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Application Of The BIM Methodology In The Construction Planning Of The UNEMI Postgraduate Building

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Abstract– ***The purpose of this project is to plan the construction of the Graduate Building of the State University of Milagro (UNEMI) through the BIM methodology and its dimensions (5D) of idea, sketch, modeling, planning and costs, based on a pre-existing 2D scheme. This was developed using 3D modeled elements in the Revit 2022 Software, which were later linked to a work schedule and the specification of items to obtain the budget. Once the 3D design processes and time and cost planning were completed, the obtained information was integrated into the Navisworks Software for the review of the composition of disciplines of the three-dimensional model, resulting in the obtaining of a comprehensive modeling of the construction process, with time and cost.***

Keywords-- BIM, CONSTRUCTION, MODELING, REVIT, NAVISWORKS, BUDGET, SCHEDULE.

I. Introduction

The construction sector is immersed in constant transformations, which respond to the changing need to adapt to the challenges of optimization, continuous improvement and profitable increase, seeing the need for the implementation of new technological currents where the inhibition to their adoption would imply defects, long times, cost increases and low predictability [1]

In this way, the use of the Building Information Modeling (BIM) methodology facilitates at the design level according to the Building Smart Spanish Chapter (2014) a construction detail of precise and high quality, involving investments, functionalities and comparative analysis throughout the planning of the construction project, allowing greater alternatives of action due to its efficient implication for the construction industry.[2] [3]

For this reason, the objective of this research is based on the application of the BIM methodology in the postgraduate building of the State University of Milagro (UNEMI), to achieve greater efficiency during project planning, developing technological alternatives hand in hand with planning, collaborative work, simulations, process management and information transfer[4]

This planning, based on the fundamentals of the BIM methodology and its principle of optimization through five of its dimensions (5D) of idea, sketch, information model of the building, time and cost, aims to develop a quality project that seeks to meet the initial expectations and requirements [5]

II. MATERIAL AND METHODS

The present research is developed under a quantitative methodology, since it allows, from an objective perspective, the grouping of information and the study of data in order to establish concrete and measurable conclusions and parameters [6]

With this, the entire quantifiable process applicable to the BIM methodology is developed and evaluated, in such a way that quantities, resources and budget analysis, dimensions and numerical data are estimated. [7] [8]

2.1. Methods

The research method carried out in this study is descriptive, where it is based on the storage of data, its respective analysis and subsequent interpretation, on how a situation and/or aspect works in the present [9]

2.2. Techniques

The techniques developed for this study are defined by three approaches: The observation of projects and research that address the BIM methodology from its use, development and applications, from experimental and theoretical approaches; the limitation of the approach to be studied and the analysis of information, identifying objectives, methodological routes, development scheme and the systemic study of the information studied; and, finally, obtaining results, as the final process of the study, comparing the objectives set with the resulting information.[10]

2.3. Instruments

The instruments used to carry out this study consist of illustrations, tables, photographic resources and pre-designs of the existing project in question: plans (architectural, structural, sanitary) of the construction project of the postgraduate building of the State University of Milagro (UNEMI), as well as the specifications, technical specifications, analysis of unit prices (APUS) and terms of reference (TOR) of the same.

In the same way, the use of digital tools for development, such as specialized software such as Revit, Navisworks, Microsoft Project, Microsoft Excel, among others, allowing the management, execution of project planning and obtaining results.[11]

2.4. Processing and Analysis Plan

For the elaboration of this study, its development is carried out in four stages, detailed under the planning requirements for each process.

- Collection of Information
- Development in Revit 2022
- Project Planning
- Integration and simulation at Naviswork 2022

III. RESULTS AND DISCUSSION

3.1. Descriptive Report

The Postgraduate Building of the UNEMI University is located in the province of Guayas in the city of Milagro. It has four floors with a mezzanine height of 3.50 meters and a metal structure roof.

The present project corresponds to a building that contains 39 properly equipped classrooms: with 4 bathrooms, a cellar, an information department, an elevator, 2 stairs with access to higher levels, an emergency staircase and a system of steps at the front of the building. In the same way, it has a central space that functions as a hall, which allows greater access between the departments.

On the other hand, the foundation is composed of 64 piles of 14 meters of reinforced concrete, with a compressive strength factor of 280 kg/cm2; and footings that consist of a depth of 1.10 meters linked together, by reinforced concrete beams with the same compressive strength. At the same time, the columns, beams and slabs are composed of reinforced concrete with the same characteristics mentioned above, except for 6 columns that are made up of a metal structure. Additionally, the columns are quadratic and the beams are rectangular.

The slab has a 40x40 centimeter slab, whose thickness corresponds to a polyurethane material of 15 centimeters, except for the slab on the ground floor, which is purely reinforced concrete.

