terms)	Consistency of technical content and description Allows to divide the project information in work packages (easier distribution of information	Broader scope/range than the existing ones It aims to unify and comprise existing classification systems It can be used by several practitioners of many disciplines It was design to arrange files in computer databases	Its actual structure enables flexibility to accommodate future growth in construction material and technology Enables to create a database throughout the entire lifecycle of a building It provides a meeting standard of practice and improves documentation organization	It is compatible with international classification systems standards Its reported to be attacking the total classification problem Its development and dissemination depends only on the industry It uses numeric code which is universal And allows users to expand the code It allows an open-ended structure Its success lies in its implementation in computer technology Subjects addressed at any level inside a table are broad in their scope and content It is compatible with information stored in computerized databases It is freely available to anyone	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

Acronym/ Name	CI/SfB Construction Indexing Manual	EPIC Electronic Product Information Co-operation	CAWS Common Arrangement Work Sections	Uniclass Unified Classification for the Construction Industry	MasterFormat	OMNICLASS The Overall Construction Classification System	BS ISO 12006-2_2001, Part 2: Framework for Classification Information
Weakness	Filling order goes from detailed to general information It was created before the existence and use of actual technologies	It is limited in range coverage and application	It has to be used with other system to obtain a full coverage It is not very easy to understand by all involved	Being based on CAWS and advise to be use with it may present confusion and misinterpretations of use It is alphanumeric	It does not establish design disciplines, trade jurisdictions or product classifications Enables creativity in the classification information process It does not applicable to engineering work	It doesn't have sufficient practical application	With technology use and growth a framework for the object-oriented information exchange approach was developed has part of ISO 12006.

APPENDIX 2

SURVEY QUESTIONNAIRE AND COVER LETTERS

Dear Sir/Madam:

I am a PhD student in the field of Information Technologies applied to Construction, in the University of Salford, Manchester, United Kingdom. My PhD project aims to understand how design and construction project information in Portugal is produced, treated and stored. With the enclosed questionnaire I intend to identify:

- Portuguese knowledge and application of existing Standards related to project process and construction;
- Portuguese knowledge and application of existing information management systems related with project process and construction;
- Information management systems applied by Portuguese companies.

Your experience is of utmost importance to the development of this project, so I ask you to read carefully the following questions and answer as rigorously as possible. All the data gathered is confidential and for use in this study only. Questionnaires are not to be personally identified.

As I am under time constraints it would be wonderful if you could answer the questionnaire as soon as possible. After answering the questionnaire please insert it in the attached stamped envelope and post it to me.

If you have any queries please do not hesitate in contact me at: +351 96 4630573.

I kindly thank you for all your attention and help regarding this matter.

Yours sincerely,

Sara Biscaya

Professor Mustafa Alshawi
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08 July 2008

To Whom it May Concern

Re: Sara Viera Nobre Biscaya

The above-named is a part-time registered PhD research student at the School of the Built Environment, Research Institute for the Built & Human Environment.

This is to confirm that she is conducting a survey as part of her study research methodology for her PhD research at the University of Salford.

Category of Candidature:	Part time
Date of start of period of study:	1 April 2005
IMinimum duration of period of study:	5 years plus 2 year writing up
Supervisor:	Professor Ghassan Aouad
Field of further study and research:	Coordination and management of information for construction projects: A framework for Portugal

Yours faithfully

PP. **Dr Vian Ahmed**
Director of Postgraduate Studies
Research Institute for the Built and Human Environment
For enquiries please contact

M. Hartley

For enquires please contact
Carol Gordon (Ms). Postgraduate Research Co-ordinator
School of Construction & Property Management
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Survey

All questions are for practitioners and/or companies developing construction work in Portugal. The data is for use in a study about Information management in construction projects in Portugal. Please note: All information provided will be treated in the strictest of confidence. Thank you for your participation.

Please respond to the following questions by ticking the appropriate box/boxes or by writing your answer in the space provided.

Section 0 – Questions related with the inquiry's role in the office/company

What is your position in the Office/company?

1 □ Architect
2 □ Engineer
3 □ Economist
4 □ Administrative
5 □ Lawyer
99 □ No answer

How long have you been working in the field?

A.: ____________

In what year were you born?

A.: ____________

What are your academic qualifications?

