International Journal of Engineering Trends and Technology Volume 69 Issue 7, 92-100, July, 2021
ISSN: 2231 – 5381 /doi:10.14445/22315381/IJETT-V69I7P214

Maturity of BIM Implementation in the Construction Industry: Governmental Policies

Alcínia Zita Sampaio

Professor &Department of Civil Engineering &Higher Technical School &University of Lisbon, Av. Rovisco Pais, 1049-011, Lisbon, Portugal

zita.sampaio@tecnico.ulisboa.pt

Abstract *- The Building Information Modelling (BIM) methodology is currently the most widely used working platform in the construction industry. The benefit of its implementation is recognized across all activities and is considered a milestone in technological innovation applied in the sector. The increasing acceptance of the methodology by the industry covers the areas of the project, construction, management, and maintenance; within a business, after a prior period of investment in technology and training, the gains in value-added to the enterprise become evident. Architects, engineers, builders, and managers have gradually been recognizing the high capacity in the use of BIM-based tools for modeling, visualization, analysis, and simulation processes, motivating growth in the adoption of BIM around the world. This reflective study is supported and contextualized by its reference to BIM's main features: its genesis, the concept, the range of applicability, and the main fundamentals of the methodology, namely, the parametric modeling process and the interoperability capacity of the software. These aspects have led to the involvement of the governments of several countries in adopting the methodology, establishing the implementation of BIM, initially in public construction, following a progressive mandatory process. The level of BIM implementation achieved described in the text demonstrates the current maturity of the construction sector around the world.*

Keywords — *BIM methodology, Genesis, Governmental policies, Implementation, Maturity.*

I. INTRODUCTION

The Building Information Modelling (BIM) concept encompasses the generation, updating, and reuse of information, centralized in a federated digital model. The data incorporated in the model concern all technical disciplines and the multiple tasks that are normally performed during a building project, construction planning, maintenance operation, and facility management activities [1]. The methodology is supported by the use of BIM-based platforms that incorporate the most recent technological advances achieved, allowing easy access to the model database and the development of collaborative work processes involving all the design team. A collaborative BIM project is drawn upon a technological platform, where each professional operates, retrieving information from the model and adding new data that are required in the context of each specific activity [2]. A BIM process needs the efficient integration of all steps, and for that, a satisfactory degree of interoperability between the specific software used is required [3].

In all areas of the construction industry, owners, designers, builders, and managers have already reported the benefits of adopting the BIM methodology [4]. This has led to its increasing acceptance, at a global level and exponentially, to governmental entities establishing regulations for activities and mandatory implementation dates in the public construction domain [5]. In addition, the technical school, with its important educational and societal mission to empower future engineers to take their place in this increasingly global arena by providing them with the fundamental teachings on the most innovative construction issues, has been adapting its curriculum in order to teach both the practical aspects and the methodology related to BIM.

The schools have also been offering short courses and workshops on BIM to professionals in order to improve their skills and competitiveness. The text presents the state-of-the-art of BIM implementation in the sector, with the incidence in Europe, following the introduction of the fundamentals of the methodology, namely, genesis, concept, applicability, and implementation strategies. The unlike degree of BIM implementation reached on the construction sector in each country push governments to act in a way that reduces the differences currently existing and, in particular, Portugal govern must take action rapidly to ensure its position in the global industrial world.

As a **methodology** for the present study: first, a conceptual introduction to BIM is refereed; followed by the description of its range applicability, the problems related to the implementation process in the sector, and a breve revision of the genesis of BIM; finally, deep research concerning the levels of BIM maturity found in European countries is present. As a complement, other non-Europeans countries like the United States of America, Singapore, South Korea, Japan, Brazil, and Chile are also refereed in a breve exposition.

II. THE BIM CONCEPT

Construction involves a wide range of professionals in building design, requiring a high degree of collaboration, sharing and transposition of data, and also an important degree of coordination. The development of projects of considerable size and complexity, based on a technological culture of individual action and the use of computer tools with gaps in data transfer processes, often leads to the fragmentation of the sequence of t tasks and the reuse of information with the interruption of a project's process cycle.

Given the multifaceted participation of the many professionals from distinctly different professional areas, a greater degree of integration, cooperation, and coordination is needed. In recent years, the construction industry has been adopting Building Information Modelling (BIM) methodology in order to increase productivity, obtaining more efficient constructions, and enhancing a satisfactory thermal and economic performance throughout the building's lifecycle (Fig1).

Fig1: Building's life cycle in a BIM environment [3].