In this way, for the realization of this study, it is developed based on an existing project, obtained within the Public Procurement portal (SERCOP), soon to be executed, based on a design and preliminary information addressed by the Public Company of Production and Strategic Development of the State University of Milagro (EPUNEMI), as contracting entity.

3.2. BIM 1D: Idea

3.2.1. Initial Conditions

The project to be executed is located at the State University of Milagro, in the University Citadel "Dr. Rómulo Minchala Murillo", at Kilometer 1 1/2 via Milagro- Virgen de Fátima of the Guayas Canton of Ecuador. It consists of a four-story building, which will be used for educational purposes and with a reference budget of Two Million Nine Hundred Ninety-Nine Thousand Three Hundred Forty-Six Dollars without VAT included.[12]

3.3. BIM 2D: Sketch

Based on the plans obtained from the public procurement portal, it is possible to visualize from the AutoCAD software, the architectural, structural and sanitary designs (wastewater, drinking water and rainwater) in 2D, thus observing the details of the postgraduate building. [13]

3.3.1. Architectural Plans

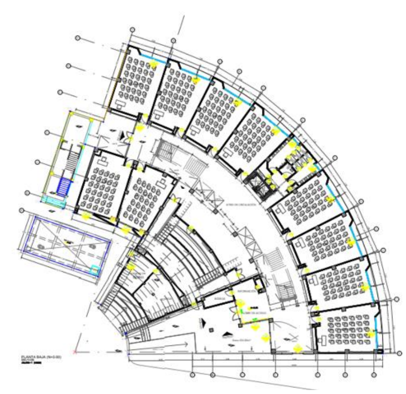

Figure 1. 2D architectural plan of the UNEMI postgraduate building, Ground Floor.
Source: (EPUNEMI, 2022)

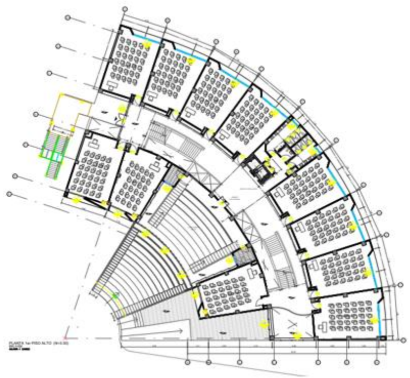

Figure 2. Architectural plan of UNEMI postgraduate building, 1st Upper Floor.
Source: (EPUNEMI, 2022)

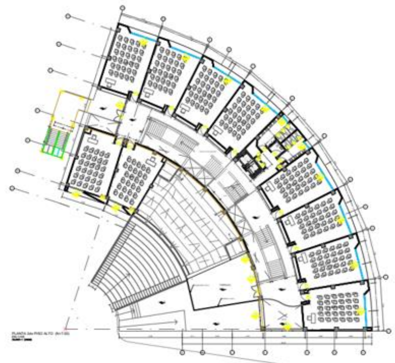

Figure 3. Architectural plan of the UNEMI postgraduate building, 2nd Upper Floor.
Source: (EPUNEMI, 2022)

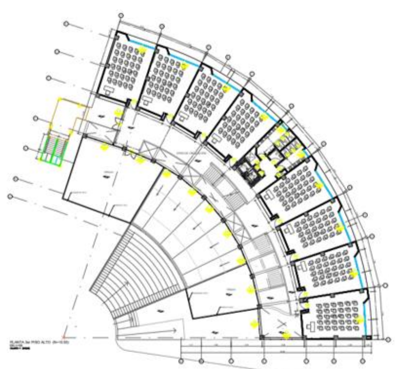

Figure 4. Architectural plan of the UNEMI postgraduate building, 3rd Floor Up.
Source : (EPUNEMI, 2022)

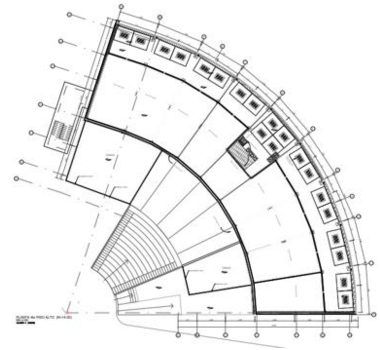

Figure 5. Architectural plan of the UNEMI postgraduate building, 4th Upper Floor.
Source: (EPUNEMI, 2022)

3.3.2. Structural Drawings

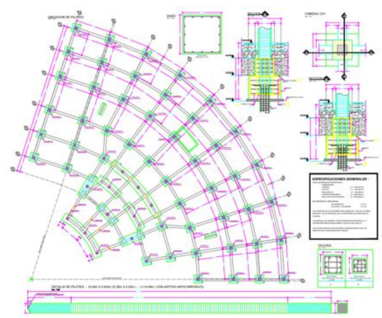

Figure 6. Structural plan of the UNEMI postgraduate building, distribution of piles.
Source: (EPUNEMI, 2022)