1 □ High School Diploma
2 □ Undergraduate
3 □ Postgraduate- Masters
4 □ PhD
99 □ No answer

Section 1 – Questions related to the office/company

What is your office/company' business?

1 □ Architecture office

2 □ Engineer office

3 □ Building construction company

98 □ I don´t know

99 □ No answer

Is it a public or private office/company?

1 □ Private

2 □ Public

3 □ Public/Private

98 □ I don´t know

99 □ No answer

Since when did your office/company exist (please state the year)?

A.: ____________

How many people work in your office/company (please state a number)?

A.: ____________

In what fields? (please tick as many boxes as needed)

1 □ Architecture

2 □ Engineer

3 □ Economy/Finances

4 □ Administrative

5 □ Law

6 □ Others (please specify)

98 □ I don´t know

99 □ No answer

What are their academic qualifications? (please tick as many boxes as needed)

1 □ High School

2 □ Undergraduate

3 □ Postgraduate - Masters

4 □ PhD

98 □ I don´t know

99 □ No answer

What type of projects is your office/company involved in? (please tick as many boxes as needed)

1 □ Housing

2 □ Commerce

3 □ Social infrastructures

4 □ Urban-planning and design

5 □ Refurbishment

6 □ Others (please specify what type): _______________

98 □ I don´t know

99 □ No answer

What is the company business volume?

1 □ To 1 000 000 euros

2 □ To 5 000 000euros

3 □ To 10 000 000euros

4 □ To 50 000 000euros

5 □ To 100 000 000euros

6 □ To 500 000 000euros

7 □ From 500 000 000euros

98 □ I don´t know

99 □ No answer

What type of clients does your office/company work for typically? (please tick as many boxes as needed)

1 □ Private

2 □ Private offices/companies

3 □ Public offices/companies

4 □ Public/private offices/companies

98 □ I don´t know

99 □ No answer

Has your office/company been involved in International projects?

1 □ Yes

2 □ No (please jump to question 1.8)

98 □ I don´t know

99 □ No answer

If you answered yes in question 1.7.1 please mark which type they were from the list below

1 □ Housing

2 □ Commerce

3 □ Social Infrastructures

4 □ Urban-planning and design

5 □ Refurbishment

6 □ Others (please specify what type): ________________

98 □ I don´t know

99 □ No answer

Has your office/company collaborated with international companies in projects in Portugal?

1 □ Yes

2 □ No

98 □ I don´t know

99 □ No answer

If so please specify which: ________________________________

Section 2 – Questions related with the knowledge and application in Portugal of existing standards for construction project processes

2.1

2.1.1 Which standards, methods and procedures for construction projects from the list below do you know about? (please tick as many boxes as needed)

1 □ BS 1192-5:1998 *Construction drawing practice*, Guide for the structuring and exchange of CAD data

2 □ BS 1192:2007 *Collaborative Production of Architectural, Engineering and construction information- Code of practice*

3 □ IAI - IFC, *Industry Foundation Classes*, an industry standard for holding and exchanging digital data

4 □ ISO Standard 10303-STEP, *Standard for the Exchange of Product Model Data*

5 □ ISO/TR 14177:1994, *Classification of information in the construction industry*

6 □ BS ISO 12006-2:2001, *Building Construction- Organization of Information about construction works- Part 2: Framework for classification of information*

7 □ ISO/PAS 12006-3:2001. *Building Construction- Organization of Information about construction works- Part 3, Framework for object-oriented information exchange*

8 □ ISO 13584 Series of International Standards for representing and exchanging part library data

9 □ EN ISO 11442:2006 (Ed. 1) *Technical product documentation. Document management* (ISO 11442:2006). TC - CSF01

10□ NP EN ISO 13567-1:2002 (Ed. 1) *"Documentação técnica de produtos. Organização e designação de camadas ("layers") em CAD. Parte 1: Visão geral e princípios"* (ISO 13567-1:1998). CT- 1

11□ NP EN ISO 13567-2:2002 (Ed. 1) *"Documentação técnica de produtos. Organização e designação de camadas ("layers") em CAD. Parte 2: Conceitos,* *formatos e códigos utilizados na documentação de construção*" (ISO 13567-2:1998). CT - 1

12 BS ISO 22263:2008, *Organization of information about construction works – Framework for management of project information*

