Brazilian BIM Objects Standard- How to Deal with Acoustics?”

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Abstract

The Brazilian government and construction market are setting the scene for the extensive adoption of the Building Information Modeling (BIM). Therefore, a special committee ABNT CEE 134, was established at the Brazilian organization for Technical Standardization with a dedicated WG for developing BIM objects parameters national standard. This paper shows the challenges and solutions adopted on the development of this standard, integrating the BIM workflow on an acoustic consultancy framework.

Keywords: BIM Acoustics, National Standard.

1 Introduction

With the arising of new technologies and methodologies, the exchange of information in many economic sectors is getting faster and easier. Digital Transformation is already a part of the day-today of many professionals and it is not different for the construction sector. The use of BIM (Building Information Modelling) is expanding and transforming the processes of building design, construction, and facility management. According to Jung [1] the design models generated digitally through this methodology, can provide accurate and fundamental information that help decision making, improves collaboration and cost reduction.

The adoption of BIM in Latin America is still in its initial phase. Based on a study [2] conducted with the construction companies in 2020, it is possible to conclude that only 33% of the interviewed subjects are using BIM for more than 5 years. Figure 01 represents the trajectory in the use of this methodology.

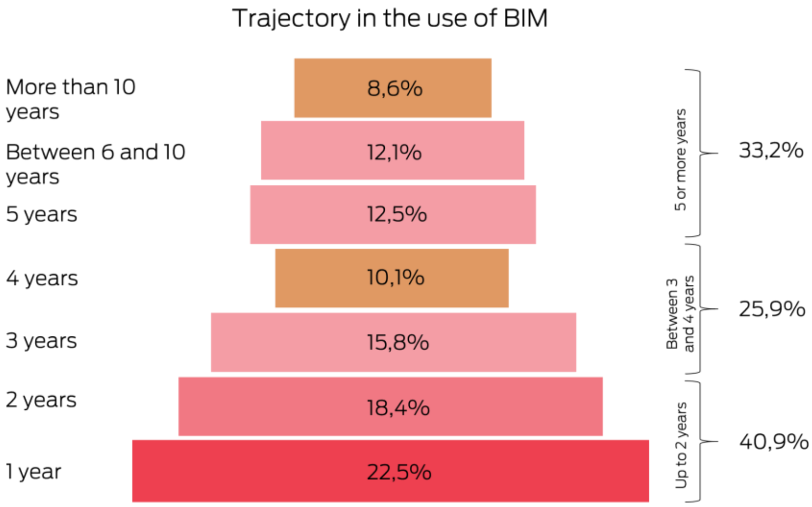

Figure 1 –Trajectory in the use of BIM in Latin America based on study [2]

Figure 2, however, indicates that more than 47,6% of the companies that participated in this research are using BIM in more than 60% of their project portfolio.

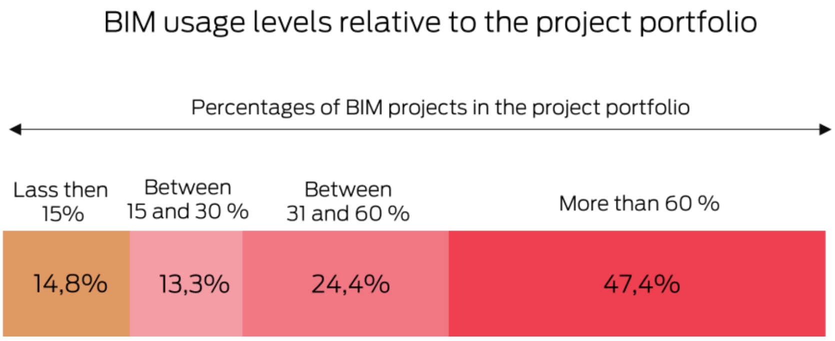

Figure 2 –BIM usage levels relative to the project portfolio in Latin America based on study [2]

According to the Latin American analysis [2] there are many actions that can be taken for the implementation of BIM on a large scale. Firstly, BIM of the consultant companies adopted the trial-and-error model. Although there are many different paths that can be adopted for the implementation of BIM, it is of great importance that a National Roadmap is implemented. This could guide the workforce of the construction market to the same objective. The Brazilian government in 2019 implemented a regulation, Decreto 9983 Estratégia Nacional de Disseminação do Building Information Modelling no Brasil – Estratégia BIM BR [3] (National Strategy for Dissemination of Building Information Modelling in Brazil - BIM BR Strategy), with the purpose of promoting an adequate environment for investment in Building Information Modeling (BIM) and its dissemination in the country. The roadmap proposed within the regulation was divided in three phases. From January 2021, for certain public works, the use of BIM in the design process is already mandatory. Figure 3 represents the phases from 2021 to 2028.