The BIM concept is based on the generation of a federated digital model, centralizing all building-related information, which is kept organized and up-to-date, in order to support the development of the entire design project involving all areas of specialization: architecture, structures, and services; construction planning and control; maintenance and management activities (Figure 2).

The creation of the BIM model is strongly supported by the current technological capabilities of the modeling tools used, where parametric objects are accurately representative of the building where its geometric shape and the physical properties of the materials applied are concerned.

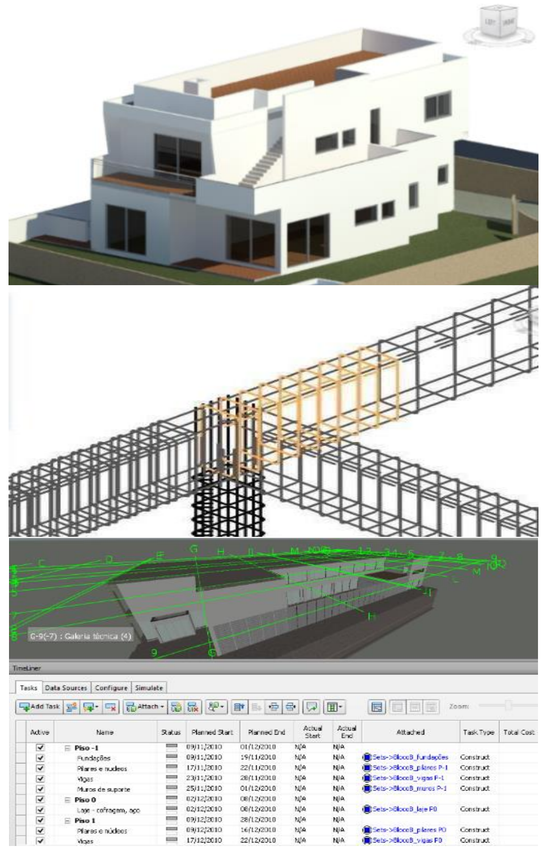

Fig 2: Architectural and structural models and simulation of the construction planning [6].

The methodology supports working collaboratively. Based on the ease of communication between specialists and involving a satisfactory level of interoperability, the transfer of information between design steps can be carried out with an elevated degree of confidence in the correctness of the transferred data.

Collaboration and communication based on a technological platform with a high capacity of interoperability lead to the reduction of errors of inconsistency, a conflict between construction components, or omission of data, all of which result in sustained cost-levels at all stages of the lifecycle of the building and an optimized construction product. Its benefits, revealed in the quality of developed projects, reflect effective process integration and clear collaboration between all parties.

The methodology emerged, therefore, as a way of obtaining better final products, and the BIM concept began to be implemented in the construction industry as an innovation in the sector at the beginning of this century. The demonstrable benefits are particularly due to the use of BIM-based tools, which incorporate the latest technological contributions, mainly addressed to the two pillars that underpin the methodology [6]:

- The concept of **parametric modeling**, with the establishment of new families of parametric objects to be applied in the representation of buildings;
- The process of **transferring information** between systems, which has achieved high levels of efficiency and correction.

In a BIM context, construction-related enterprises show their understanding of this, encouraging professionals to seek training opportunities that can add to their knowledge, a requirement in a globalized industrial world that is increasingly competitive. The technical school has contributed positively to the updating of building industry professionals' knowledge by organizing BIM training courses, according to the interest and expectation expressed by engineering departments and public entities. During short courses, the methodological concepts and a wide range of the applicability inherent in the development of projects in the BIM environment are presented [7]. Industry and the technical school have, in recent years, been collaborating in finding the best strategy for establishing effective community teaching activities [8].

III. APPLICABILITY OF BIM

The theoretical notion of BIM acquires a practical meaning with software that incorporates this methodology and integrates the most innovative technological achievements. The practical concept of BIM can be translated into three essential strands:

- The **generation** of a 3D geometric model composed of all the information associated with the design of the different disciplines that make up a project (architecture, structures, and services);
- The use of data, **centralized** in the model created, supporting the execution of diverse complementary activities, which are normally developed during the lifetime of the project (construction planning or budgeting);
- The **maintenance** of information generated, transformed, and added in such a way as to constitute an updated repository of data, which can be retrieved and used to support distinct types of study (energy simulation or inspections).

The use of BIM-based technological tools in the development of the representative model of the project, which is being generated throughout the design process, supports clear and accurate communication between owners, architects, and engineers. Initially, the BIM concept was referred to as a technology that aims to support the development of disparate disciplines of a project from a purely geometric perspective.

However, through the use of parametric objects with a considerable amount of information, BIM modeling tools allow the definition of very realistic models, both in geometry and in contents.

