v. 3, n. 2, 2022

Journal of
Engineering
Research

IMPLEMENTATION OF THE BIM METHODOLOGY IN THE DEPARTMENT OF BUILDINGS AND ROADS IN MINAS GERAIS

Anna Luiza Braga Amaral Bicalho
Departamento de Edificações e Estradas de Rodagem de Minas Gerais
Belo Horizonte - MG
Work group: BIM-MG

Bruna Cristina Beltrão Silva Beleigoli
Departamento de Edificações e Estradas de Rodagem de Minas Gerais
Belo Horizonte - MG
Alternate Representative Strategy Management Committee: BIM-MG

Maria de Fátima Amazonas de Sá Araújo
Departamento de Edificações e Estradas de Rodagem de Minas Gerais
Belo Horizonte - MG
Executive Secretary Working Group: BIM DER/MG

Vitor Calixto Curi
Departamento de Edificações e Estradas de Rodagem de Minas Gerais
Belo Horizonte - MG
Main Representative Strategy Management Committee: BIM-MG

Abstract: BIM (Building Information Modeling) is a methodology applied to the process of designing preliminary projects, preparing basic and executive projects, virtual construction and construction simulation, schedule, budget, as well as documentation for contracting and executing a work. Allows you to monitor construction, history of adaptations and asset management. In Brazil, it is common to increase costs and deadlines in public works contracts, resulting in numerous competitive disadvantages for the country. It is noticed that the causes of this increase arise from the fragility of planning and the difficulty of monitoring and controlling projects and works. BIM has become a State matter, by the Federal Government through Decree Number 9.337/2018 and in Minas Gerais by Decree Number 48.146/2021. The implementation of BIM in public works makes it possible to manage multidisciplinary information in real time by unifying and interconnecting all construction processes in a coordinated and transparent manner. LaBIM /DER/MG was implemented, with the support of CODEMGE, and internal diagnoses were carried out, mapping the level of BIM maturity in the institution, formation of a Study Group, for the internal acculturation and dissemination of BIM. DER/MG participates in the THEMATIC CHAMBER OF THE BIM STRATEGY COSUD, and through partnerships, benchmarking and participation in Seminars, it has been expanding its knowledge in BIM. Recently, laser scanning and modeling of a bridge covering 10,000 m² were carried out, laser scanning was contracted for 6 regional hospitals, such as a cadastral survey of around 150,000 m² and the Public Notice for the Hemonucleo de São João del Rey. The next steps to be taken will be the experiences of the pilots directed towards the development of the regulatory framework, the BIM Library, the specification book for bidding in BIM and the publication of the first public notice that contemplates the BIM concept.

Keywords: BIM, Transparency, Technology, Public works, LaBIM/DER/MG.

INTRODUCTION

Building Information Modeling (BIM) has been increasingly used as a tool for managing information throughout the entire life cycle of construction projects. This requires, however, radical changes in the way of thinking of designers, who need to work in a digitally collaborative way. (MacDonald, 2012).

With regard to the infrastructure sector, BIM is represented by four key elements: collaboration, representation, process and lifecycle, which interact with each other to create an innovative and efficient environment.

Despite being widely used in civil construction, the infrastructure sector is lagging behind in the use of BIM. This sector can be divided into five areas: Transport infrastructure (roads, railways, bridges, tunnels and mass transit hubs); Energy infrastructure (power generation plants, oil and gas and mining); Utilities infrastructure (networks/ pipes for delivery and removal of electricity, gas, water and sewage); Infrastructure of recreational facilities (Parks, stadiums, etc.), Environmental infrastructure (Structures for flood management and coastal defense such as dams, dykes, weirs or embankments). BIM can be applied in each of these areas, achieving the ultimate goal of innovating, facilitating processes, increasing productivity, identifying and managing conflicts with transparency. In the case of linear structures, linked to transport infrastructure, the main difficulties may be related to marked differences in data structure, connectivity, diversity within the collaborative team and project size, which is much more extensive than building construction projects. traditional. (Cheng,

JCP et. al., 2016).