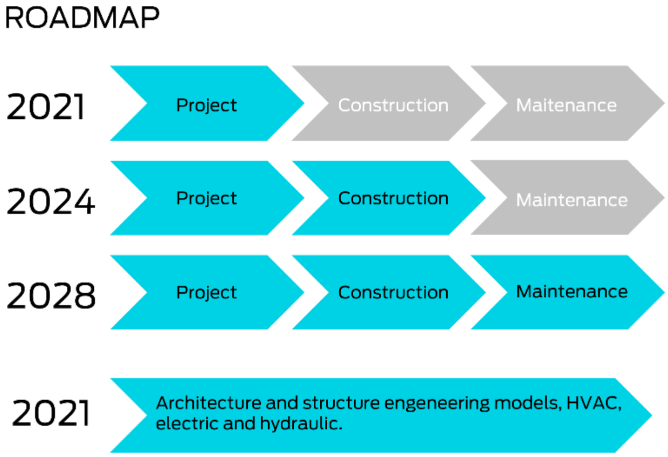

Figure 3 – BIM BR Roadmap [4].

For the BIM BR Strategy [4] nine different objectives were created, each one with their own action plans. One of these objectives, the sixth one, is the development of technical standards, guides, and specific protocols for the BIM adoption in the country.

A dedicated WG was created inside a special committee ABNT CEE 134 hosted at the Brazilian Organization for Technical Standardization – ABNT. This Working Group has the responsibility for establishing the BIM object parameters and was entitled “Requisitos de Objetos para Modelagem da Informação da Construção (BIM)” [5] (Object Requirements for Building Information Modelling -BIM). It will also develop the second set of Brazilian Standard related to BIM following the ABNT NBR 15965 series [6], published from 2011 to 2015.

The ninth part of this new ABNT standard (NWI without assigned number) is dedicated to discussing BIM object requirements for acoustic analyses and is entitled “Objects in models used for acoustic analysis”. The technical specification developed in this subgroup and presented in this paper are under the responsibility of the here presented authors.

1.1 Objectives

The goal of this paper is to be a first approach on understanding how acoustic requirements could be incorporated in the BIM object to enable, in synergy with the other stakeholders, acoustic specialists developing their projects based on useful and reliable information contained in the BIM object.

2 The Brazilian BIM and Acoustic Panorama

2.1 The Acoustic Project

In Brazil the building design and construction business consider acoustic as a complementary discipline. In the early stages of the building design, in general, acoustics consultants come into play by studies, simulations and calculations in order to predict the acoustic behaviour of the proposed building design and its construction systems.

To plan a construction, to design a building, or even carry out a retrofit might be a complex task. To make this task easier, Architects commonly apply the strategy of breaking it into smaller parts. This work plan composed of phases can vary from place to place, but the aim is always the same: to divide the design and construction process into steps to be followed.

In this study an adopted Architecture Plan Work with 5 generic stages is presented in Table 01. This plan was based on the established by AIA (American Institute of Architects) [7] and the one suggested by RIBA (Royal Institute of British Architects) [8].

Being acoustic a complementary discipline of the design and construction process, dividing the acoustic project into smaller phases that are interdependent of the ones in the architecture plan of work, is favorable and can bring many benefits. For example, calculations and performance predictions should be done in the early stages of the design process so that adjustment can be done without further cost and construction implications. With this in mind, and based on the author's experience, an Acoustic Plan of Work was developed. As can be seen in Table 01, it contains 5 stages as defined below:

Stage 01 - Discovery and Criteria Definitions - Analyses of the architectural program, each room use, the desired performance and the site constraints. Definition of acoustic criteria.

Stage 02 - Design Analyses and Prediction Simulations - Building design and construction system analyses through prediction simulations. Adjustments and solutions are recommended.