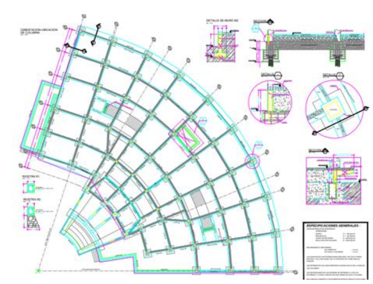

Figure 7. Structural plan of the UNEMI postgraduate building, distribution of piles.
Source : (EPUNEMI, 2022)

3.3.3. Sanitary Plans

The sanitary plans corresponding to the first, second and third floors of the Postgraduate building are equivalent, presenting regularity in the plans obtained, both for sewage, as well as for drinking water and rainwater.

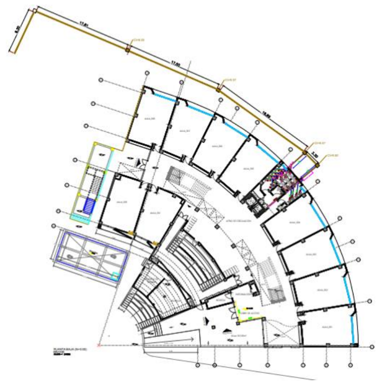

Figure 8. Architectural plan of the Sanitary Sewage System (AASS).
Source : (EPUNEMI, 2022)

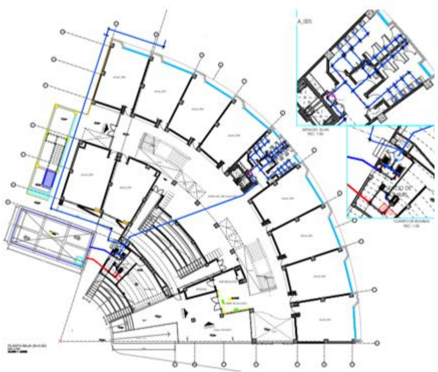

Figure 9. Architectural plan of the Potable Water Sanitary System (AAPP).
Source : (EPUNEMI, 2022)

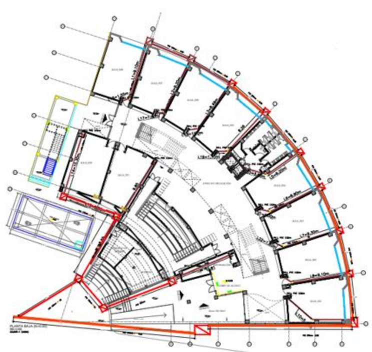

Figure 10. Architectural plan of the rainwater sanitary system (AALL).
Source : (EPUNEMI, 2022)

3.4. Template

The Revit 2022 Software allows the selection of the type of template required to work, chosen according to the specific functions of this project. Each template has essential characteristics taking into account the selected branch, as is the case of the architecture template, which involves the dimension of structural elements, unlike the structural template that focuses on the assembly of columns, beams, braces, among others that share common elements, however, each template has different incidents throughout the 3D modeling.

3.4.1. Units

Once the work template has been selected, the desired measurement system will be chosen in which the project plan will be developed, where in this study it will be configured according to the international metric system.

3.4.2. Levels

For an easy and quick handling of each of the floors of the project, we proceed to use the "levels" option located in the architecture section, thus delimiting the height of each floor and thus accurately implementing the columns, beams and floor of each level, as indicated in the elevation of the plan in AutoCAD 2D.

3.4.3. Import CAD

Revit 2022 Software, belonging to the same Autodesk family, has the option to manage and import CAD files (dwg.), so that files from AutoCAD are incorporated into Revit, where the latter allows modification to the required format, under parameters of units, color, and other specifications.

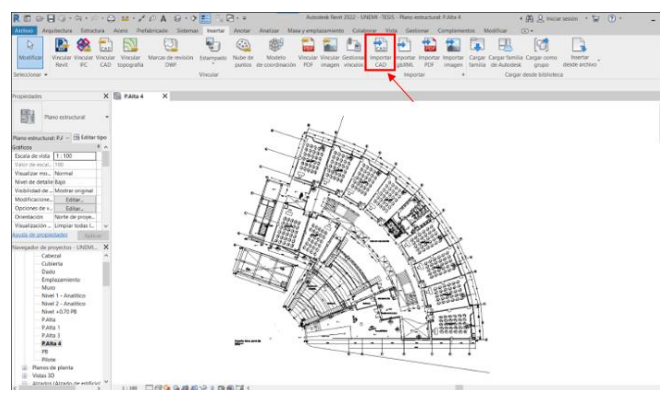

Figure 11. Importing CAD drawings into Autodesk Revit
Source : Own elaboration

3.5. Structure

3.5.1. Piles

To create the structural piles, we use the "isolated" option located in the structure section, immediately appearing the types of piles that Revit software provides by default. We choose one of the options to duplicate the element and thus assign properties according to the 2D drawings.