A design model based on BIM can contribute to sustainability through its three main dimensions which are environmental, economic and social and it can be inferred that although there are many improvements in the implementation of BIM, in the environmental and economic aspects of sustainability, its potential impact on the social dimension has not been explicitly explored, and further studies need to be carried out in this area. (Sahar, 2016).

Standards exist to provide guidance and best practices on specific subjects and are effective within a given domain. The most relevant standards on BIM in infrastructure and construction are contained in the IFC – Industry Foundation Classes, which was developed by BuildingSmart and documented as an international standard in its latest version of 2020 (ISO16739:2013), with the aim of providing a definition Rigid, authoritative semantics of active elements and associated relationships, properties, and descriptive information to facilitate consolidation of knowledge across disciplines and BIM tools into a common format.

The EN ISO 29481-2016 aims to facilitate interoperability between software applications used during all stages of the construction works lifecycle, including briefing, design, documentation, construction, operation and maintenance and demolition. It promotes digital collaboration between actors in the construction process and provides a basis for accurate, reliable, repeatable and high-quality information exchange.

Despite the continuous development of BIM standards, not all its dimensions are supported to the same extent, often being insufficient to support modeling automation scenarios. (Vieira et al., 2020). The lag in the use of BIM in linear structures can also be explained due to the IFC acting as a large scale transfer mechanism for infrastructure design data and yet having the disadvantage that specific objects and types are not recognized and transferred. as unknown elements, leading to the loss of semantic meaning. Certain aspects such as IFC for bridges and the extension of alignments, recently released, are well developed and have begun the necessary steps to incorporate linear assets within the IFC environment,

If the detection of conflicts and clarity of information is an advantage of modeling buildings, in highway projects such detection does not add so much value. The advantage in linear designs comes from the coordination and visual integration of non-graphic data in the model, and can be used more efficiently during the pre-construction and construction phases, linking information collected in the field and generating models of BIM project information. accurate and data-rich. (Bradley et al., 2016).

The large volume of research in the construction phase also highlights the concept that the cost and time dimensions of BIM can provide increased gains in efficiency and quality in the infrastructure sector. As an application example, we have Han et al. (2013) who report ways of monitoring construction using high-resolution satellite images in BIM, necessary throughout the lifecycle of the work (design, construction, maintenance), and Kim et al. (2014), discusses the use of integrated cost and schedule models for rapid evaluation of highway alignments.

The Pandemic highlighted deficiencies in priority areas, such as the Regional Hospitals, in Minas Gerais, with works paralyzed by previous governments in the State that presented planning, design and execution problems. Public resources are increasingly scarce and must be used efficiently. The BIM methodology is an innovation for the architecture, engineering, construction

and operation sectors. With the digital collaboration of different disciplines, a virtual construction model is developed, with which it is possible to manage interferences between project elements, quantitative and revisions, from the conception to the operation of the enterprise, causing disruption of the current process, which presents criticism for not meeting society's expectations. The implementation of BIM is necessary as a way to modernize, optimize public spending,

In the Study on the causes of increased costs and deadlines in municipal public building works (Santos, Starling, & Andery, 2015) the five causes with the greatest potential to affect the deadline of public undertakings in Minas Gerais: contractual changes of value; unrealistic contract length; lack of project compatibility; delay in reviews and approvals of design documents by the contractor; errors in quantitative surveys, spreadsheet, and soil investigations. It is noticed that these causes arise from the fragility of planning and the difficulty of monitoring and controlling projects and works.

With the use of BIM, developers, executors and inspectors now have access to all phases of the project digitally, as well as more accurate and reliable calculations of the amount of material needed for each step. The integration of information makes it possible to anticipate flaws and problems in the project, even before execution, reducing the need for contractual amendments and embargoes that so commonly make works more expensive and delay.

Thus, the implementation of BIM in the State of Minas Gerais becomes an opportunity to develop and increase the planning of public works, improving the capacity for project development, monitoring and inspection of works and, consequently, the delivery of better services.