13 NP EN ISO 9000:2005 (Ed. 2) *Sistemas de gestão da qualidade. Fundamentos e vocabulário* (ISO 9000:2005). CT - 80

14 NP EN ISO 9001:2000 (Ed. 2) *Sistemas de gestão da qualidade.* Requisitos (ISO 9001:2000). CT – 80

15 aecXML *Standard framework for using the eXtensible Markup Language* (XML). standard for electronic communications in the architectural, engineering and construction industries

16 *Production Information – A code of procedure for the construction industry*

17 Others (please specify which): ____________________________

98 I don´t know

99 No answer

2.2

2.2.1 How did you learn about them? (tick one box only)

1 University

2 In your current job

3 Previous job

4 Through a colleague in the same field

5 Through a colleague from another field

6 Other (please specify): _______________________________

98 I don´t know

99 No answer

2.3

2.3.1 Which ones do you use? (please tick as many boxes as needed)

1 BS 1192-5:1998 *Construction drawing practice,* Guide for the structuring and exchange of CAD data

2 BS 1192:2007 *Collaborative Production of Architectural, Engineering and construction information- Code of practice*

3 IAI - IFC, *Industry Foundation Classes*, an industry standard for holding and exchanging digital data

4 ISO Standard 10303-STEP, *Standard for the Exchange of Product Model Data*

5 ISO/TR 14177:1994, *Classification of information in the construction industry*

6 BS ISO 12006-2:2001, *Building Construction- Organization of Information about construction works- Part 2: Framework for classification of information*

7 ISO/PAS 12006-3:2001. *Building Construction- Organization of Information about construction works- Part 3, Framework for object-oriented information exchange*

8 ISO 13584 Series of International Standards for representing and exchanging part library data

9 EN ISO 11442:2006 (Ed. 1) *Technical product documentation. Document management* (ISO 11442:2006). TC - CSF01

10 NP EN ISO 13567-1:2002 (Ed. 1) "*Documentação técnica de produtos. Organização e designação de camadas ("layers") em CAD. Parte 1: Visão geral e princípios"* (ISO 13567-1:1998). CT- 1

11 NP EN ISO 13567-2:2002 (Ed. 1) "*Documentação técnica de produtos. Organização e designação de camadas ("layers") em CAD. Parte 2: Conceitos, formatos e códigos utilizados na documentação de construção*" (ISO 13567-2:1998). CT - 1

12 BS ISO 22263:2008, *Organization of information about construction works – Framework for management of project information*

13 NP EN ISO 9000:2005 (Ed. 2) *Sistemas de gestão da qualidade. Fundamentos e vocabulário* (ISO 9000:2005). CT - 80

14 NP EN ISO 9001:2000 (Ed. 2) *Sistemas de gestão da qualidade.* Requisitos (ISO 9001:2000). CT – 80

15 aecXML *Standard framework for using the eXtensible Markup Language* (XML). standard for electronic communications in the architectural, engineering and construction industries

16□ *Production Information – A code of procedure for the construction industry*

17□ Others (please specify which): ___________________________

98 □ I don´t know

99 □ No answer

2.3.2

A Why do you use them? (tick one box only)

1 □ The system makes it mandatory

2 □ Company policy

3 □ Personal choice

4 □ Consider them to be useful

5 □ Never thought about that, always used them

6 □ Other (please specify): ___________________________________

98 □ I don´t know

99 □ No answer

B Why don't you use them? (tick one box only)

1 □ The system doesn´t make them mandatory

2 □ Don't consider them useful

3 □ Never thought about that, never used them

4 □ Other (please specify): ___________________________________

98 □ I don´t know

99 □ No answer

Regarding the systems you use and referred to in Section A above please answer the following:

When did you begin to use them? (please state the year): ________

98 □ I don´t know

99 □ No answer

Why did you start to use them? (tick one box only)

1 □ Obliged by the system

2 □ Personal choice

3 □ Office/company policy

4 □ Other (please specify): ____________

98 □ I don´t know

99 □ No answer

2.3.5 Do you think/feel they are easy to comprehend and use? (tick one box only)

1 □ Yes

2 □ Some are

3 □ Some aren't

4 □ No

98 □ I don´t know

99 □ No answer

2.3.6 Do you find them useful? (tick one box only)

1 □ Yes

2 □ Some are

3 □ Some aren't

4 □ No

98 □ I don´t know

99 □ No answer

Section 3 – Questions related with the knowledge and application in Portugal of existing information production, storage and management systems for construction project processes