The 64 piles will have a length of 14 meters. This same number of piles corresponds to the number of reinforced concrete columns, in addition to the 6 steel structure columns.

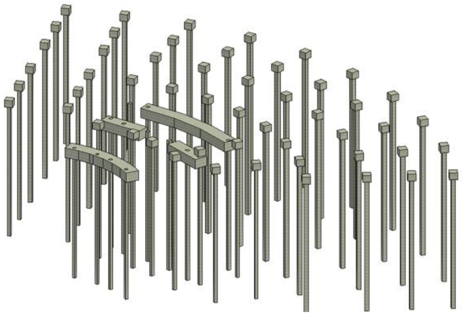

Figure 12. Piloting
Source : Own elaboration

3.5.2. Foundations

The die and the head of the foundation of this project will be made by means of the "isolated" option located in the structure section, which will allow to give depth and dimensions to it. In addition, the material to be used must be configured, which is 280 kg/cm² concrete.

Also, due to the architecture of the building, the "align element" tool will be required to align the foundation in the most opportune way, using the imported dwg and the reference lines.

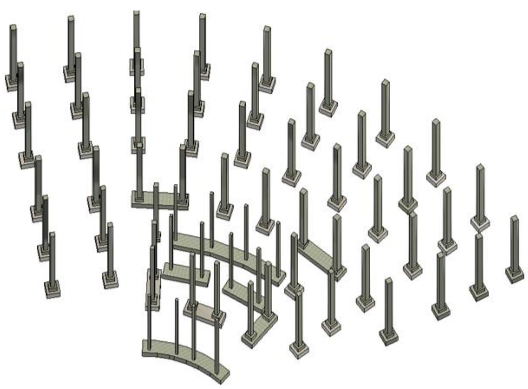

Figure 13. Dado y cabezal
Source : Own elaboration

3.5.3. Columns

The structural column is created in the structure section, through the “structural column” option, and the types of columns that the software contains by default appear immediately, select one of the options to duplicate the element and assign it a name, which must contain its dimensions for quick identification when drawing. In the same way, the properties of the concrete must be assigned, including the compressive strength, which in this case is 280 kg/cm².

Due to the nature of the building, the "align element" tool will be needed which, with the help of the imported CAD drawing and reference lines, allows the correct alignment as indicated in the 2D plan.

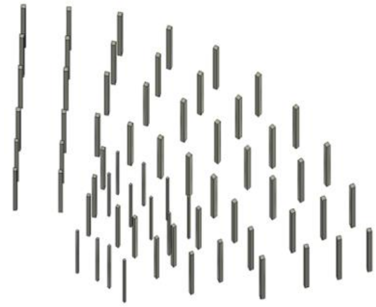

Figure 14. Structural Pillar
Source : Own elaboration

3.5.4. Beams

In the structure or architecture section you will find the "beams" option, this tool allows you to draw the beams according to the building axes and 2D drawings, taking care not to omit the modification of parameters, such as the type of material to be used, in this case a 280 kg/cm2 concrete, and it is positioned at the corresponding reference level. In the same way, the braces will be created as if they were beams.

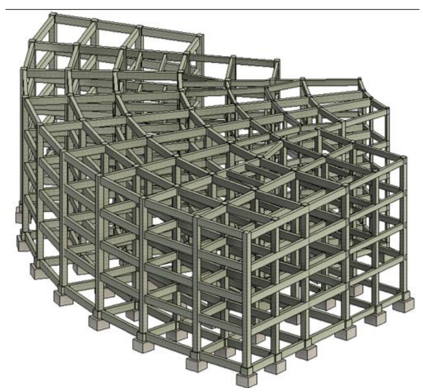

Figure 15. Beams
Source : Own elaboration

3.5.5. Structural Walls

The structural walls are made of reinforced concrete with f'c= 280 kg/cm2 of resistance, with a thickness of 25 cm, which goes from the foundation section to the fourth floor of the building.

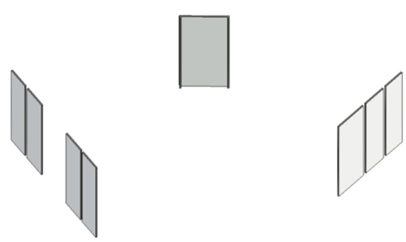

Figure 16. Walls
Source : Own elaboration

3.5.6. Slab

For the modeling of the slab, the tool “component: create in situ” is used to locate the slab reliefs and delimit the edges, thus giving it the curved shape of the building, in addition to the slab thickness, which in this case is 20 cm with a concrete of 280 kg/cm2.