In collaborative work, the BIM model allows a complete, comprehensive database with reliable and easy access, thus providing important support for the efficient transfer of digital information between individual stakeholders, which enhances the process of timely and sustained decision-making. The database of the model created is directly used, by the system, in the preparation of multiple tasks, in which the type of information is extracted and manipulated according to the objective and requirements of the expert. The recognition of the use of model data in multiple applications is all the more evident as the involvement of the office team and inter-company partners in the adoption of BIM in their specific activities.

The BIM-based tools also allow the updating of the model. As a BIM model presents an organized information structure, it is possible to continually update it with the contributions of all the team members involved in the sustained monitoring of the lifecycle of the building. The BIM manager is, therefore, necessarily required to assume the role of supervisor of an integrated partnership, made up of those responsible for each of the separate, contributing activities involved in the development and maintenance of the BIM project.

The visible component of the methodology is the BIM 3D geometric model. From this perspective, the building is defined through a 3D digital representation, consisting of parametric objects selected in order to accurately represent their configuration and physical behavior. The information included in the 3D model forms an important platform that supports the integration of all processes required in monitoring the lifecycle of the building. The many uses that can be made of the information retrieved from the model are frequently considered as BIM nD applications or models (Fig 3) [9]:

- The **BIM 3D** model represents the set of 3D parametric objects referred to in all project specialties (architecture, structures, and systems) and incorporates the various aspects of the building (geometry, spatial interrelation, construction components constitution, and physical properties of the materials);
- The **BIM 4D** model is concerned with the simulation of the building's construction process, planned according to the critical path network studied and associated with groups of elements of the 3D model. It provides dynamic support of the evolution of the actual construction, the management of the building-site according to the changes and local logistics, the chronological control of materials supply, the availability of human resources, and the monitoring of the work construction;
- The **BIM 5D** model supports the prediction of the work costs (quantity take-off of material and estimation of

costs at different stages of the project and construction);

- The **BIM 6D** model supports energy and sustainability studies (energy consumption estimation and consumption measurement and verification monitoring during the building use);
- The **BIM 7D** model deals with the management and maintenance of the building throughout its period of use (retrieving and updating all the information concerning the state of conservation, maintenance and operation manuals, or even specification documents and component guarantees);
- The **BIM 8D** model encompasses aspects related to safety in construction, supporting preventive care actions (risk detection in construction and operational processes).

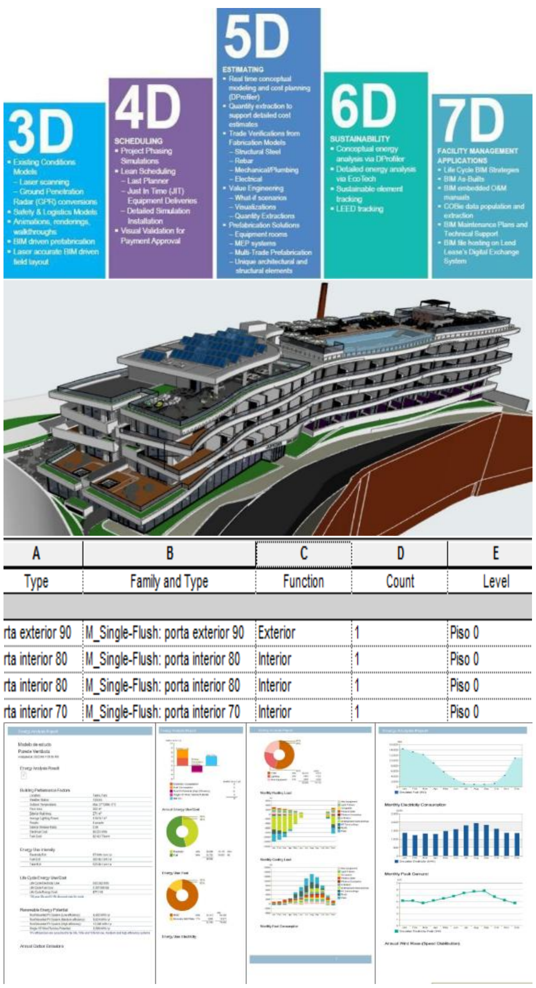

Fig 3: BIM nD models and examples of 3D, 5D, and 7D [6] [9].

IV. IMPLEMENTATION PROCESS

Currently, BIM influences multiple sectors of the construction activity and can bring benefits in attaining fully collaborative and agile work practices; it does, however, require the involvement of all stakeholders [10]. Initially, it was common for beginners to see the methodology as just new technology and match it to their skills already acquired in the modeling process only. In fact, the final product, the generated BIM model, presents, as a more evident aspect, its 3D geometric appearance.