3.1 Which of the following classification information systems for construction projects do you know about? (please tick as many boxes as needed)

1 □ *CI/SfB , Construction Indexing Manual*

2 □ *EPIC - Electronic Product Information Co-ordination*

3 □ *CAWS - Common Arrangement Work Sections*

4 □ *Uniclass – Unified Classification for the Construction Industry*

5 □ *MasterFormat*

6 □ *OmniClass – The Overall Construction Classification System*

7 □ Other (please state which): ___________________________

98 □ I don´t know

99 □ No answer

How did you come to know about them? (tick one box only)

1 □ University

2 □ In your present work

3 □ Previous work

4 □ Through a colleague in the same field

5 □ Through a colleague from another field

6 □ Other (please specify): _______________________________

98 □ I don´t know

99 □ No answer

3.3

Which one do you apply/follow? (please tick as many boxes as needed)

1 □ *CI/SfB , Construction Indexing Manual*

2 □ *EPIC - Electronic Product Information Co-ordination*

3 □ *CAWS - Common Arrangement Work Sections*

4 □ *Uniclass – Unified Classification for the Construction Industry*

5 □ *MasterFormat*

6 □ *OmniClass – The Overall Construction Classification System*

7 □ Other (please specify): _________________________________

98 □ I don´t know

99 □ No answer

A Why do you use them? (tick one box only)

1 □ Obliged by the system

2 □ Company policy

3 □ Personal choice

4 □ Consider them to be useful

5 □ Never thought about that, always used them

6 □ Other (please specify): ________________________________

98 □ I don´t know

99 □ No answer

B Why don’t you use them? (tick one box only)

1 □ Not obliged by the system

2 □ Don’t consider them useful

3 □ Never thought about that, never used them

4 □ Other (please specify): _________________________________

98 □ I don´t know

99 □ No answer

Regarding the classification systems you use and referred to in Section A above please answer the following:

When did you begin to use them? (please state the year)

____

Why did you start to use them? (tick one box only)

1 □ Obliged by the system

2 □ Personal choice

3 □ Office/company policy

4 □ Other (please specify): _________________________________

98 □ I don´t know

99 □ No answer

Do you think/feel they are easy to comprehend and use? (tick one box only)

1 □ Yes

2 □ Some are

3 □ Some aren't

4 □ No

98 □ I don´t know

99 □ No answer

Do you find them useful? (tick one box only)

1 □ Yes

2 □ Some are

3 □ Some aren't

4 □ No

98 □ I don´t know

99 □ No answer

Section 4 – Questions related with adopted production, storage and management information systems in offices/companies in the civil construction in Portugal

4.1

4.1.1 How do you produce, manage and store information regarding project processes (including: materials specifications, drawings, management and financial information, bills of quantity) in your office/company?

1 □ Through a system created by the office/company

2 □ Adoption of one of the mentioned systems/methods in 3.1.

If so which one/s? ______________________

____

3 □ Each project is treated in a different way

4 □ No system is used

5 □ Other (please specify): _________________________

98 □ I don´t know

99 □ No answer

4.1.2 Do you consider it easy to retrieve the information?

1 □ Yes

2 □ No

98 □ I don´t know

99 □ No answer

4.1.2 How many members in your office/company know how to produce and manage the generated information? (please state a number)

____

98 □ I don´t know

99 □ No answer

4.1.4 How many members in your office/company actually manage the generated information? (please state a number)

____

98 □ I don´t know

99 □ No answer

4.1.5 What background does he/she/them has/have?

1 □ Architect

2 □ Civil Engineer

3 □ Informatics Engineer

4 □ Documentalist/Archivist

5 □ Administrative

6 □ Lawyer

7 □ Other (please specify): _________________________

98 □ I don´t know

99 □ No answer

What do you do with the information received by your office/company?

____

98 □ I don´t know

99 □No answer

4.3 How does your Office/company exchange information with other teams involved in the construction project process?

1 □ Via e-mail

2 □ Paper (post and other delivery services)

3 □ Common knowledge base

4 □ Other (please specify): ___________________________________

98 □ I don´t know

99 □ No answer

Thank you for your participation, please send the completed questionnaires in the self addressed envelope provided.