On the other hand, Revit does not have a ribbed slab family by default, so we created a family of relief block that is made of polyurethane, with the purpose of forming the ribs, which discount the concrete volume of the slab and can be accounted for in a quantification table.

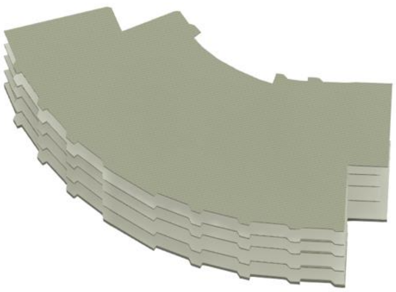

Figure 17. Slabs
Source : Own elaboration

3.5.7. Stairs

For the creation of the bleachers, located in the main part of the building, the "component" option will be used in the architecture section, selecting "model in situ", which will automatically open the "parameters and categories" box where the "floors" option will be used to create the bleacher shape adapted to the project by "sweeping".

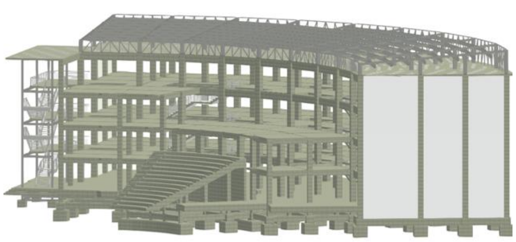

Figure 18. Stairs
Source : Own elaboration

3.5.8. Metal Structure

The steel structure was built in the structural section with the "lattice girder" option, giving it the properties corresponding to the project, such as a height of 2.70 meters in the rear section of the building and 1.35 meters in the main section, as well as a HE100A metal material.

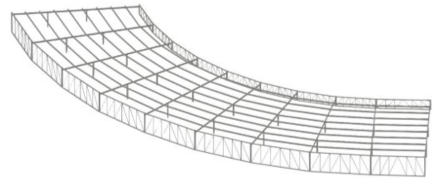

Figure 19. Metal Structure
Source : Own elaboration

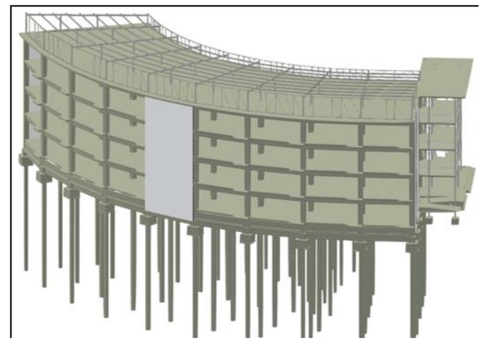

Figure 20. Implanted metal structure
Source : Own elaboration

3.5.9. Structural reinforcement

For the creation of the structural reinforcement within the Revit software, the diameters established by the CAD drawings of the project under development must be taken into account, where, after the definition of the structural elements with the assigned coatings, each one of them is selected for the elaboration of the reinforcement as indicated in the drawing, using the reinforcement form that the program has by default, where the rod of the desired diameter was duplicated, configuring its name according to the established diameter to avoid future inconveniences.

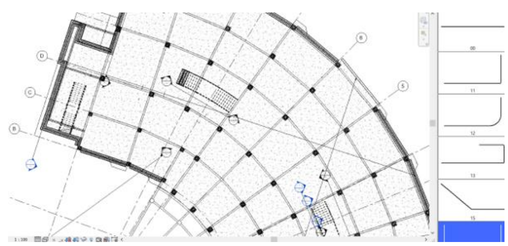

Figure 21. Structural reinforcement
Source : Own elaboration

3.6. Architecture

3.6.1. Masonry and Finishes

The masonry walls are created through the "architectural walls" option located in the architecture section, which allows to give a thickness, in this case of 15 cm for interiors and 20 cm for exteriors, in addition to giving the respective details of architectural finishes composed of "concrete block", plastering on both sides and interior filling.

In the same way, the exterior walls have the same composition, however, as for the finishes of the external part of the building, the exterior rendering was selected. This, with a total wall height of 3.50 m, thus creating a type of wall that meets the needs of the project.