However, the modeling process is accompanied by the selection of a high volume of information, which is associated with each parametric object applied to the model [11]. The information is adequately organized internally, hierarchically classified, and structured by specialties in order to provide support for the execution of different types of analysis or complementary activity, using tools that directly access the database of the model [12].

The transition from a traditional process, rooted in technical drawings (2D) generated by the use of Computer-Aided Design (CAD) systems, to a new BIM approach, in which the model is parametric and is continuously updated, demands both procedural changes and a significant initial investment in technology and training. Within an enterprise, the BIM implementation requires the restructure of its internal functional processes as part of a strategy to adapt the traditional work methods to the new methodological concept, as well as a change to the inter-business communication necessary to take part in the full range of construction activities.

The development of new BIM-based computational applications has experienced a robust increase, as research in this field is driven by the competitive need of software houses. However, the internal reorganization within the enterprises and the change in collaborative practices between partners in a project present some limitations mainly due to a lack of awareness. On the part of some more conservative professionals in the field of construction, the real advantages in the development of their activity, using an integrated BIM platform, and the recognizing of the technological potential available is still an unknown issue.

The meddling, as some might have seen the introduction of a concept such as BIM, into an enterprise with a structured work environment and established routines that involve a sequence of traditional steps associated with duly attributed responsibilities, initially fomented a resistance to change and huge mistrust. At present, in the context of the office, there is a very different scenario, as the need for updating practices to this collaborative model of work is recognized as the means of coping with a globalized industry, already sufficiently adapted to the new methodology [13].

At present, companies recognize that the transition of traditional work (supported on drawings) to the BIM project is inevitable, and its implementation in their working practices be understood as a mandatory requirement, and neither as a technological evolution of support for traditional work nor optional in character. Thus, today, the main concern of the director in a project office is, fundamentally, to upskill employees with sufficient training so that the whole team assimilates the concept underlying the BIM process and they acquire knowledge relating to the supporting technology available [14].

Architects, in the first instance, followed by engineers, easily adhere to the use of BIM modeling tools because these are appealing and very intuitive to use. The 3D modeling process is quite agile, easy to manipulate, and allows an immediate spatial perception because it is associated with a highly realistic viewing capacity.

Additionally, any patterning inaccuracies are detected by the system, in the form of inconsistency warnings, thereby supporting the creation of technical solutions, for any discipline of the project, without overlapping elements or erroneous definitions. On this basis, the designer easily rehearses different alternative options and makes the necessary adjustments and adaptations in order to obtain correct solutions [15].

V. THE GENESIS OF BIM

The full implementation of BIM, in the form of a single system for managing all information and a perfect standard of communication supporting the various parties involved in the project, is still a utopian perspective. The conceptual idea of creating a federated digital model for the development of the entire project was initially mentioned by Eastman in the 1970s, with the term BIM being applied in 1987, when the first BIM commercial product, ArchiCAD, was launched [16]. Although BIM support technology currently allows a much more integrated approach to the digital representation of all building disciplines and methods that sustain model growth during all phases of its lifecycle, there are still gaps that research proposes to try and overcome.

One such proposal was to establish a hierarchical system of components of a building, based on a process involving a correct and exhaustive geometric description of the elements and the assignment of a single identification classification, associated with conditions of interrelationship and belonging, had its genesis in Eastman's studies presented in 1974, under the name “Building Description System”. Since then, the intention to design the geometric model with the information integrated into the form of a structured database has evolved into “Building Product Model and Product Information Model”, the concept attaining global recognition under the designation “Building Information Modeling”. The idea of representing building components as geometric elements with associated identity and attributes, and not solely as a set of graphic lines, represents the concept of object-driven modeling [17].

In 1985, the Technical Research Centre of Finland (VTT), involving leading Finnish construction enterprises, developed the RATAS project, identifying the representative model of construction as the central product of all construction activity, named “Building Product Model”, and referred to the need to define a hierarchical classification system based on common understanding. Although in an embryonic state, this concept refers to the data pattern, addressed in a more advanced manner, in “Product Information Model”, adding a classification to information, expressed in ISO 10303 (ISO 10303: Industrial Automation Systems – Product DataRepresentation and Exchange), developed by STEP (STandard for the Exchange of Product model data). Thus, the establishment of the first international standard for the integration, presentation, and exchange of industrial product data was begun, which has now evolved into the Industry Foundation Classes (IFC) standard, currently the responsibility of the international organism Building SMART [18].

