Recebido:
08/09/2017
Aprovado:
08/08/2019

Specification of Objects for Modeling Information in Construction: A Study with Fire Doors

Claudio Alcides Jacoski[1], Universidade Comunitária da Região de Chapecó
Juliana Ferrari Andreis[2], Universidade Comunitária da Região de Chapecó
Lissandro Machado Hoffmeister[3], Universidade Comunitária da Região de Chapecó
Marcelo Fabiano Costella[4], Universidade Comunitária da Região de Chapecó

ABSTRACT

The study of Building Information Modeling (BIM) is driven by alternatives in information management support within the construction design process. It seeks to improve the budgeting and planning system of works and to reduce the rework and incompatibilities faced, automating works and consequently reducing costs. Faced with this no-longer two-dimensional universe, objects in BIM are classified according to their levels of development (LOD), i.e., the level specifying the content and stage of the information available for these models. The objective of this study was to create and enter properties in a parametric object model (using a "fire door" as example object), in addition to associating it with the levels of development according to the LOD classification developed by the American Institute of Architects - AIA. A significant amount of limitations was observed based on this classification, mostly related to the evolution of the BIM methodology in projects, since the process is still under development in Brazil.

Keywords: *Level of development (LOD), Parametric Object, BIM, Fire door, Construction Industry.*

Editor Responsável: Prof. Dr. Hermes Moretti Ribeiro da Silva

1. Servidão Anjo da Guarda, 295-D - Efapi, Chapecó - SC, 89809-900, claudio@unochapeco.edu.br; 2. claudio.jacoski@gmail.com; 3. lissandro@unochapeco.edu.br; 4. costella@unochapeco.edu.br

JACOSKI, C.A.; ANDREIS, J.F.; HOFFMEISTER, L.M.; COSTELLA.M.F. Specification of Objects for Modeling Information in Construction: A Study with Fire Doors. **GEPROS. Gestão da Produção, Operações e Sistemas**, v. 15, n. 1, p. 212 - 227, 2020.

DOI: 10.15675/gepros.v15i1.2196

1. INTRODUCTION

The poor performance of the civil construction sector has been discussed for a long time, both in Brazil and abroad. The overall evolution of the sector is rather slow compared to other sectors (the automobile industry, for example) and there are questions about how a new methodology, the Building Information Modeling (BIM) platform - can contribute to accelerating this evolution, enabling the automation of processes in the execution of works and constructions.

The main point is that the methodology recently emerged with a lot of force, but it has been introduced by manufacturers without properly considering its implementation in a broader context. This is not the role of manufacturers, however, but of companies, universities and professionals (MANZIONE, 2013).

According to Jacoski (2003), the BIM methodology enables envisioning the creation of a design that represents the work virtually, which could be called an ideal design, containing all the information necessary to this end. Some problems must still be resolved for this to occur, however, mainly regarding the transfer and interoperability of data, since a lot of data is not used in the design process due to the lack of standardization and formalization in the information transfer process.

According to Manzione (2013, p. 297): "If the investment in designs were to be expanded intelligently, providing conditions to anticipate the main decisions with more quality, this would greatly facilitate the collaboration between all agents, making the implementation of BIM methodology progress more swiftly [...]".

The same author points out that if this implementation is done with the right support from management, involving planning and incentive methods for collaborative works, and if the programs were developed in an integrated manner with a lot of technical information, then all stakeholders involved would be happy: the designers, those responsible for the legal approvals and especially the end customer.

In general, however, one can see that the designers have a limited access to the major manufacturers who are able to produce BIM objects of their products. These objects are available in some virtual repositories, and each repository is based on the standards of another country (HOFFMEISTER, 2015).

Many studies are currently under way to use the advantages offered by BIM in various situations, such as in the field of emergency fire escapes (Li *et al.*, 2014), in the field of building simulations considering energy and thermal performance (HENSEN; LAMBERTS, 2011), and the expansion of virtualization and control possibilities of engineering designs (DING; ZHOU;AKINCI, 2014).

In the Brazilian context, the lack of a library with parametric objects aligned with Brazilian standards and serving as a basis for professionals to use in their designs, can also be observed. Additionally, the public sectors in the country are not close to grabbing this opportunity to improve designs and control the execution of works, which would significantly help in the formalization of BIM deployment in the country.