Stage 03 - Technical Specifications and Drawings - Compatibilization of architecture and other disciplines design, definition and drawings of acoustic solutions or technical specifications.

Stage 04 - Construction Documents and Acoustic Solutions Details - Construction documents with consolidated acoustic solutions and technical specification are developed together with detailed acoustic solutions.

Stage 05 - Construction Administration -Field visits and acoustic objects through the construction site are conducted; reports are generated, and adjustments are recommended.

2.2 BIM in the Acoustic Project

Currently the BIM model has the capacity to deliver valuable information for each of the plan stages as indicated in Table 01. For example, for prediction simulation it is possible to obtain room geometry, elements material and manufacturers specifications. However, there is still a gap in the interoperability between BIM and simulation tools. According to a study conducted by Jung [1]- Extended Capabilities of BIM to Support Performance Based Design - there is no acoustic prediction software that is compatible with BIM. The main problem remains in the data exchange between BIM authoring tools and performance assessment tools.

Table 1 – BIM usage within an Acoustics Plan of Work

Architecture Plan of Work	**Acoustic Plan of Work**	**BIM Usage**
1.Preparation and Briefing	1. Discovery and Criteria Definitions	3D geometry, areas/zones, project location for acoustics analysis
2. Concept Design	2. Design Analyses and Prediction Simulations	3D geometry, areas/zones, elements material and manufacturer specifications for acoustics simulations
3. Development Design	3. Technical Specifications and Drawings	Optimized communication between disciplines for acoustics specifications
4. Construction Documents or Technical Design	4. Construction Documents and Acoustic Solutions Details	Optimized documentation and quantitative extractions for construction detailing
5. Construction Administration	5. Construction Administration	Use of augmented reality and/or digital twin for construction administration

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3 Development of the Brazilian Standard Object requirements for BIM - Acoustic Analysis

During the development of the standard some challenges were faced. Firstly, BIM Objects cannot be dealt with by themselves in a Building Acoustics context. For sound insulation predictions the performance of the flanking elements and how they are connected is as important as the performance of the isolated partition. For example, when predicting the airborne sound insulation between two adjacent rooms, it is indispensable to consider the acoustical performance of the walls, which type of junction they have with the flanking slabs, the acoustic performance of windows, doors, etc.

The second challenge is the lack of international references on how the acoustic parameters are being incorporated to the BIM Object. So far in Europe, CEN TC 126 WG 12 is responsible for BIM Acoustics, but up to now its main delivery has been a dictionary of acoustic properties that then correctly can be used in databases, following the instructions of prEN ISO 23386 (Building Information Modelling and other digital processes used in construction – Methodology to describe author, and maintain properties in interconnected dictionaries). Given this scenario, it was not possible to follow a model that could be adapted for Brazilian reality in the timeline of the BIM strategy Roadmap.

Following, the next section will describe the step-by-step approach that was followed to draft the proposed standard.

3.1 List of Acoustic Parameters

In the first step all the different acoustic parameters that are used in Brazil were listed as presented in Table 2.

Table 2: First proposal of Acoustic descriptors to be included in the BIM object.

Parameters	Description	Standard	Level of Geometry Detail
Sound Insulation			
R /R_w (dB)	Weighted Sound Reduction Index	ISO 10140-2	Schematic
ΔR/ ΔR_w (dB)	Weighted Sound Reduction Improvement Index	ISO 10140-2	Schematic
Ln/ L_{nw} (dB)	Weighted normalized impact sound pressure level	ISO 10140-3	Schematic
ΔL_n /ΔL_{nw} (dB)	Weighted reduction in impact sound pressure level	ISO 10140-3	Schematic
m (kg/m²)	Surface Density	-	-
η (-)	Internal Loss	ISO 18233:2006, ISO 10848:2006,	-
fc (Hz)	Critical Frequency	-	-
s' (MN/m³)	Dynamic Stiffness	ISO 9052-1:1989; ISO 12354-2	-
Room Acoustics			
α (-)	Sound Absorption Coefficient	ISO 354	Coordination
α_w (-)	Weighted Sound Absorption Coefficient	ISO 354 e ISO 11654	
Aeq (m²Sabine)	Equivalent Sound Absorption Area Per Single Object	ISO 354 e ISO 20189	Coordination Visualization
s (-)	Random incidence Scattering Coefficient	ISO 17497-1:2004	Coordination Visualization
Noise Control			
L_w	Sound Power Level	ISO 3741, ISO 3742, ISO 3743. ISO 3744, ISO 3745, ISO 3746, ISO 3747, ISO 9614-1, ISO 9614-2, ISO 9614-3	Schematic
Fn	Natural frequency	ISO 2041 e ISO 4866	-