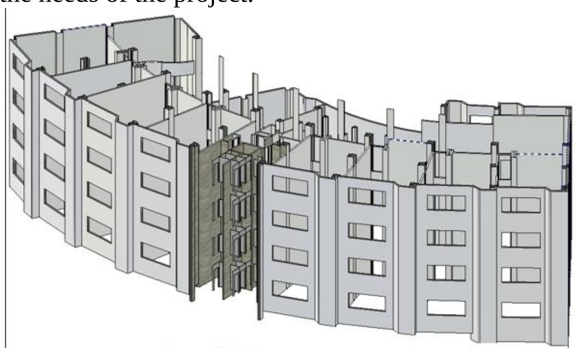

Figure 22. Masonry
Source : Own elaboration

3.6.2. Floor finishes

Through the "architectural flooring" option, the slab finish is created, consisting of a 2 cm thick porcelain tile, respecting the empty spaces for stairs and hollow parts as indicated in the plan.

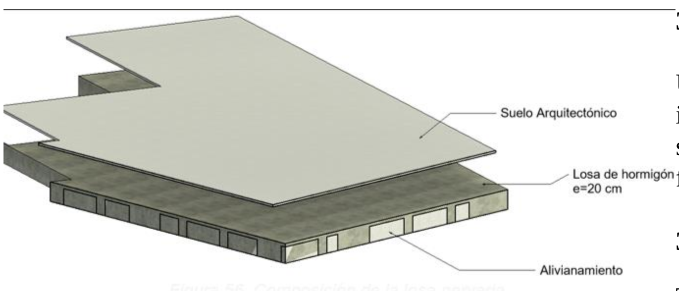

Figure 23. Floor Finishing
Source : Own elaboration

3.6.3. Ceiling

Using the "ceilings" option located in the architecture section we proceed to create our ceiling, the free height between the slab level and our ceiling is 3 meters.

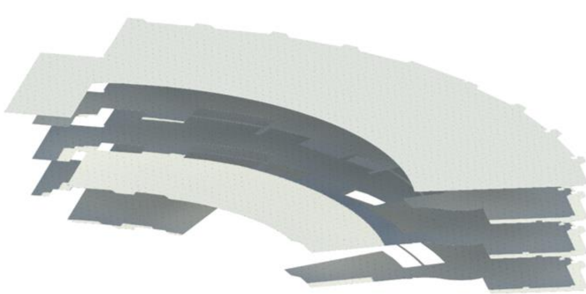

Figure 24. Ceiling
Source : Own elaboration

3.6.4. Windows

For the elaboration of the windows, use was made of the existing families provided in the architectural section, modifying the parameters required for the adaptation in the present project, as indicated by the architectural details in the CAD files.

3.6.5. Doors

In the same way as the windows were developed, the doors are modeled with the corresponding properties as indicated in the technical specifications provided by SERCOP.

3.6.6. Handrails

For the incorporation of the handrails in the building, we make use of the "railings" tool located in the architecture section, selecting the "glass panel" family, duplicating and assigning the corresponding name for the present project. These handrails, including the glass panel, constitute all the stairs of the building, both emergency stairs and access stairs to higher levels.

3.6.7. Site furniture

Using the "Component" tool, select the "load family" option to insert the desired materials and characteristics for the furniture such as: chairs for students and teachers, desks, shelves for filing, blackboards, mirrors and bathroom counters.

3.6.8. Cover

To model the roof of the building, the "roof" option located in the architecture section is used, which immediately provides lines for the creation of its perimeter. Also, Revit Software provides a generic default roof, which will be applied with the "duplicate" option to give it the properties of the roof as indicated in the 3D model.

3.7. Sanitary System

For the 3D development of the pipes of the different systems such as drinking water, sewage, ventilation system and rainwater, it will be done using the BIM files offered by Plastigama S.A. on its home page, which contain pipe fittings, sanitary registry boxes, pipes of different diameters by catalog and above all divided by their various systems, thus facilitating the 3D modeling.