The widespread growth in the adoption of BIM by technicians who recognize a high capacity for modeling, visualization, analysis and simulation, provided by available systems represents a transition to an information infrastructure based on an internal organization-defined on native formats and common transfer patterns. Since then, planning construction offices have been investing in BIM technology and in training their personnel, driven by the global competitiveness of the sector and also by the introduction of governmental mandates so that BIIM is now beginning to be established in an increasing number of countries.

VI. LEVELS OF BIM MATURITY

In Europe, the main entities and professionals using BIM, already in 2015 were, to a significant degree, architects (47%) and engineers (38%), because the technological potential for modeling design support was evident, and, to a smaller extent, contractors (24%), smaller because this group is made up of diverse professionals, individual, dispersed and heterogeneous and, also, rooted in traditional working practices. With regard to construction enterprises, current attitudes are beginning to change. In addition, there has been a rapidly increasing awareness of which steps, such as budgeting, local work, and human resource management and the overall coordination of tasks to be carried out by contractors, are facilitated when based on the satisfactory manipulation of the BIM model.

On the European continent, Scandinavian countries have the greatest penetration of BIM into the sector, having identified state-supported entities as the first section of the construction industry for mandatory implementation as part of a progressive adoption strategy. These institutions coordinate the establishment of a Building SMART Nordic, responsible for establishing standards of practice and requirements in public buildings.

A. Scandinavian Countries

In **Finland**, following the pioneering research carried out at the VTT Research Centre, professionals in the sector have been structuring pilot projects in order to acquire technological skills, using the national software Teckla, and experience in the application of the methodology, in order to systematize procedures and identify new avenues of research and development. Since 2001, the use of BIM modeling tools has greatly increased, supporting project design, achieving, in 2007, participation in the continuity of its application by 93% of architectural firms and 60% of engineering businesses, which would seem to indicate a cultural acceptance of the BIM platform as the work practice in the sector. In addition, the Finnish association of the construction industry requires, as part of the certification of software products, the incorporation of the IFC standard and requires mandatory application in state-owned enterprises, in particular, the Finnish Transport Agency [19].

Neighboring countries, largely through exchanges in collaborative work, have followed Finland's conceptual and technological advances, also achieving a high level of adoption, particularly widespread in project offices and service companies supporting construction-related activities. The governmental option of institutional obligation was adopted in 2007 by **Sweden**, Norway, and **Denmark**, in particular in state-supported public services such as with Swedish Transport Administration, Norwegian Public Roads Administration, Norwegian National Rail Administration, e Danish Defense Construction Service. In Sweden, the Swedish Standards Institute has been publishing, since 1991, a progressive set of guides for the promotion of BIM in the country [19].

B. Mandatory Implementation

In the **United Kingdom**, the Cabinet Office, the administrative office of the government, published on 31 May 2011 the Government Construction Strategy. This document, prepared by the Efficiency and Reform group working with the Construction Unit of the Department for Business Innovation and Skills, recognizes the implementation of the BIM methodology as necessary to achieve the "objective of reducing construction costs in the public sector between 15 and 20%". In addition, together with the claims of the Low Carbon Construction Innovation & Growth Team, to "reduce the intensity of carbon emissions in construction, management, and maintenance in public infrastructure," BIM strategy is demanded [20].

The document determines that from 2016 the projects submitted in the context of public procurement must be defined in accordance with the requirements of BIM maturity level 2. As support to institutions in the submission of a project, "a data structure has been defined to provide consistent and structured information of useful goods to the owner and operators in the decision-making process", with easy access and control, as designated by Construction Operations Building Information Exchange (COBie). To provide governmental continuity, and work with the industry, the new document Construction 2025 was issued, establishing the year 015 as the limit for achieving the country's goal of reaching BIM maturity level 3. This requires effective, integrated collaboration throughout all processes, which may lead to an initial reduction in the cost of up to 33%, construction, and maintenance

The strategy adopted by **Italy** for progressively mandatory implementation of BIM was initiated with the entry into force of UNI 11337 regulations in 2017 and driven in 2018 with Decree BIM 560/2017, known as the *DecretoBaratono*. UNI 11337 establishes indicative guides related to the management of information processes in construction in the form of a documentary structure segmented into 10 specific sections of BIM, provided BIM coordination and management, and contractual legal aspects. According to the *DecretoBaratono*, the Italian administration requires, from 2019 onwards, the use of BIM for large-scale infrastructure projects and public buildings. This to be a gradual obligation until 2025, when the whole public building sector is required to be compliant [19].

Since 2011, the **Netherlands** government has required the implementation of BIM in public projects and, since 2012, the Dutch Ministry of the interior requires its use in maintenance activities of major projects through the establishment of protocols adapted to long-term contracts. This also was done in order to include the requirement and specifications of electronic documents in BIM, having a strong potential to improve management efficiency and maintenance in the public building area.