Three parts compose the Table 2: Sound Insulation, Room Acoustics and Noise Control. Each of the sections is composed of 4 columns. Column one is the list of acoustic parameters used in each of the acoustic fields mentioned; the second is the description of the parameter; the next one is the referenced standard; the last is the recommended geometric detail that should be used in the BIM model.

The Object Requirements for Building Information Modelling WG decided to keep three levels of geometric detail after analysing the standards NBR/ISO 16757-2 [9] and BS 8541-3 [10]: Esquemático (Schematic), Coordenação (Coordination) and Visualização (Visualization). The three levels are compatible with the three 3D levels of the NBR/ISO 16757-2 and those presented in the BS8541-3. Although correlated to the five LOD (Level of Development) introduced by American Institute of Architects (AIA) in 2008 [11], only the LOD, 200, 300-350 and 400 were contemplated.

Once the descriptors were listed, the issue of how they would be incorporated into the BIM object remained unsolved. As mentioned earlier in section 2.1, in one of the stages of the Acoustic Plan of Work (stage 02) is where acoustic prediction simulations are carried out. To be able to perform this detailed analysis the acoustic consultancy needs the values of the corresponding acoustic descriptor in octave bands or ⅓ octave bands from 100 Hz to 3150 Hz, according to the required ISO Standard. To obtain these results, accredited laboratory measurements must be conducted to characterize the construction object/system. Individual accredited laboratory reports are of great importance as in Brazil there is no official construction database with validated acoustic data.

Also, Brazilian main construction systems are poorly standardized, essentially because they are not industrialized off site solutions. In this scenario, for each solution adopted, a specific laboratory test might be required. Therefore, the most pertinent solution to integrate the acoustic parameters to the BIM object was the simplest possible: to incorporate, via link, the acoustic PDF test report of the applicable object elaborated by any laboratory accredited by an entity associated with ILAC MR. In this way, solid and suitable data can be extracted for acoustic predictions and design by specialists.

3.2 New Proposal

With the outcome of this first solution of adopting a laboratory link report, discussions about the final requirements started to be developed within the working group. Table 3 presents the conclusion of what was agreed. The entity ifcDocumentInformation was chosen for the IFC mapping. It is important to point out that this entity can capture the metadata of any external document. The attributes: identification/DocumentID, Name, Description, Document Owner, and IFCdate/time; were selected since the content of the document is not defined in the specification.

The fundamental BIM model/object data for the acoustic simulation workflow would be as follows:

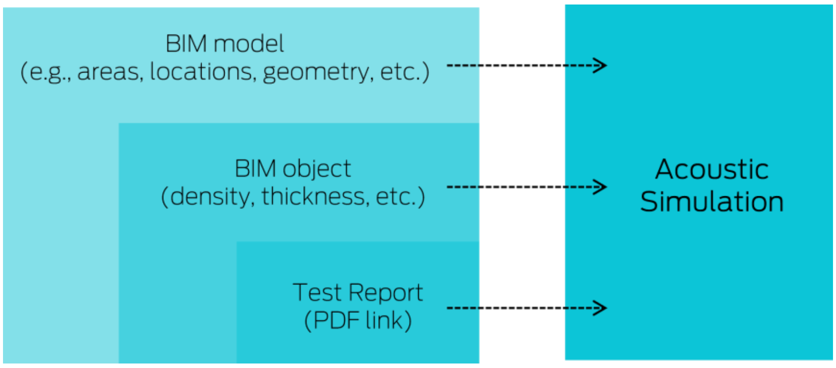

Figure 4 – BIM data for the acoustic simulation workflow.

Table 3 incorporates necessary data for BIM object properties specified by the Working Group, as well as acoustic parameters. An example is presented using the acoustic descriptor R_w -Weighted Sound Reduction Index, as a requirement for BIM objects for acoustic analysis.