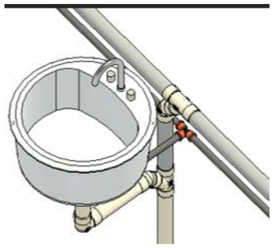

Figure 25. Sanitary system
Source : Own elaboration

3.7.1. Drinking water system, AAPP

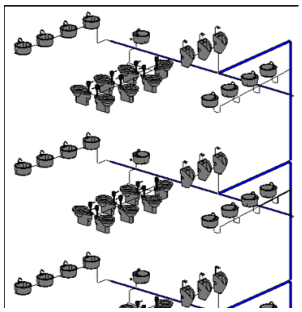

Figure 26. Sanitary system
Source : Own elaboration

3.7.2. Potable water system, AASS

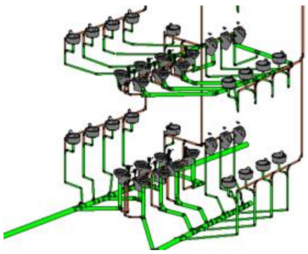

Figure 27. Potable Water System, AASS
Source : Own elaboration

3.7.3. Rain water system (AALL)

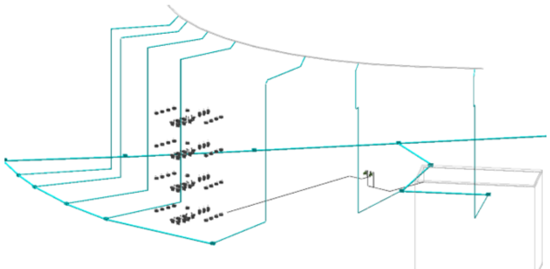

Figure 28. Rainwater System
Source : Own elaboration

3.7.4. Integration of the health care system: AAPP, AASS, AALL

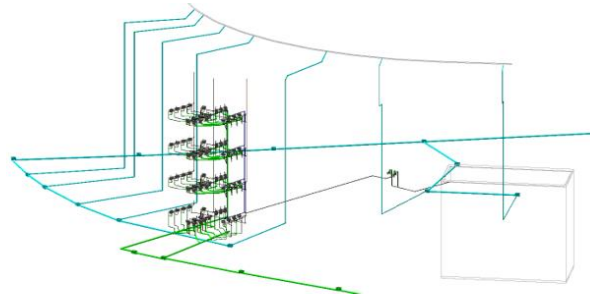

Figure 29. Integration of the health care system: AAPP, AASS, AALL
Source : Own elaboration

3.8. 3D model integration: structural, architectural, and sanitary

Figure 30. Integrated 3D model.
Source : Own elaboration

3.9. BIM 4D: Construction Planning

3.9.1. Construction schedule

The work chronogram was elaborated with the Ms Project program for the development of the planning based on the duration of activities, logical sequence, dependence and the cost involved in order to obtain the critical route and the Gantt diagram graphically, corresponding to each sectorization of the defined items.[14] [15] [16]

3.10. BIM 5D: Construction Costs and Budget

3.10.1. Quantities of work

The planning tables of work quantities for the present project were determined under the guidelines of the elements previously created in accordance with the quantifications provided by the Revit software.

3.10.2. Construction budget

The construction budget was made taking into account the construction planning tables provided by the Revit software.

3.11. 5D BIM Integrated Model: Autodesk Navisworks Manage

For the revision of the three-dimensional model of the UNEMI Postgraduate Building, the integration of the different engineering, the architectural model, the linkage with the Microsoft Project tool for the duration time and the cost section established for the present project as described in the 5 dimensions of the BIM methodology developed in the present project are used.

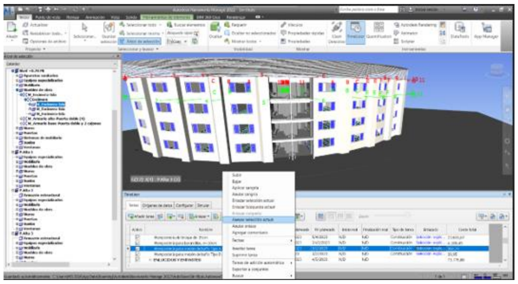

Figure 31. Maviswork Manage
Source : Own elaboration

The activities that are planned to be carried out on a defined date, according to the BIM 5D model schedule, are shown below.

On 11/19/2022, according to the 5D model, pile driving and supply of piles is 74% complete, reinforcing steel of corrugated rods fy=4200 kg/cm2 is 29% complete, concrete f'c= 280 kg/cm2 is 27% complete, and the foundation item is 39% complete. The direct cost of the project to date is $38,144.42.

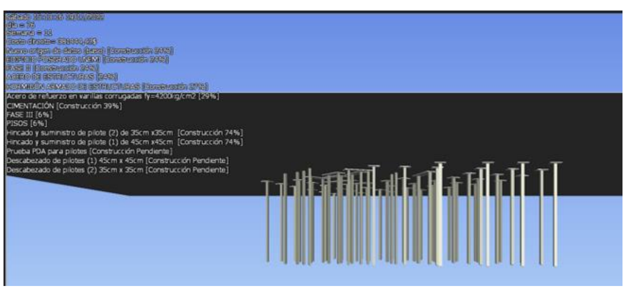

Figure 32. Pile advance control in 5D Model
Source : Own elaboration

Date 05/29/2023, according to the 5D model, installation of sanitary fixtures 39%, installation of porcelain tile for slab carries 80%, installation of doors and windows 85%, installation of furniture 37% leading to a building construction of 88%. The direct cost of the project to date is $2,814,512.18.

Figure 33. 5D Model 5D feedforward control of finishes
Source : Own elaboration

On 07/04/2023, according to the 5D BIM model, the construction of the Postgraduate Building of the State University of Milagro (UNEMI) would be completed at a direct cost of $2,967,212.94.