The main change in Brazil was the development of NBR 15965-2 (classification system for construction information), which provides the characteristics of construction objects. This standard gives continuity to NBR 15965-1 and deals specifically with the classification tables of construction materials and construction properties (HOFFMEISTER, 2015).

Brazil is still structuring the set of standards and preparing the set of objects that will be used more effectively in the next few years. An effective use at the architecture and engineering firms is still lacking to reach this objective in the country, however.

The proposal of this paper follows these guidelines, seeking to show a condition for a real object, using a fire door object as a model, which was assigned a set of data points and classifications according to its level of development, which will be detailed so professionals can understand the informational organization of an object used in civil construction in a practical manner.

The objective is for the stakeholders in the design process to be able to find the necessary information and, furthermore, for the level of development (LOD) to be clear and standardized so it can serve as a basis for any other parametric object, in general, with its classifications being subsequently made available to designers and other construction industry agents.

In addition, employing a structured classification of construction information, specifying object properties, its groups and their relations for a model, should contribute to the development of a Brazilian standard that is in alignment with the internationally adopted standards.

2. THEORETICAL REFERENCE

2.1 BIM Technology as Support for the Automation of Construction Processes and LOD Classification

The term BIM (Building Information Modeling) must be demystified because many professionals mistakenly see it is a new three-dimensional design model or a system to enable the compatibility of designs, or some other erroneous understanding. In fact, BIM is a technology that will allow a significant evolution in designs and in design processes, mainly by providing a large amount of information on objects, processes and project deployment stages. The gains with the adoption of BIM technologies are known to be significant in the fields of Architecture, Engineering and Construction (WALASEK BARSZCZB, 2017);

According to Eastman *et al.* (2011, p. 1): "With BIM technology, one or more exact virtual models of a building are built in digital form. BIM incorporates the design through its phases, allowing for a better analysis and control of manual processes."

BIM is not just a change in technology, but also a change in process. That is, by allowing a building to be represented by intelligent objects with detailed information, all major processes constituting the design are changed, as is the way its drawings and visualizations are created (EASTMAN *et al.*, 2011).

Arayici *et al.* (2018) sees interoperability as the possibility of users employing the same information through software, extracting and adding data without losing any existing condition, which allows you to export and import different information to describe the same object. Interoperability is one of the possible gains in the use of BIM in designs, in addition to the use of the parameterization of objects.

The parameterization of information consists in the ability to create virtual models that accurately represent real objects. According to Jacoski (2003, p. 42), this means "[...] an object ceases to only contain lines, taking the form of a blueprint, and becomes a model where the characteristics and properties of the building are known, in addition to its geometry."

According to the BIM Forum (2013, p. 8), "the specification of the level of development (LOD) is a reference that allows professionals of the construction industry to specify the content of the information for the construction of models in BIM, at various stages of the design and construction process".

Still according to the BIM Forum, in 2008, the *American Institute of Architects* - AIA developed its first set of definitions for the levels of development. Since the evolution of BIM Modeling occurred quickly, the AIA evaluated such definitions and included other levels of detail. These results are documented in conjunction with a document called Guide, Instructions, and Commentary to the AIA Digital Practice Documents.

In summary, Manzione (2013) mentions that levels of development are represented on a scale of one to five, each one corresponding to the design that occurs progressively throughout the project. According to him, the design phases represent the levels: 100 (conceptual phase), 200 (approximate geometry), 300 (precise geometry), 400 (execution or manufacture) and 500 (finished work). This scale was made in a gradient of 100 units, foreseeing the future possibility for the creation of intermediate levels, as was the case when LOD 350 was created.

Latiffi *et al.* (2015) define the LOD classification as:

LOD 100: (Concept/presentation). A conceptual view in which the elements of the model are represented graphically in a symbol. The information in LOD 100 is typically used for the pre-planning of the design, feasibility studies and basic cost estimates.

LOD 200: (Design) Completes the development of LOD 100 with other information for LOD 200, such as width, depth, height, in addition to the manufacturer of the product. LOD 200 is a design development of a product. The building model elements in LOD 200 are represented as generic systems, objects with accurate quantity, size, shape, location as well as the orientation of the product. At this level, performance analysis could be conducted to determine which building model elements should be used.