Table 3: Object Requirements for Building Information Modelling for Objects in models used for acoustic analysis.

ABNT NBR (no number) Object Requirements for Building Information Modelling (BIM) – Part 9: Objects in models used for acoustic analysis		
Item	**Object Requirements**	**Example**
01	Parâmetros (Parameters)	R_W
02	Descrição (Description)	Weighted sound reduction index
03	Termo 0P (0P Therm)	Weighted sound reduction index
04	Código 0P (0P Code)	0P. 60. 90. 23
05	Classe/Atributo IFC (BSDD) (IFC class/atribute BSDD)	Weighted sound reduction index
06	Obs: BSDD	http://bsdd.buildingsmart.org/#concept/details/0N7ETm1OvCJwERvFLRdQmQ http://bsdd.buildingsmart.org/#concept/details/1gEgviIuzFDOP1Y1EEcejv
07	Preenchimento: (O)brigatório/ (P)laceholder (Fullfillment: (O) Mandatory/ (P)laceholder)	O
08	Condição (Condition)	Link to report of objects tested according to ISO 10140-1 and/or ISO 10140-2 and ISO 717-1 in an accredited laboratory by an ILAC MRA signatory entity.
09	Observação (Observation)	

Item 01 represents the symbol of the chosen parameters, shown in Table 1 after the red ones were discarded, to enable acoustic simulations.

Item 02 contains the parameters description.

Item 03 consists of the NBR 15965-2012 - Construction Information Classification System- that determines terminologies, classification systems and group classification relating to the characteristics of the construction objects. The NBR 15965-2012- Part 2: Characteristics of Construction Objects, present the classification of the Zero Group [12]. Being related to the characteristics of the construction objects, the Zero Group introduces two classes; the 0M Classification that corresponds to construction materials, and 0P Classification that corresponds to the construction properties. Acoustic properties are incorporated to the 0P class which is represented by the table in Figure 3.

One of the tasks during the framework development was to verify if any of the requested acoustic parameters were already contemplated in the 0P table. Since none of them were catalogue, new ones should be included once the 0P table is reviewed.

Item 04 presents the new 0P codes related to the new 0P parameters.

Código	Termo
0P. 60. 90. 00.	Propriedades acústicas
0P. 60. 90. 01.	Impedância acústica
0P. 60. 90. 02.	Tempo de reverberação
0P. 60. 90. 03.	Nível de ruído
0P. 60. 90. 04.	Coeficiente de redução de ruído
0P. 60. 90. 05.	Absorção acústica
0P. 60. 90. 06.	Absorção do som
0P. 60. 90. 07.	Média de absorção sonora
0P. 60. 90. 08.	Atenuação do som
0P. 60. 90. 09.	Densidade de energia sonora
0P. 60. 90. 10.	Fluxo de energia sonora
0P. 60. 90. 11.	Frequência do som
0P. 60. 90. 12.	Isolação acústica
0P. 60. 90. 13.	Isolação sonora
0P. 60. 90. 14.	Intensidade do som
0P. 60. 90. 15.	Isolamento do som
0P. 60. 90. 16.	Potência sonora
0P. 60. 90. 17.	Pressão sonora
0P. 60. 90. 18.	Velocidade do som
0P. 60. 90. 19.	Reflectância do som
0P. 60. 90. 20.	Classe de transmissão sonora
0P. 60. 90. 21.	Inteligibilidade da fala

Figure 5 – 0P Table of NBR 15965-2012- Part 2

Items 05 and 06 are associated with IFC classes and attributes. In addition, the right IFC class or attribute needed to be listed according to each of the chosen parameters. It is possible to have access to this type of information via an online service: the buildingSMART Data Dictionary (bSDD). This database hosts classification and their properties, allowed value, units, and translations [13]. It was possible to find some of the descriptors, such as Sound Power Level, Weighted Sound Reduction Index, Weighted Normalized Impact Sound Pressure Level and Weighted Sound Absorption Coefficient which web links were listed.

Item 07 corresponds to the type of data if it is a placeholder or mandatory. The acoustic parameters were all considered mandatory.