The adoption of BIM in private institutions in the infrastructure sector still has a low degree of maturity, but higher than public institutions. The public sector has increasingly shown interest in the subject, exemplifying bodies that are in the process of implementing the methodology, such as the Brazilian Army, the Court of Justice of Minas Gerais, the Secretariat of Infrastructure and Logistics of Paraná, the Government of Santa Catarina, among others.

The implementation of BIM depends on the structuring of a collaborative network, from the perspective of taking advantage of existing human resources in the bodies, with the objective of promoting investments in infrastructure, training and management with the optimization of public resources. (Fanning, B et al., 2015)

According to a report published by Construcao Mercado Magazine, signed by Fernando Augusto Corrêa da Silva, the implementation of BIM in Singapore followed a program in which the public sector took the lead, proposing an implementation schedule for new projects, constituting a task force to coordinate the delivery of integrated projects with the aim of improving collaboration between designers and builders, removing inconsistencies before the works start, created a Committee of Guidelines for the preparation of standards, and indication of priority areas for application of the model, released reference manuals free of charge for the use of BIM and invested in education and meritocracy.

HISTORY

In Brazil, the BIMbecame a State issue in 2018 through Federal Decree Number 9,337 and had two updates: decree number 9,983 on August 22, 2019 and decree number 10,306 on April 2, 2020.

Later, in Minas Gerais, State Decree number 48.146/2021 (Provides for the State Strategy for the dissemination of Building Information

Modeling - BIM-MG Strategy and establishes the BIM-MG Strategy Management Committee, 2021), which provides for the implementation of the methodology in the various developments in Minas |Gerais, in a gradual, planned and strategic way, with the first model to be contracted in 2021, and two other phases scheduled for 2024 and 2028.

The BIM Strategy Management Committee is made up of a main representative and an alternate, from the State Secretariat for Infrastructure and Mobility (SEINFRA), who exercises the presidency; the State Department of Education (SEE), the State Department of Justice and Public Security (SEJUSP); the State Secretariat for Planning and Management (SEPLAG) the State Secretariat for Health (SES) and the Department of Buildings and Highways of the State of Minas Gerais (DER/MG).

In 2019, the Governments of the states of the South and Southeast regions of Brazil (Minas Gerais, Espírito Santo, Rio de Janeiro, São Paulo, Paraná, Santa Catarina and Rio Grande do Sul) established the Consortium for Integration South and Southeast (COSUD). Participating states have the highest Gross Domestic Product (GDP) and represent 70% of the country's economy. The purpose of forming the consortium is to discuss joint agendas between the States related to issues of public security, combating smuggling, the prison system, health, reducing bureaucracy, tourism, education, economic development, logistics and transport, innovation and technology.

COSUD was divided into the BIM Strategy Thematic Chamber, which is an advisory body of the Logistics and Transport Working Group, and has the objective of assisting and coordinating activities related to the implementation of the COSUD BIM Strategy. Among its attributions are those of defining and managing the necessary actions to achieve the objectives of the Strategy and to ensure that the programs, projects and initiatives of state public bodies and entities that contract and carry out public works are consistent with the same.

In addition, the Chamber is also an environment for sharing information and experiences, with the ability to verify the impact of sectoral and/or state initiatives related to BIM, with a view to harmonizing and promoting efficiency and synergy between the actions of the bodies and state public entities.

Resolution Number 22, of November 27, 2019, appointed representatives of the Infrastructure and Mobility System of Minas Gerais to compose the Thematic Chamber of the BIM Strategy and creation of the Infrastructure Working Group - CT BIM COSUD.

IMPLEMENTATION PLAN

Currently, DER/MG continues to execute the BIM-MG strategy through the implementation plan, created in 2019 by the agency's own team, emphasizing the following critical components: vision, training, incentives, resources and action plan, to produce better deliveries from public services to users, with more assertive planning, fairer prices and greater transparency. Considering this premise, we follow the following specific objectives:

- Foster the BIM Working Group, through a collaborative environment, to encourage the exchange of knowledge about BIM, between servers from different sectors.
- Structuring the learning environment of the BIM methodology, the BIM Laboratory (LaBIM/MG), where the necessary activities are carried out to know, develop, improve and apply the BIM methodology to the planning and execution processes of public works.