APPENDIX 3

SURVEY RESULTS

Cross-tabulations:

Q2.1.1: Known Standards	Q1.4: How many people work in your office/company (please state a number)? <= 4 employees	5 - 8 employees	9 - 28 employees	>=29 employees	Total
BS 1192-51998	25%	-	38%	38%	100%
BS 11922007	20%	-	20%	60%	100%
IAI - IFC	50%	-	-	50%	100%
ISO Standard 10303-STEP	33%	-	33%	33%	100%
ISO/TR 141771994	-	-	-	100%	100%
BS ISO 12006-22001	-	-	50%	50%	100%
ISO/PAS 12006-32001	-	-	67%	33%	100%
ISO 13584	17%	-	50%	33%	100%
EN ISO 114422006 (Ed.1)	25%	-	25%	50%	100%
NP EN ISO 13567-12002 (Ed.1)	21%	-	43%	36%	100%
NP EN ISO 13567-22002 (Ed.1)	23%	-	46%	31%	100%
BS ISO 222632008	20%	-	40%	40%	100%
NP EN ISO 90002005 (Ed.2)	35%	9%	22%	35%	100%
NP EN ISO 90012000 (Ed. 2)	32%	8%	20%	40%	100%
aecXML	33%	-	33%	33%	100%
Production Information	-	-	-	100%	100%
Others	50%	50%	-	-	100%
I Don´t Know	27%	36%	27%	9%	100%
No answer	50%	14%	14%	21%	100%

Table 21- Number of employees by known Standards (%): 2008, Portugal.

Q2.1.1: Known Standards	Q1.6: What is the company business volume? To 1 000 000 euros	To 5 000 000 euros	To 10 000 000 euros	To 50 000 000 euros	To 100 000 000 euros	To 500 000 000 euros	From 500 000 000 euros	I Don´t Know	No Answer	Total
BS 1192-51998	38%	13%	25%	-	13%	-	-	13%	-	100%
BS 11922007	40%	-	20%	20%	-	-	-	20%	-	100%
IAI - IFC	50%	-	-	-	-	-	-	50%	-	100%
ISO Standard 10303-STEP	33%	33%	-	17%	-	-	-	17%	-	100%
ISO/TR 141771994	-	33%	-	-	33%	-	-	33%	-	100%
BS ISO 12006-22001	50%	-	-	-	-	-	-	50%	-	100%
ISO/PAS 12006-32001	33%	33%	-	-	-	-	-	33%	-	100%
ISO 13584	43%	14%	14%	-	-	14%	-	14%	-	100%
EN ISO 114422006 (Ed.1)	25%	50%	-	-	-	-	-	25%	-	100%
NP EN ISO 13567-12002 (Ed.1)	47%	20%	7%	7%	-	13%	-	7%	-	100%
NP EN ISO 13567-22002 (Ed. 1)	46%	15%	8%	8%	-	15%	-	8%	-	100%
BS ISO 222632008	40%	20%	-	20%	-	%	-	20%	-	100%
NP EN ISO 90002005 (Ed.2)	39%	17%	17%	9%	4%	4%	-	4%	4%	100%
NP EN ISO 90012000 (Ed. 2)	36%	16%	24%	8%	4%	4%	-	4%	4%	100%
aecXML	67%	-	-	-	-	-	-	33%	-	100%
Production Information	-	-	-	-	-	-	-	100%	-	100%
Others	50%	-	-	-	-	-	-	50%	-	100%
I Don´t Know	36%	9%	-	9%	9%	9%	9%	18%	-	100%
No Answer	57%	7%	14%	14%	-	7%	-	-	-	100%

Table 22- Companies business volume by known Standards (Line %): 2008, Portugal.

Q2.3.1: Which Standards do you use?	Q1.4.1: How many people work in your office/company (please state a number)?			
	<= 4 employees	5 - 8 employees	9 - 28 employees	>= 29 employees
BS 1192-51998	7%	-	4%	5%
BS 11922007	4%	-	-	3%
IAI - IFC	4%	-	4%	3%
ISO Standard 10303-STEP	4%	-	-	3%
ISO/TR 141771994	-	-	-	5%
BS ISO 12006-22001	-	-	-	3%
ISO/PAS 12006-32001	-	-	-	5%
ISO 13584	-	-	4%	3%
EN ISO 114422006 (Ed.1)	-	-	-	3%
NP EN ISO 13567-12002 (Ed.1)	11%	-	4%	5%
NP EN ISO 13567-22002 (Ed.1)	7%	-	4%	5%
BS ISO 222632008	4%	-	-	3%
NP EN ISO 90002005 (Ed.2)	-	10%	17%	18%
NP EN ISO 90012000 (Ed. 2)	4%	10%	17%	25%
aecXML	-	-	4%	3%
Production Information	-	-	-	3%
Others	4%	20%	-	-
I Don´t Know	18%	40%	22%	5%
No Answer	36%	20%	17%	5%
Total	100%	100%	100%	100%

Table 23- Number of employees by applied Standards (Line %): 2008, Portugal.