LOD 300: (Documentation) This LOD refers to the documentation of a product. LOD 300 is also made up of non-graphic information, such as an estimate and schedule. This level is more precise in terms of quantity, size, shape, location, as well as orientation, since it is defined by the client. Specific details on the performance aspect of the components may be added with necessary information defined by the client in order to develop construction documents.

LOD 350: (Coordination) This level is used to develop the coordination between any disciplines, such as the detection of conflicts. The use of LOD varies according to country, just as the construction requirements, which depend on the scope and requirements of the work.

LOD 400: (Construction of elements) This level is compatible with the construction of the product and more suitable for manufacturers and constructors. This occurs because the elements of the model in this LOD are represented as a system and specific object, which consist in detailing the orientation, fabrication and installation information.

LOD 500: (Facilities Management) Finally, LOD 500 is represented as an *as-built* model, which consists of information required for the facilities management. This LOD could be considered as a totally accurate digital representation of a manufactured product.

3. RESEARCH DEVELOPMENT AND METHOD

This study is classified as basic research with a qualitative nature and is classified as exploratory when it comes to its objective. Regarding its technical procedures, this research is characterized as a case study.

The study was structured in three different stages: definition of the object, definition of the object's properties and association of the properties according to the LOD classification.

Multiple repositories of BIM objects were consulted to define the object and in the absence of an object in a Brazilian repository, a fire door of the brand Kaso (Finland) was found in the *BIM Object* repository with a compatible extension to the *Archicad* 18® software.

Next, the object properties were defined based on information from the manufacturer and the BIM repository. To this end, a BIM object was created through modeling in the *Archicad* 18® software, included in the software's object tool box. The chosen object is a door of the fire-door type, to which several properties and types of information were added to change the options provided by the software. The element was classified according to the type of intended use for the BIM. The standards NBR 11742 (ABNT, 2003), NBR 13768, (ABNT, 1997) and IN 009 (SANTA CATARINA, 2014) were observed in the definition of the properties that would be added to the door. In addition, a comparative study was performed with a fire-door of an already existing manufacturer in order to obtain such information as physical properties, requirements and/or the manufacturer's technical specification and estimated costs, among others. One of these analyses consisted in seeking a model object that had already been created by a manufacturer, which could serve as a foundation for the information added to the created door.

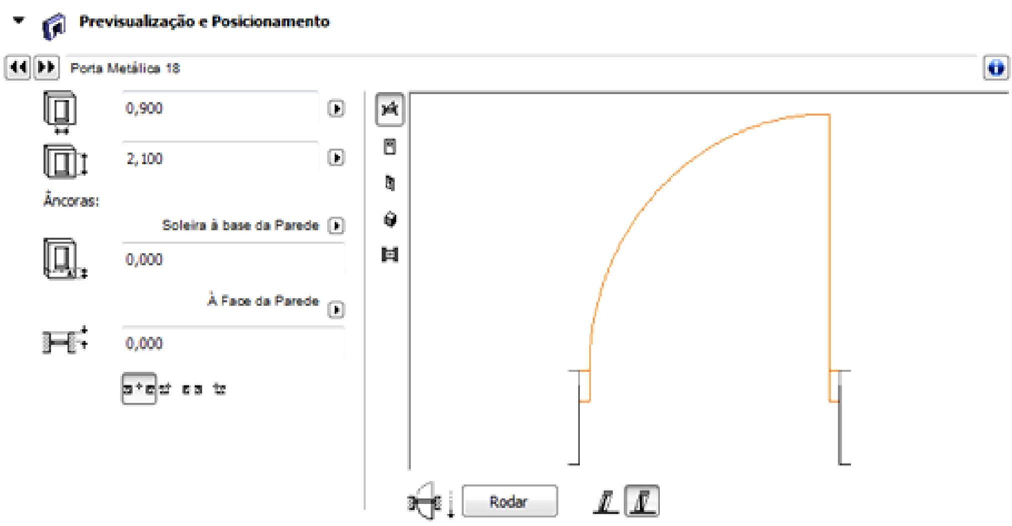
Finally, after the creation and characterization of the door model, the levels of development in accordance with the LOD classification were associated to the object based on the concepts and guidelines developed by the AIA and other materials that were judged necessary, in order to make a comparison between the variation of different levels and possible information. The LOD results will be presented at the end of the results directly in LOD 500, the most complete category, and will contain the properties and characteristics that evolved during each LOD: 100, 200, 300, 350, 400 and 500 (which covers the others). This is done because the LOD classification scales occur gradually, which means a LOD 200 classification automatically also includes the required items of LOD 100 and so on.