- Develop, in LaBIM/MG, the bidding book for projects and works in BIM;
- Develop a cooperation agreement with software developers interested in contributing to the BIM Implementation project.
- Define, plan and execute pilot projects;
- Study the process flows of the administrative units of the DER and create requirements for contracting projects and works in the BIM methodology, using the contribution of the technical staff of the body itself;
- Study and implement sectoral agreements;
- Stimulate and promote the collective learning of the DER through qualifications, training, visits, technical monitoring and seminars;
- Define, justify, plan and execute the necessary purchases of software for State bodies;
- Plan, disseminate and promote internal and external acculturation in bodies and entities of the state and municipal public administration;
- Encourage the qualification and participation of State suppliers, so that they can meet the demands of BIM contracts;
- Mapping the risks involved and planning predictive, preventive and corrective actions to be adopted throughout the project's implementation;
- Working primarily with OpenBIM open universal versions.

The studies were conducted based on the collection and analysis of internal data, expert opinion, technical meetings and the ability of the coordination team, based on a survey of various hardware, as well as their performance and availability; inventory of available engineering software and its compatibility with BIM; creation of an organization chart for engineers and architects by area of activity in order to scale the LaBIM/MG infrastructure; obtaining an internal diagnosis through an electronic questionnaire with strategic questions about BIM.

The intention of implementing BIM in public works in the State of Minas Gerais is to enable the management of multidisciplinary information in real time, unifying and interconnecting all construction processes in a coordinated and transparent manner. The expectation of gains from the effective implementation of BIM in the State of Minas Gerais is, mainly, in information management and cost reduction throughout the life cycle of the enterprise. The aim is to facilitate the identification of conflicts, still in the design phase, to reduce the incompatibilities between work and project, especially in terms of costs and deadlines, and to gradually replace paper with digital models, with detailed information, enabling the sharing of the project in an expanded and unified way.

With the implementation of the methodology, it is intended to optimize the investment of public resources, through the elimination of costs in project revision, contractual amendments in the works and extension of deadlines for completion and delivery of the work, strengthening the body, with well-defined processes and simplified. This way, the elaboration of projects and works with greater quality, assertiveness and effectiveness for the user is expected.

The Implementation Plan enabled the dimensioning of the necessary structure to meet the proposed object, which was consolidated with the idealization of LaBIM – DER/MG (Laboratório de Inovação em BIM). To implement its structuring, a Research and Development Agreement was signed with the

Development Company of Minas Gerais – CODEMGE, in the amount of R$1,830,199.50, covering equipment, software, training and having as counterpart the development of projects -pilot, seminars and specification booklets for contracting projects in BIM.

In the human resources area, diagnoses were carried out, with the aim, among others, of mapping the level of BIM maturity in the institution, and promoting internal acculturation through the identification of interrelated parts in the collaborative BIM process. Among these parties, we have 48 engineers and 13 architects for DER, making it unnecessary, initially, to hire additional servers. A training structure divided into cycles is being organized, with the execution of pilot projects, separated into three distinct areas: highways, buildings and special works of art. The training of these professionals started the process of multiplying knowledge through the formation of a study group that, in addition to encouraging the spontaneous participation of the entire internal team,

BIM LABORATORY OF DER/MG

The LaBIM DER/MG, BIM laboratory, is a multidisciplinary technological park aimed at learning the BIM methodology, which simulates a collaborative environment for contracting BIM modeling and contributes to the development of contracting models, specifications and standard projects that will be made available to the public and to the technical teams of city halls and other bodies in the civil construction sector.

Partnerships were made with various entities and companies to obtain software, training and execution of pilot projects aimed at the development of the regulatory framework, the BIM Library, the specification book for BIM tenders and the publication of the first public notice that contemplates the BIM concept.