Spain's administration, using a strategy of increasing obligation, requested that all projects concerning public buildings should be drawn upon BIM platforms by the end of 2018. As part of the activity of the Ministry of Development, in 2015, EsBIM, the multidisciplinary working group involving professionals related to administration, engineering, and projects, was created, with the mission of supporting the implementation of BIM in Spain. It projected a working horizon of 3 to 4 years and aimed to increase productivity in the construction sector and to reduce infrastructure costs during its lifecycle. In addition, the recent public sector procurement law establishes the requirement of public works projects submitted to tender, be prepared on the basis of the BIM methodology, and specifies that for public contracts, works concession, services and project competition, procurement bodies may require the use of specific electronic tools such as BIM modelling tools or similar [21].

C. Progressive Implementation

In **France**, the document *Plan de Transition Numériquedans le Bâtiment* presented in 2014 by the

Ministère de la Cohésion des Territoires of the French government, adopted a strategy to transfer the current construction support procedure to the digital platform during the period 2015 to 2017, in order to respond to the expectations of the construction industry, and aiming to achieve, by 2022, the complete dissemination of BIM strategies in the design and management of public buildings and large infrastructure. A reference is made in the 2014 technical report Actions pour la relance de la construction de logement, to the fact that one of the priorities is to encourage BIM-based technological innovation, and sets out the requirements of its progressive adoption in public works from 2017 on.. However, the use of BIM still has a relatively low level of adoption, with around 40% among architects, 44% in engineering offices and 29% in construction enterprises [22].

Germany's government promoted, in 2015, the national strategic plan for digital construction management, Stufenplan Digital Planen und Bauen, with the purpose of introducing innovation inro the construction industry, in response to an approach from local associations and working groups. Its implementation was introduced into ongoing activities related to infrastructure and the planning and monitoring of public construction costs, in order to test the benefits of the BIM platform. Thus, pilot projects developed in the area of roads and railways were promoted, as were the management and planning of institutional building construction. By 2020, the regulatory standard should be king the use of BIM mandatory in public buildings [23].

In **Portugal**, the Portuguese Technological Platform for Construction, with a view to boosting the process of digitizing construction, created, in 2011, the BIM Working Group, whose mission was to promote the dissemination and adoption of the BIM methodology by the national industry and to establish regulations for its government-mandated implementation [24]. The group is an active participant in the technical committee CT 197, coordinated by the Sector Standardization Body of the Higher Technical School. CT197 is the entity, delegated by the Portuguese Institute of Quality, responsible for "developing standardization within classification systems, modelling of information and processes throughout the lifecycle of construction projects" and accompanying the work of the Technical Committee on European BIM Standardization, CEN/TC 442 (European Committee of Normalization, CEN)

The preliminary study, carried out by the committee, addresses an analysis of the current working methodology in order to identify critical factors that support the strategies of change that, it is intended , are to be established. Many related aspects, such as those documented by the Construction Vision 2020 CT197 are still being analyzed namely: customer maturity, competence and industry; digitization and innovation; information, knowledge and sustainability. In addition, technical subcommittees are being created, organized by sectors of action and maturity, oriented to study the exchanges and information requirements as well as both the development of BIM methodologies and BIM libraries of parametric objects. The BIM Working Group outlined an application guide for ISO 12006 on the way in which the information classification system in BIM should be organized, adapting the disparate classification systems available with the objective of supporting the automation of the tasks carried out from the BIM model, as well as its relationship with existing documentation.

D. Other Countries

In the **United States of America**, in 2003, the General Services Administration, through its public buildings service, created the national 3D-4D-BIM Program, in order to commit the sector to a progressive strategic and incremental adoption of the methodology, focusing on project design (3D) and construction planning and management (4D). In 2006, the administration decreed the mandatory use of BIM for the design phase of public works, including military construction, specifically that carried out by the US Army Corps of Engineers and US Coast Guard. Although the introduction of BIM in the USA goes back to the 1970s, its most evident implementation occurred from the 1990s onwards, rapidly surpassing Europe, since in 2010, about half (49%) professionals had already adopted BIM, while in Europe the percentage was much lower (36%). The level of implementation of the BIM methodology in the USA is now the most advanced in the world, regarding the depth of knowledge and dissemination and the experience of using BIM tools. following the strong technological development driven by North American software companies.

In **Asia** and **South America**, where the implementation of BIM, in general, is still lagging behind, it is worth highlighting important references in its internal dissemination and in the development of supporting documentation in countries such as Singapore, South Korea and Japan, as well as the government strategies adopted in Brazil and Chile [23].