4. MODELING OF THE OBJECT - FIRE DOOR

The object properties for the fire door *Door Arctos 10* from *KasoGuard* include reinforced steel frames and it has been tested for protection against theft and certified. It also offers protection against fire (EI45 class in Europe) and acoustic insulation of 41 decibels.

For the theoretical LOD 100, only the following information is listed as property at this level: Identification (ID), structural function, position, element classification, x axis coordinate, y axis coordinate, total width and total height (Figure 1).

Figure 1 - Preview and positioning in 2D (LOD 100)



Source: The authors.

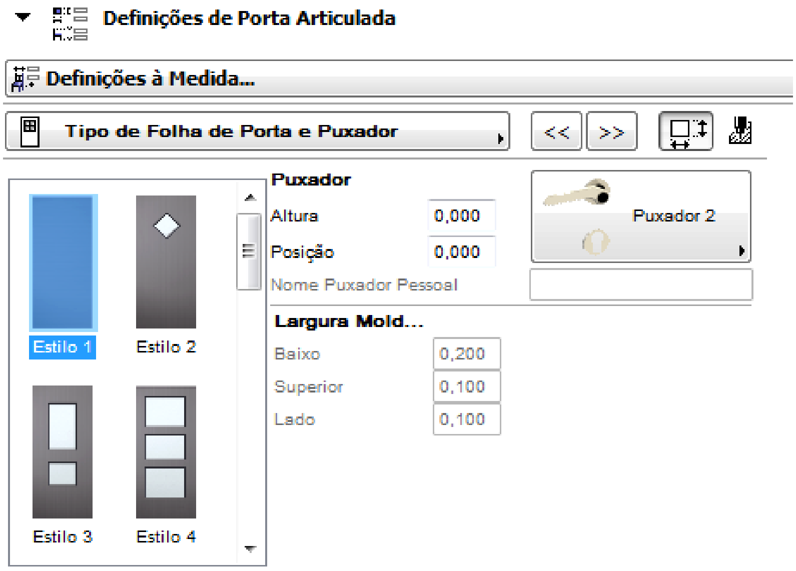
In the theoretical LOD 200, the information is already displayed in 3D and includes details on materials and costs (Figure 2).

Figure 2 - Preview and positioning in 3D and listing parameters (LOD 200)

Source: The authors.

In the theoretical LOD 300, the information includes the opening direction, which in this case is standardized in the push direction. The material of the panel, frame and handle, and the type of panel and door handle are also defined (Figure 3).

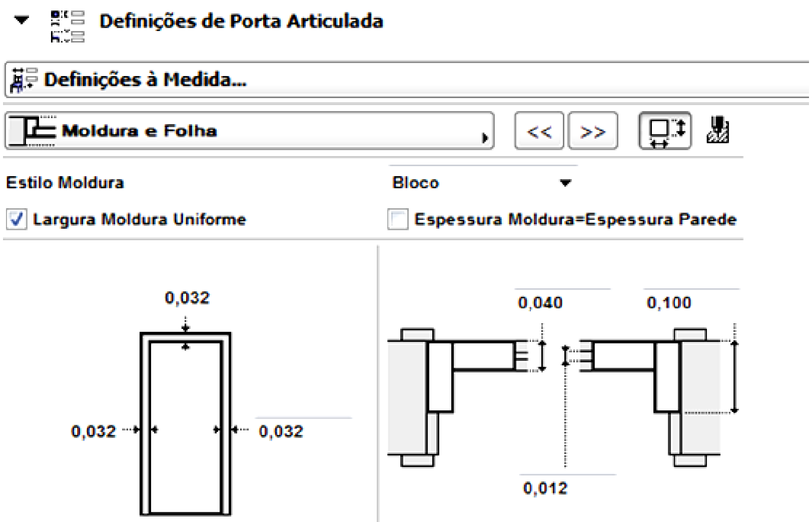
Figure 3 - Hinged door definition: type of panel and handle (LOD 300)