Q2.3.1: Which Standards do you use?	Q1.6: What is the company business volume?									
	To 1 000 000 euros	To 5 000 000 euros	To 10 000 000 euros	To 50 000 000 euros	To 100 000 000 euros	To 500 000 000 euros	From 500 000 000 euros	I Don´t Know	No Answer	Total
BS 1192-51998	40%	-	20%	20%	-	-	-	20%	-	100%
BS 11922007	50%	-	-	-	-	-	-	50%	-	100%
IAI - IFC	67%	-	-	-	-	-	-	33%	-	100%
ISO Standard 10303-STEP	50%	-	-	-	-	-	-	50%	-	100%
ISO/TR 141771994	-	50%	-	-	-	-	-	50%	-	100%
BS ISO 12006-22001	-	-	-	-	-	-	-	100%	-	100%
ISO/PAS 12006-32001	-	50%	-	-	-	-	-	50%	-	100%
ISO 13584	33%	33%	-	-	-	-	-	33%	-	100%
EN ISO 114422006 (Ed.1)	50%	-	-	-	-	-	-	50%	-	100%
NP EN ISO 13567-12002 (Ed.1)	43%	29%	-	14%	-	-	-	14%	-	100%
NP EN ISO 13567-22002 (Ed.1)	20%	40%	-	20%	-	-	-	20%	-	100%
BS ISO 222632008	50%	-	-	-	-	-	-	50%	-	100%
NP EN ISO 90002005 (Ed.2)	17%	33%	8%	8%	8%	8%	-	8%	8%	100%
NP EN ISO 90012000 (Ed. 2)	19%	25%	25%	6%	6%	6%	-	6%	6%	100%
aecXML	50%	-	-	-	-	-	-	50%	-	100%
Production Information	-	-	-	-	-	-	-	100%	-	100%
Others	33%	-	-	-	-	-	-	33%	33%	100%
I Don´t Know	50%	6%	-	19%	6%	6%	6%	6%	-	100%
No Answer	67%	6%	11%	6%	-	11%	-	-	-	100%

Table 24-Companies’ business volume by applied Standards (Line %): 2008, Portugal.

		Q04: What are your academic qualifications?					
		High School Diploma	Undergraduate	Postgraduate-Masters	PhD	No answer	Total
Q2.1.1: Known Standards	BS 1192-51998	20%	60%	20%	-	-	100%
	BS 11922007	-	-	100%	-	-	100%
	IAI - IFC	-	67%	33%	-	-	100%
	ISO Standard 10303-STEP	-	50%	50%	-	-	100%
	ISO/TR 141771994	-	-	50%	50%	-	100%
	BS ISO 12006-22001	-	-	100%	-	-	100%
	ISO/PAS 12006-32001	-	-	50%	50%	-	100%
	ISO 13584	-	-	67%	33%	-	100%
	EN ISO 114422006 (Ed.1)	-	-	50%	50%	-	100%
	NP EN ISO 13567-12002 (Ed.1)	-	29%	29%	43%	-	100%
	NP EN ISO 13567-22002 (Ed. 1)	-	20%	40%	40%	-	100%
	BS ISO 222632008	-	-	100%	-	-	100%
	NP EN ISO 90002005 (Ed.2)	8%	42%	33%	8%	8%	100%
	NP EN ISO 90012000 (Ed. 2)	6%	38%	44%	6%	6%	100%
	aecXML	-	50%	50%	-	-	100%
	Production Information	-	-	100%	-	-	100%
	Others	-	33%	33%	-	33%	100%
	I Don´t Know	13%	50%	25%	13%	-	100%
	No answer	11%	72%	17%	-	-	100%

Table 25-Academic qualifications by known Standards (Line %): 2008, Portugal.