The laboratory has three arterial purposes for the plan: potentially being the reference environment in training and improvement of the technical staff of the State of Minas Gerais, carrying out the training of DER servers; develop pilot projects in BIM that will cover projects and concessions for road, rail and building infrastructure, standard projects for city halls, public works agreements and strategic projects. The third purpose refers to the dissemination of the BIM concept in Minas Gerais. Understanding the grandeur of the state's extension and its socioeconomic heterogeneity, the laboratory will spread the BIM concept using the previously mentioned benefits, through regionalized actions of pilots and training, which will involve partners such as educational institutions, technology, city halls,work in the dissemination of the efficient use of technologies and procedures in BIM. The adoption of open standards - Open BIM will enable better interoperability, collaboration and transparency in the process.

CASE STUDIES

Some initiatives were taken seeking the implementation of the BIM methodology and dissemination of the idea to the State and its collaborators. Are they:

- Cooperation with Potenza Engenharia to carry out laser scanning and modeling of a bridge covering 10,000 m²;
- Contracting laser scanning of 6 regional hospitals that are disabled as a cadastral survey of around 150,000 m²;
- São João del Rey Hemonucleus Pilot Notice;
- Public notice for Ipatinga Airport project (land/air area);
- Laser scanning of the MG-445, stretch: Porto Firme – Guaraciaba;

- Realization and presentation of layout studies in BIM software;

Some proposals for alternative road layouts are developed and presented to authorities and the population in BIM software. Relevant information about the region and operational characteristics of the project are modeled in order to provide reliable data that are easy to understand and visualize for everyone.

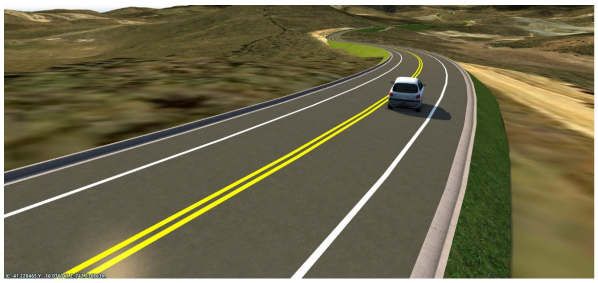

Figure 1: Tracing study (Jaboticatubas – MG-010)

Source: The authors.

Figure 2: Plan view - Tracing study (Jaboticatubas – MG-010)

Source: The authors.

Still with the aim of disseminating the BIM methodology to public entities, the 3rd and 4th SEBIM (BIM Seminar) were held, in compliance with Decree Number 48146 OF 03/02/2021, which provides for the state strategy for disseminating BIM, with the face-to-face participation of more than 500 people. To expand the dissemination of Bim, a website was created (https://www.bim.mg.gov.br), with periodic updating of information about the methodology implementation process. The BIM-MG Strategy is formed by an active network of supporters who, like the State of Minas Gerais, agree with the importance of adopting the BIM concept for the development of services and works related to civil construction, in addition to understanding the scale gains in its adoption and its results as the production of a more dynamic and efficient economy capable of bringing greater effectiveness of public enterprises to society.

CONCLUSION

It is observed that there are still several gaps for the effective implementation of BIM in the State. These gaps are related to technical and cultural behaviors. Cultural barriers are being knocked down every day, with the improvement of the team, training and, mainly, with the demonstration, in practice, of the benefits that the process has.

Regarding the technical barriers, we have, mainly, the difficulty with the integration of information in a common data format, which generates distrust in a sector that is already conservative.

We also have the financial barrier, as the acquisition cost of BIM software and the currently predominant marketing modalities of the rental type (subscription) is a challenge for public resource managers who face budgetary and bureaucratic barriers. Dialoguing with software developers, seeking alternatives on the market, developing our own tools, signing cooperation and agreements with other public bodies are actions we have taken to overcome the adversities encountered.

The strategy of the State of Minas Gerais follows in the footsteps of other places where BIM is already more consolidated, such as, for example, Singapore (Revista Construção Mercado, 2016), where the public sector had to take some initiatives, creating committees for disclosure, collaboration and development of guidelines, advising and guiding companies

in which main areas there would be an effective application of the model. With short but continuous steps, Minas Gerais, through the BIM Implementation Plan of DER/MG, is conquering the improvement of contracting processes for projects, works and management of public enterprises.