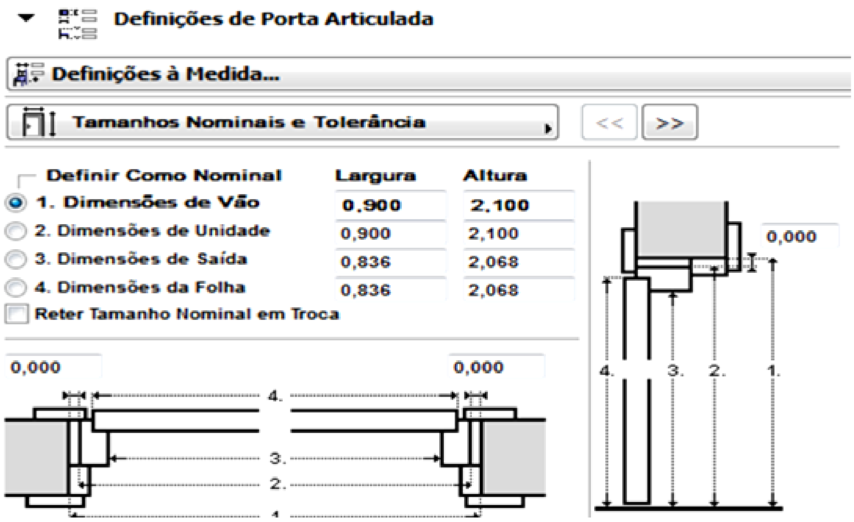


Source: The authors.

LOD 350 adds the door's fire resistance, weight and year of production to the classification. In LOD 400, the focus is on the production of the door. It is therefore necessary to list information for the production, such as the frame, the panel, minimum sizes and tolerances (Figure 4), in addition to the height and position of the handle.

Figure 4 - Hinged door definitions: frame, panel, nominal sizes and tolerance (LOD 400)





Source: The authors.

In LOD 500, parameters related to the cost and tolerances of the installation are added.

Table 1 shows all the LOD, with the column "Description of the level of development" describing the LOD level of the object in accordance with the amount of information. "Information Item" provides the type of information specified in the creation of the door object. This data is filled out in "Data of the created object", as an example, based on existing doors and on standards.

Table 1 - Classification of a fire-door with theoretical LOD 500

FIRE DOOR		
DESCRIPTION OF THE LEVEL OF DEVELOPMENT	**INFORMATION ITEM**	**DATA OF THE CREATED OBJECT**
LOD 100: Mass studies indicating area, weight, volume, location and orientation (2D format).	ID (Identification) Structural function Position Classification X-axis coordinate Y-axis coordinate Total width Total height	Fire Door Non-structural Interior Door 0.00 m 0.00 m 0.90 m 2.10 m
DESCRIPTION OF THE LEVEL OF DEVELOPMENT	**INFORMATION ITEM**	**DATA OF THE CREATED OBJECT**
LOD 200: General systems or assemblies with approximate quantities, size, shape, location and orientation (3D format).	Total length Volume Plinth	0.90 m 0.42622 m³ 0.100 m

	Conceptual cost Location	R$ 1,000.00 Chapecó - SC
LOD 300: General systems or assemblies with precise quantities, size, shape, location and orientation.	Type of opening Opening position Port coating Handle coating Door panel type Handle type	Fixed laterally Right Galvanized steel Cast iron Style 1 Style 2
LOD 350: Specific system, object or assembly in terms of quantity, size, shape, orientation and interfaces with other building systems.	Fire resistance Object weight Type of group Production year	60 min 47 kg Security and escape 2015
LOD 400: Precise assemblies or executions in terms of size, shape, location, quantities and orientation with detailing of the information (installation).	Manufacturer Type of operation Frame size Gap size Exit size [Dimensões de saída] Panel size Handle height Handle position	*KasoGuard* *Single Swing Right* 0.032 m 0.90 x 2.10 m 0.0836 x 2. 068 m 0.0836 x 2. 068 m 1.05 m 0.04 m
LOD 500: As built with precision in terms of size, shape, location, quantities and orientation.	Unit cost Cost x units Installation cost Exceeded cost Constructive deviation in the panel (height x width x thickness)	R$ 1,000.00 R$ 1,000.00 x 1 R$ 400.00 R$ 0.00 0.003x0.002x0.002m

Source: developed by the authors.

The tables reveal that for each LOD level variation (100, 200. 300, 350, 400 and 500), an extra set of information was added to the object in such a way that the modeling is further explored, providing more accurate and complete data at each level.