		Q04: What are your academic qualifications?					
		High School Diploma	Undergraduate	Postgraduate-Masters	PhD	I Don´t Know	Total
Q2.3.1: Which Standards do you use?	BS 1192-51998	-	75%	25%	-	-	100%
	BS 11922007	20%	40%	40%	-	-	100%
	IAI - IFC	-	50%	50%	-	-	100%
	ISO Standard 10303-STEP	-	50%	33%	17%	-	100%
	ISO/TR 141771994	-	33%	33%	33%	-	100%
	BS ISO 12006-22001	-	50%	50%	-	-	100%
	ISO/PAS 12006-32001	-	33%	67%	-	-	100%
	ISO 13584	-	57%	29%	14%	-	100%
	EN ISO 114422006 (Ed.1)	-	25%	50%	25%	-	100%
	NP EN ISO 13567-12002 (Ed.1)	-	53%	27%	20%	-	100%
	NP EN ISO 13567-22002 (Ed. 1)	-	62%	31%	8%	-	100%
	BS ISO 222632008	20%	20%	60%	-	-	100%
	NP EN ISO 90002005 (Ed.2)	4%	52%	30%	9%	4%	100%
	NP EN ISO 90012000 (Ed. 2)	4%	52%	32%	8%	4%	100%
	aecXML	-	67%	33%	-	-	100%
	Production Information	-	-	100%	-	-	100%
	Others	-	50%	50%	-	-	100%
	I Don´t Know	18%	36%	27%	18%	-	100%
	No Answer	14%	64%	21%	-	-	100%

Table 26- Academic qualifications by applied Standards (Line %): 2008, Portugal.

		Q1.4_2: In what fields								
		Architecture	Engineer	Economy/ Finances	Administrative	Law	Others	I Don´t know	No answer	Total
Q2.3.1: Wich Standardsdo you use?	BS 1192-51998	25%	13%	-	13%	13%	25%	-	13%	100%
	BS 11922007	-	50%	-	-	-	50%	-	-	100%
	IAI - IFC	33%	17%	17%	-	-	33%	-	-	100%
	ISO Standard 10303-STEP	-	33%	-	-	-	67%	-	-	100%
	ISO/TR 141771994	-	50%	-	-	-	50%	-	-	100%
	BS ISO 12006-22001	-	-	-	-	-	100%	-	-	100%
	ISO/PAS 12006-32001	-	50%	-	-	-	50%	-	-	100%
	ISO 13584	17%	17%	17%	17%	-	33%	-	-	100%
	EN ISO 114422006 (Ed.1)	50%	-	-	-	-	50%	-	-	100%
	NP EN ISO 13567-12002 (Ed.1)	33%	44%	-	-	-	22%	-	-	100%
	NP EN ISO 13567-22002 (Ed. 1)	14%	57%	-	-	-	29%	-	-	100%
	BS ISO 222632008	%	50%	-	-	-	50%	-	-	100%
	NP EN ISO 90002005 (Ed.2)	17%	31%	14%	20%	6%	11%	-	-	100%
	NP EN ISO 90012000 (Ed. 2)	15%	31%	15%	23%	6%	10%	-	-	100%
	aecXML	-	-	-	-	-	100%	-	-	100%
	Production Information	-	-	-	-	-	100%	-	-	100%
	Others	50%	17%	17%	17%	-	-	-	-	100%
	I Don´t know	33%	31%	11%	19%	3%	3%	-	-	100%
	No Answer	32%	32%	-	19%	5%	8%	-	3%	100%

Table 27- Activity areas by applied Standards (Line %): 2008, Portugal.

APPENDIX 4

SEMI-STRUCTURED INTERVIEW SCRIPT

Please note that the script was used as guidance and that each interview took its own course, with some issues being more elaborated upon than others, depending on the interviewee's take on them.

Can you give a description of the design/construction/retrieval process in your office/company? Or: what is in general the design process project used by your company? (simple scheme)

- Do you use a standard procedure in all your projects/works? (Or each one is approached in a different form?)

- What system or framework for producing, managing and storing information throughout the design/construction/retrieval process do/does you/your company use? Do you always use that system/framework?
  - Do you find it easy to understand and retrieve the information? E.g. if a project is started and at an advanced stage of that process another practitioner engages on it, is it easy to understand what has been done and to retrieve that information? Including knowing who was the last person responsible for that information or piece of it? Or if, for example, you have to use a drawing that another practitioner has been working on, is it easy to find?
  - Do you know exactly where you can find it?
  - How long does it take for you to find a drawing or to identify the person responsible for that piece of information?
    - Is there accountability of practitioners that produce/use the information, how do you keep track of that?
  - Being aware of existing information classification systems, which one do/does you/your office adopt?