REFERENCES

Agência Brasileira de Desenvolvimento Industrial. Estrategia BIM BR. Fonte: https://estrategiabimbr.abdi.com.br/estrategia - (2018)

Bradley A., Li H., Lark R., Dunn S., BIM for Infrastructure: An overall review and constructor perspective, Automation in Construction 71 (2016) 139-152, http://dx.doi.org/10.1016/j.autcon.2016.08.019.

Cheng J.C.P, LU, Q., Deng, Y., Analytical review and evaluation of civil information modeling, Autom. Constr. 67 (2016) 31–47, http://dx.doi.org/10.1016/j.autcon. 2016.02.006.

Decreto Estadual nº 48146 / 2021 - Dispõe sobre a Estratégia estadual de disseminação do Building Information Modeling - Estratégia BIM-MG e institui o Comitê Gestor da Estratégia BIM-MG.. Fonte: https://www.legisweb.com.br/legislacao. (3 de Março de 2021)

Fanning, B.; Clevenger, C.M.; Ozbek, O.E.; Mahmoud, H., Implementing BIM on Infrastructure: Comparison of two bridges construction projects. Practice Periodical on Structural Design and Construction. Reston, United States of America, v.20, n.4, p01-08, 2015

Golparvar-Fard,. Savarese, S., Peña-Mora, F., Automated model-based recognition of progress using daily construction photographs and IFC-based 4D models, Construction Research Congress 2010: Innovation for Reshaping Construction Practice, Banff, AB, ISBN: 9780784411094 2010, pp. 51–60, http://dx.doi.org/10.1061/ 41109(373)6.

Han,D., Construction monitoring of civil structures using high resolution remote sensing images, 13th International Multidisciplinary Scientific Geoconference and EXPO, SGEM 2013, Vol. 2, Albena, 595–600, http://dx.doi.org/10.5593/SGEM2013/BB2.V2/S10.007

International Organization for Standardization (ISO), ISO 16739:2013 Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries, International Organization for Standardization (ISO), Geneva, 2013.

International Organization for Standardization (ISO),EN ISO 29481-1:2017 Building information models - Information delivery manual - Part 1: Methodology and format, International Organization for Standardization (ISO), Geneva, 2016.

Kim H., Orr K., Shen Z., Moon H., Ju K., Choi W., Highway Alignment Construction Comparison Using Object-Oriented 3D Visualization Modeling, J. Constr. Eng. Manag. 140 (10) (2014), http://dx.doi.org/10.1061/(asce)co.1943-7862.0000898

MacDonald, J.A., A framework for collaborative BIM education across the AEC disciplines. IN:37 th Annual Conference of Australian University Building Educators Association, 2012, Sidney. Proceedings… Sidney: AUBEA, 2012.11 Sidney, Australia.

Moon H., Dawood N., Kang L., Development of workspace conflict visualization system using 4D object of work schedule, Adv. Eng. Inform. 28 (1) (2014) 50–65, http://dx.doi.org/10.1016/j.aei.2013.12.001.

Sahar, S., The Contributions of Building Information Modelling to Sustainable Construction. World Journal of Engineering and Technology, v.4, 2016

Santos, H. D., Starling, C. M., & Andery, P. R. Um Estudo sobre as Causas de Aumentos de Custos e de Prazos em Obras de Edificações Públicas Municipais. Ambiente Construido. doi:https://doi.org/10.1590/s1678-86212015000400048 (Outubro - Dezembro de 2015).

Site Estadual da Estratégia BIM - MG, http://www.bim.mg.gov.br

Silva, Fernando A.C. As lições de Singapura - http://construcaomercado.pini.com.br/negocios-incorporacao-construcao/171/artigo364801-1.aspx

Vieira, R., Carreira,P., Domingues, P.,Costa, A.A., Supporting building automation systems in BIM/IFC : reviewing the existing information gap. Engineering, Construction and Architectural Management v. 29, 2020. https://www.emerald.com/insight/content/doi/10.1108/ECAM-07-2018-0294/full/html