5. CONCLUSIONS

The use of objects that are constituted of data already incorporated in the models by manufacturers enables a good communication between supplier tools (including for more automated manufacturing) and software designers. Objects are a key system for improving results in BIM-modeled designs and to gain productivity, both in the design process and in the execution of the work.

By making information sharing possible, BIM has become interesting for suppliers, who have begun sharing detailed information about their products, offering a range of information which until now could not be made available in a design format. This information could resolve design discrepancies, which until recently could only be resolved with the intervention of a professional at the work site, often generating labor costs with rework and material expenses. This trend can already be observed in the most recent works, where a more controlled industrialization process is starting to emerge, reducing actions reminiscing of craftsmanship, which were so common in works until not so long ago.

Based on this new concept, several libraries containing repositories of objects have been created across the world, providing objects including manufacturer information. However, there is no national repository aligned with the Brazilian standard for modeling building information that can serve as a foundation for the professional use of these objects in designs. This gap should be one of the main drivers for the adoption of the BIM model by Brazilian designers.

With this information, suppliers can add detail to their product, including: composition, assembly methods, format or size, weight, capacity, color, price, structural aspects, mechanical aspects, fire & thermal properties, among others. As has already been argued by Manzioni (2013), a significant evolution in the design process can be seen because this type of information will be very useful to improve the integration and performance of designs in the execution itself. As a result, processes may be automated in the future, aiming at the future robotization of civil construction.

By adopting this system in their day-to-day, professionals eliminate one of the major problems in the construction sector, i.e., the lack of information in CAD designs (which are currently getting increasingly automated versions with realistic results - as already mentioned above, by Ding *et al.* (2014). Professionals can now more easily develop material quantities, automatically generate calculation logs, prepare budgets and perform any activity that requires data, which will be automatically extracted from the BIM objects included in the design.

The sharing of information will inform decision-making, reduce times, organize schedules, reduce errors in the alignment and interpretation of designs, and allow for the quick retrieval of object and process information, among other features that weren't possible previously.

The objectives in the three stages of the performed study were reached, namely the definition of the object, the definition of the properties of the object and the association of the properties according to the LOD classification, since a real object (a fire door) from a repository (brand *Kaso*®) was used as definition. The most important contribution of the work was the definition of the properties of the object based on information from the manufacturer and the BIM repository. In this case, various properties and pieces of information were added, with the element being classified according to the type of intended use for BIM (addressed by HOFFMEISTER, 2015). The study also resulted in the association of the levels of development to the object in accordance with the LOD classification, which is very important for defining the level of completeness one aims for when drafting the design, proving the effectiveness and importance of the classification produced by the *American Institute of Architects (AIA).*

The proposal is that once the structure of information has been completed and data and attributes of the object have been entered, manufacturers can determine and fill out the fields for the LOD level best fitting the object that is made available, facilitating the understanding and organization of professionals responsible for drafting designs that use their product.

When performing a search for an object with BIM modeling, the user will be able to filter it according to its LOD level, thus choosing which level of that object he wants to integrate in his architectural design. One must understand that defining the LOD to achieve the pre-established objectives is the designer's prerogative, in alignment with the expectations of the contractor and the design's executor.

For example, an engineer developing a comprehensive budget for an architectural design and who needs relevant information regarding the costs of the objects that will be used, can obtain a door (the digital object) to know in advance what level of information this door covers, using a more detailed level in LOD 400, in this case. Another point is that an object with LOD 100 would not meet his needs, assisting the designer in the search for an object with more detailed information.

In the study, it was possible to use a fire door as model, providing the design of an object with various LOD levels to understand the magnitude that the different levels can reach depending on the amount of information presented in each object. With the laid out example, it is possible to establish a relationship with other objects and services used in civil engineering works.

The detailing of the fire door offered a series of information specifically produced for Brazilian civil construction, creating an instance of an object completely modeled in various LOD levels, providing an understanding to professionals on how the object should behave, with all the opportunities for the extraction of information that have been presented in this study.

The construction industry needs to advance in the production of modeled objects (with the set of information as the one shown for the fire door in this work) because there is a global trend for requiring the availability of information elements for each object included in the design (especially in public projects).