At an enterprise level, **Singapore** drew up its own set of rules, Singapore BIM Guide, considered worldwide to be the most comprehensive for public works. In 2008, the Building Construction Authority of Singapore implemented the BCA29 system for the evaluation of BIM projects, establishing the time-limit for the approval of submissions of about one month. Through an electronic device, the designer submits the BIM model of the proposal, prepared with a high Level of Development (LoD) and composed of the information necessary for its assessment, including the networks of hydraulic, electrical and air conditioning installations. The forecast for 2025 is that a level of 80% of projects in the country will be designed in BIM, and that the aim of reducing the period of evaluation for such projects to

10 days will have been met.

In **South Korea**, the Public Procurement Service, the government agency responsible for the country's housing sector, has forced the use of BIM from 2016 on onto all entities involved in public building and also on those in the private sector whose projects have a budgeted value of more than US$50 million.

In **Japan**, in 2016 and in the context of building, including private construction, a level of BIM application was recorded, covering about half of the professionals, whose activity was mainly related to the project and construction phases.

In **Brazil**, the federal government decreed, in 2018 the creation of a committee to support the implementation of BIM in the country. It is tasked with: the definition of strategic actions to promote the implementation of BIM in the sector. This includes raising awareness of the benefits of BIM coordinating and structuring the public sector which is using BIM, stimulating the necessary public and private investment; and defining the specific technical standards, guide-lines and protocols.

In **Chile**, since 2011, the Ministry of Public Works has required the application of BIM in hospital building projects [25].

VII. CONCLUSIONS

A government's action taken to legislate for the adoption of BIM in the sector is decisive. The first step should be to declare it mandatory in institutional construction. The public sector involves the largest volume of all building work in each country, requiring a significant participation of national professionals, and covering all types of professional activity. This contributes to a progressive adoption in each project office and, therefore, throughout each national construction sector.

This text reports that public intuitions are more open to the introduction of BIM methodology, as seen in Scandinavian countries. The implementation is also relevant in large-scale infrastructure projects and in the public building sector. It was found that governments require project proposals to be delivered in a digital BIM format. Some countries, such as the United Kingdom, Italy, the Netherlands and Spain, have implemented strategic programs to impose its mandatory use, while others, such as France and Germany, are doing so progressively, but this status is planned to be achieved by 2025.

One important conclusion that can be drawn from this study is that for Portugal to hold its position in the global context of construction it is incumbent upon the Government to issue the necessary legislation for a full and regulated application of the BIM methodology in the Portuguese national construction industry.

REFERENCES

[1] H.Chong,C.Lee and X.Wang., A mixed review of the adoption of Building Information Modelling (BIM) for sustainability. J. Clean. Prod., 142 (2017) 4114 – 4126. https://doi.org/10.1016/j.jclepro.2016.09.222

[2] C.Cavalliere,G.R.Dell'Osso, A.Pierucci, and F.Iannone., Lifecycle assessment data structure for building information modelling, J. Clean. Prod., 199 (2018) 193-204. https://doi.org/10.1016/j.jclepro.2018.07.149

[3] C. Quinn,A.Z.Shabestari, T. Misic,S.Gilani, M.Litoiu and J.J. McArthur., Building automation system - BIM integration using a linked data structure, Autom. Constr., 118 (2020) https://doi.org/10.1016/j.autcon.2020.103257

[4] H.Andriankaja,X.Boucher, K.Medini and H.Vaillant., A Framework to design integrated product-service systems based on the extended functional analysis approach , Procedia CIRP 47, (2016) 323 – 328. doi: 10.1016/j.procir.2016.03.080

[5] J.K.Wong and J.Zhou., Enhancing environmental sustainability over building lifecycles through green BIM: a review. Autom. Constr, 57 (2015) 156-165, https:// doi.org/10.1016/j.autcon.2015.06.003

[6] A.Z. Sampaio., Education of the innovative BIM methodology claimed by the Construction industry, in Proc.Agora / I International meeting of Education, Research and Employ, Badajoz, Spain, (2019) 114. ISBN: 9788409137060, https://www.agora2019.com/?lang=en

[7] A.ZSampaio., Introduction of BIM methodology in Civil Engineering education: Curricular programs adaptation, in Proc.STE 1stInternational Conference on Science and Technology Education, Porto, Portugal paper,12 (2020) 15-16. https://web.fe.up.pt/~ste2020/