- What are, in your opinion, the biggest problems/setbacks when implementing new procedures in your company or in any company that you´ve worked in (if you ever had that experience)?
    - Do you believe there are benefits? (What are they?)

- Is it important for you that information is displayed in a structured and unambiguous way?

- What are the bigger problems that you see in terms of adopting a framework for information classification system in Portugal? (framework- guidelines to produce, manage, store and retrieve information)
    - Do you believe that it could be useful to have a common knowledge base between different practitioners involved in the design process? (from different areas also). One that can also track information, users etc…
- From your perspective, what are the benefits of proper information coordination in the design process?
- If you were obliged to use an information classification system what do you think it should entail? (Important concerns or situations that the respondent finds in its average working day regarding information coordination).
    - Should standards be entailed?
    - Is it better that practitioners do as they please when producing, managing and storing information or is it best to establish a common way even if that rule needs to be adapted in some cases?

- How do you identify the drawings of a design project?
    - What is the main information content on a drawing produced by your company/office, or by you?
    - Are you aware of NP ISO 13567-1:2002? How did you become aware of it? How do you apply/use it?

- Are you familiar with programmes such as AutoCAD, Revit or ArchiCAD?
    - With which one do you work with mostly?
    - Do you know how to catalogue a window or a door within that programme?
        - How do catalogue a window or a door using that programme?
    - Are you aware of IFC´s, or where can we find them?

- Is your office/company certified?
    - If yes:
        - Do you apply quality related standards: NP EN ISO 9000:2005 and NP EN ISO 9001:2000? Can you give a general idea of how are they applied/followed?
    - If yes or not:
        - Are you familiar with other existing standards? Which ones?
        - From the standards you know/apply, are they easy to apply?
        - How do you perceive their utility and implementation? (easy, not easy, not understandable, and why)

APPENDIX 5

CONSTRAINTS AND ENABLERS TABLE PRESENTED AT THE FOCUS GROUP DISCUSSIONS

IDENTIFIED FACTORS INFLUENCING THE FRAMEWORK DEVELOPMENT AND IMPLEMENTATION

1. POLITICAL ISSUES
1.a. Government Politics-Lobbies
1.b. Public Policy
1.c. Decision making process
1.d. Inefficient Planning
1.e. Bureaucracy

2. CULTURAL AND BEHAVIOURAL ISSUES
2.a. Reluctance to novelty/ standardization
2.b. Lack of Accountability
2.c. Lack of Organization
2.d. Lack of Professionalism
2.e. Poor Professional development

3. LEGAL ISSUES
3.a. Accountability not assigned
3.b. Non-compliance in timelines and deadlines
3.c. Delays in solving litigations
3.d. Insurance problems
3.e. Inefficiency of regulations
3.f. Difficulties in identifying obligations
3.g. Inexistence of effective penalties
3.h. Lack of Competitiveness

5. ECONOMIC AND FINANCIAL ISSUES
5.a. Economic crises
5.b. Economic planning
5.c. Software
5.d. Skills development
5.e. Companies certification

FRAMEWORK

6. ORGANIZATIONAL
6.a. Addressing the classification of different types of information
6.b. Storage methodology
6.c. Security
6.d. Misplacement of information
6.e. Management and leadership
6.f. Deadlines and timetables

4. TECHNICAL AND EDUCATIONAL ISSUES
4.a. Diversified Methodology:
4.a.1.Work Plan
4.a.2. Producing information
4.a.3.Management and storage of information
4.b. Poor Skills
4.b.1. Production of information
4.b.2.IT support and understand
4.b.3. Knowledge on existing standards
4.c. Professional
4. c.1.Absence of Accountability
4. c.2.Deficient quality information on projects
4.d. Problems with security of information
4.e. Absence of Interoperability
4.f.Lack of a user-friendly system
4.g.Language issues
4.h.Lack of semantics for a common/universal terminology
4.i. Lack of technical education and qualified skills development

OVERARCHING ISSUES
Corruption * Lack of Accountability * Non- compliance timelines and deadlines/time management