Item 08 determines the object condition. The only prerequisite, for acoustics analysis, is that every manufacturer/designer that wants to embody acoustic properties of an BIM Object must add a link to the corresponding laboratory tests reports, following the corresponded ISO standards. This report must be issued by a laboratory accredited by an entity associated to ILAC Group,

Item 09 is an open field for any comments or observations.

4 Conclusions

It is understood that incorporating acoustic requirements on BIM objects through an external link that leads to the PDF report perhaps is not the most innovative solution, but it answers the present Brazilian demand. When considering the acoustic project and its integration with BIM, this result does not solve the interoperability problem between BIM tools and acoustic prediction tools, but it will help acousticians with stage 02 - Design Analyses and Prediction Simulations, where it will be easier to extract the necessary data from the BIM object for acoustic simulations and studies.

It is also taken for granted that a construction database that contains characteristics of the construction elements, including acoustics data, such as the CEC from CTE (Código Técnico de la Edificación) from Spain [14], would be very useful. This could increase the precision of information incorporated into the BIM object, as not only the acoustic data would be more reliable but also the one from other disciplines.

In the future there is the opportunity to reference the acoustic requirements of BIM objects as a universal file, such as the one implemented by IES (Illuminating Engineering Society) together with ANSI (American National Standard Institute). These institutions established a standard format for the electronic transfer of luminaire optical data. The published ANSI/IES TM-33-18 [15] incorporates standardized, XML-based data format for use with all lighting applications.

Further work must be done, together with software developers, so that in the future acoustic data integrated in the BIM object could be exchanged directly with acoustic performance tools. This would help not only the acoustic consultancy work but also to optimize the BIM workflow.

5 References

[1] N. Jung, T. Häkkinen, and M. Rekola, "Extending capabilities of bim to support performance based design," *J. Inf. Technol. Constr.*, vol. 23, no. February, pp. 16–52, 2018.

[2] L. Laura, "ENCUESTA BIM AMÉRICA LATINA Y EL CARIBE," p. 48, 2020.

[3] B. Df and D. De, "Atos do Poder Executivo," p. 7042, 2017.

[4] Agência Brasileira de Desenvolvimento Industrial (ABDI), "Estratégia BIMBR," *Abdi*, 2021, [Online]. Available: https://estrategiabimbr.abdi.com.br/.

[5] ABNT, "Avança a Normalização Sobre BIM," *Bol. ABNT ISSN - 01036688*, vol. 17, no. 244, p. 32, 2020.

[6] ABNT, *NBR 15965 – Sistema de classificação da informação da construção*. Brasil.

[7] AIA, "Design to Construction | AIA ETN," 2020. https://www.aiaetn.org/find-an-architect/design-to-construction/ (accessed Aug. 10, 2021).

[8] I. Davies, "The RIBA Plan of Work 2013," *Contract Adm.*, pp. 10–11, 2020, doi: 10.4324/9780429347177-2.

[9] ABNT, *NBR ISO 16757-2 - Estruturas de dados para catálogos eletrônicos de produtos para sistemas prediais Parte 2: Geometria*. 2018, p. 85.

[10] British Standards Institution (BSI), *BS 8541-3 Library objects for architecture, engineering and construction. Part 3: Shape and measurement - Code of practice*. 2012, p. 24.

[11] United BIM, "BIM Level of Development | LOD 100, 200, 300, 350, 400, 500," 2021. https://www.united-bim.com/bim-level-of-development-lod-100-200-300-350-400-500/ (accessed May 13, 2021).

[12] ABNT, *NBR 15965-2: Sistema de classifi cação da informação Parte 2: Características dos objetos*. Brasil, 2012.

[13] BuildingSMART International, "buildingSMART Data Dictionary -," 2021. https://www.buildingsmart.org/users/services/buildingsmart-data-dictionary/ (accessed May 14, 2021).

[14] Código Técnico de La Edificación, "Catálogo informático de elementos constructivos," 2011. https://www.codigotecnico.org/Programas/CatalogoElementosConstructivos.html (accessed May 18, 2021).

[15] IES, "ANSI/IES TM-33-18 Standard Format for the Electronic Transfer of Luminaire Optical Data," p. 63, 2018, [Online]. Available: https://store.ies.org/product/tm-33-18-technical-memoranda-standard-format-for-the-electronic-transfer-of-luminaire-optical-data/.