[8] R. Faust., BIM curriculum development, in Proc. 13thBIM Academic Symposium & Job Task Analysis Review (AiC), Autodesk University, Las Vegas NV, USA, (2018). https://dcp.ufl.edu/cacim/bim-education-2/

[9] R.Morlhon, R.Pellerin and M.Bourgault., Defining Building Information Modeling implementation activities based on capability maturity evaluation: a theoretical model, Int. J. Inf. Syst. Proj. Manag., 3(1) (2015) 51-65. https://doi.org/10.12821/ijispm030103

[10] L.Ding,, Y.Zhou and B.Akinci., Building Information Modeling (BIM) application framework: The process of expanding from 3D to computable nD, Autom. Constr., 46(2) (2014) 82-93. https://doi.org/10.1016/j.autcon.2014.04.009

[11] X.Gao and P.P.Bozorgi., BIM-enabled facilities operation and maintenance: A review. Adv. Eng. Inform., 39 (2019) 227-247. https://doi.org/10.1016/j.aei.2019.01.005.

[12] G. Ren, H.Li, S.Liu, J.Goonetillake, A.Khudhair and S.Arthur., Aligning BIM and ontology for information retrieve and reasoning in value for money assessment, Autom. Constr., 124 (2021) 103565. https://doi.org/10.1016/j.autcon.2021.103565.

[13] C. Eastman, P.Tcicholz, R. Sacks and K. Liston., BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors, 3rd ed, (2018). Copyright © by John Wiley & Sons, Inc.

[14] Q-J.Wen, Z-J.Ren, H.Lu and J-F.Wu., The progress and trend of BIM research: A bibliometrics-based visualization analysis, Autom. Constr., article103558, 124(2012). https://doi.org/10.1016/j.autcon.2021.103558.

[15] J.Abualdenien, P. Schneider-Marin, A. Zahedi, H. Harter, H.Exner, D. Steiner, M. Mahan Singh, A.Borrmann, W. Lang, F.Petzold, M.König, P. Geyer and M.Schnellenbach-Held., Consistent management and evaluation of building models in the early design stages, Electron. J. Inf. Technol. Constr., 25 (2020) 212-232. https://doi.org/10.36680/j.itcon.2020.013

[16] A.Z.Sampaio and J.D.Oliveira., BIM in structures: analysis of interoperability, in Proc. ICSAAM2019 - International Conference on Structural Analysis of Advanced Materials, Ischia, Italy, 12-15, paper 19, (2019) 114.

[17] R.A.Rahman and S.K.Ayer., Enhancing the non-technological skills required for effective building information modeling through problem-based learning, Electron. J. Inf. Technol. Constr., 24 (2019) 154-166. https://www.itcon.org/2019/9

[18] T.Chipman, IfcDoc Usage Guide (Version 3.8), buildingSMART

International, http://www.buildingsmart-tech.org/specifications/specification-tools/ifcdoc-tool/ifcdoc-help-page-section/IfcDoc.pdf, (accessed on 5 February 2021).

[19] A.Wong, F.Wong, and A.Nadeem., Attributes of Building Information Modelling implementations in various countries, Architect Eng. Des. Manag. 6 (2011) 288-302. 10.3763/aedm.2010.IDDS6.

[20] http://biblus.accasoftware.com/ptb/bim-na-europa-disseminacao-e-adocao-em-cada-pais-parte-2/, (accessed on 5 February 2021)

[21] R.V.Lozano-Díez, O.López-Zaldívar,S.Herrero del Cura and P.L.Mayor., First experiences in the rule of the BIM environment: The case of the degree in Building of the Polytechnic University of Madrid", Adv. Building Educ., 2(1) (2018) 109-121. http://polired.upm.es/index.php/abe/article/view/4233.

[22] M.Lahiani., Benefits of BIM implementation in the French construction industry, in Conf. Series: Earth and Environmental Science, 588 (2020). https://iopscience.iop.org/article/10.1088/1755-1315/588/4/042055/pdf

[23] M.Galić, V.Venkrbec, F. Weise, I.Feine, Z.Pučko and U.Klanšek., Survey of accomplishments in BIM implementation in Croatia, the Czech Republic, Germany, and Slovenia, Faculty of Civil Engineering and Architecture Osijek, Scientiffic paper 8, (2017) 23-35. 10.13167/2017.15.3, December 2017/, http://e-gfos.gfos.hr/app/storage/protected/22-12-2017-10-46-16-paper-3-galic.pdf, BIM Working Group, http://www.ct197.pt/index.php/bim-e-a-digitalizacao. (accessed on 5 February 2021)

[24] Chile –BIM implementation, https://cms.law/en/int/expert-guides/cms-expert-guide-to-building-information-modelling-bim/chile