By producing an organized database of the objects used in civil construction, as in the case study with the fire door, the stage is set for several advantages to take shape, whether in the design (more standardized) or in the product (building) phase, with gains in productivity, organization and control. In addition, conditions are expanded to carry out works in an automated way since information on procedures and the details of objects is accumulated, sequencing assembly and construction operations. There is no way an automated future for the civil construction industry can be imagined without the organization and modeling of both the objects and the processes to be carried out.

This paper contributes by demonstrating the effectiveness of using the informational structure of an object, using a fire door as example, which opens future possibilities for the use of various other objects, extracting the information at the desired level. This is a welcome development for an industry that seeks to automate itself and has a bottleneck in the lack of detailed information on the objects, products and processes employed.

The much-vaunted Industry 4.0 in various productive sectors has an important ally in the BIM technology and may help usher in a future involving artificial intelligence in the building processes and civil engineering works. The modeling of information is an essential element for the creation of works that can be executed smarter in a near future.

Finally, this work also opens space for changes in the evaluation criteria of designs, serving as a reference in public bids or even becoming a requirement of the final customer, who could require a more detailed design at the level of information, in addition to requiring more productivity and agility in the works, facilitated and integrated with the tools that are already available on the Architecture, Engineering and Construction market.

References

ARAYICI, Y.; FERNANDO, T.; MUNOZ, V.; BASSANINO, M. Interoperability specification development for integrated BIM use in performance based design. **Automation in Construction,** v. 85, 2018, p. 167-181.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. **NBR 11742**: Porta corta-fogo para saída de emergência. Rio de Janeiro, 2003.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. **NBR 13768**: Acessórios destinados a porta corta-fogo para saída de emergência – Requisitos. Rio de Janeiro, 1997.

BIM FORUM. **Level of development specification**. 2013. 125 p. Disponível em: http://bimforum.org/wp-content/uploads/2013/08/2013-LOD-Specification.pdf.Acesso em: 18 mai. 2015.

DING, L.; ZHOU, Y.; AKINCI, B.; Building Information Modeling (BIM) application framework: The process of expanding from 3D to computable nD. **Automation in Construction,** v. 46, p. 82-93, 2014.

EASTMAN, C.; TEICHOLZ, P.; SACKS, R.; LISTON, K. **BIM Handbook**: a guide to Building Information Modeling for owners, managers, designers, engineers, and contractors. 2.ed. New Jersey: John Wiley & Sons, 2011.

HENSEN J. L. M., LAMBERTS R. Introduction to building performance simulation. In: Hensen J. L. M., Lamberts R. (ed.) **Building performance simulation for design and operation**. London: Spon, 2011. p. 1-14.

HOFFMEISTER, L. M. **Elaboração de uma proposta do repositório de objetos BIM com base na norma brasileira de modelagem da informação de edificações**. 2015. 72 p. Dissertação (Mestrado) – Programa de Pós-Graduação em Tecnologia e Gestão da Inovação, Universidade Comunitária da Região de Chapecó - Unochapecó, Chapecó, 2015.

JACOSKI, C. A. **Integração e interoperabilidade em projetos de edificações: uma implementação com IFC/XML.** 2003. 218 p. Tese (Doutorado em Engenharia de Produção) – Programa de Pós-Graduação em Engenharia de Produção, Universidade Federal de Santa Catarina, Florianópolis, 2003.

LATIFFI, A. A.; BRAHIM, J.; MOHD, S.; FATHI, M. S. Building Information Modeling (BIM): Exploring Level of Development (LOD) in Construction Projects. **Applied Mechanics and Materials**, v. 773-774, p. 933-937, 2015.

LI, N.; BECERIK-GERBER, B.; KRISHNAMACHARI, B.; SOIBELMAN, L. BIM centered indoor localization algorithm to support building fire emergency response operations. **Automation in Construction**, v. 42, p. 78-89, jun. 2014.

MANZIONE, L. **Proposição de uma estrutura conceitual de gestão do processo de projeto colaborativo com o uso do BIM**. 2013. 343 p. Tese (Doutorado em Engenharia) – Escola Politécnica da Universidade de São Paulo, São Paulo, 2013.

SANTA CATARINA. **Instrução Normativa IN 009/DAT/CBSC**: Sistema de saídas de emergência. Santa Catarina, 2014.

WALASEK, D.; BARSZCZB, A. Analysis of the adoption rate of Building Information Modeling [BIM] and its Return on Investment [ROI]. **Procedia Engineering**, v. 1, n. 172, p.1227-1234, 01 mar. 2017.