4. Conclusions

With the realization of the present project, the three-dimensional modeling of a functional structure was obtained from the BIM methodology, which throughout the elaboration was condescended with restored and updated views in its plans, as an object to the principles of transversality offered by this methodology.

This allowed to reduce the presentation of anomalies, incongruities and conflicts as an indicator of the optimization of resources, time, management, planning and administration of the design processes as predisposed by the collaborative work of the BIM methodology.

Thus, through the application of the BIM methodology in the Postgraduate Building of the State University of Milagro (UNEMI) for the development of a correct planning of the project, the 3D modeling was carried out through the Revit 2022 software, observing the presentation of certain inconsistencies in the CAD drawings regarding the proper positioning of the reference axes of the building and the offset and/or clashes between networks of drinking water and sewage pipes corresponding to the discipline of sanitary engineering.

This not only allowed the timely correction of inconsistencies for the convenient development of the modeling of the structure, but also the management of its advantages at the time of observing in Revit Software, the previously mentioned errors, as well as the ease of correction throughout the design process.

In the same way, the development of the work schedule was allowed in order to carry out a correct management and time optimization at the time of construction planning through Ms Project Software, providing schematically each item to be used in the project, which led to the identification of the critical path and thus ensure the control, scheduling and management of the progress of the work.

Likewise, the approach to time and cost as the fourth and fifth dimension of the BIM methodology was a factor consistent with a functional simulation of costs and items, taking into consideration resources and the time allocated for each previously coordinated activity, promoting both optimization and the prevention of setbacks.

Finally, the development of this project allowed to demonstrate the feasibility and viability of the use of parametric resources compared to the traditional components offered by conventional methodologies of the construction industry, and its undeniable competitive, administrative and economic advantage for permanent decision making throughout the design process, granted by cutting-edge tools, such as BIM methodology, highlighting accurate information and in real time compared to linear representations promoters on a larger scale to errors and setbacks during the execution of a work.

5. Recommendations

For the use of Revit 2022 software as a three-dimensional modeling tool and the Navisworks application as an instrument for the review and integration of the model, specific technical knowledge is required to fully develop the objectives proposed for a structure, as well as access to and mastery of computer resources equipped for the proper development of Autodesk programs, capable of handling design interfaces.

Additionally, when using Revit software, it is recommended to divide the disciplines within the project into multiple templates, in order to avoid a heavy file and facilitate the rendering process without incurring technical problems associated with each computer; moreover, this way (considering the divisions of the disciplines) is how the modeling is integrated into the Navisworks software.

Likewise, it is pertinent to specify the limitations and scope of the project, considering the selected components to be worked on, maintaining a parameter within the proposed objectives and the time of its elaboration, in order to guarantee a complete work in accordance with the goals set.

On the other hand, recognizing that the project is undertaken within a purely academic framework, it is pertinent to identify sufficient disciplines and action scenarios for its approach, which will avoid information overload and the possibility of creating errors caused by the handling of computer programs in all the departments involved in a construction project.

B. References

[1] M. M. Rahman, “Barriers of Implementing Modern Methods of Construction,” *J. Manag. Eng.*, vol. 30, no. 1, pp. 69–77, 2014, doi: 10.1061/(asce)me.1943-5479.0000173.

[2] S. Cano, *Modelo Sistémico de Evolución de Lean construction SLC-EMODEL*. 2021.

[3] B.-G. Hwang, L. Zhu, and J. T. T. Ming, “Factors Affecting Productivity in Green Building Construction Projects: The Case of Singapore,” *J. Manag. Eng.*, vol. 33, no. 3, p. 04016052, 2017, doi: 10.1061/(asce)me.1943-5479.0000499.

[4] L. Sabol, “Building information modeling,” *Build. Inf. Model.*, pp. 1–285, 2014, doi: 10.4324/9781315797076.

[5] G. Guido, J. Gadze, and R. Wehbe, *Fundamentos de La Direccion de Proyectos*. 2006.

[6] D. Neill and L. Cortez, *Procesos y fundamentos de la investigación científica*, vol. 53, no. 9. 2017.

[7] X. Brioso, “El análisis de la construcción sin pérdidas (Lean Construction) y su relación con el project & construction management: Propuesta de regulación en españa y su inclusión en la ley de la ordenación de la edificación,” Universidad Politécnica de Madrid, 2015.

[8] F. Hamzeh, G. Ballard, and I. D. Tommelein, “Rethinking lookahead planning to optimize construction workflow,” *Lean Constr. J.*, vol. 2012, no. January, pp. 15–34, 2012, [Online]. Available: https://www.researchgate.net/profile/Farook-Hamzeh/publication/242112250_Rethinking_Lookahead_Planning_to_Optimize_Construction_Workflow/links/0deec51d52c5dba37c000000/Rethinking-Lookahead-Planning-to-Optimize-Construction-Workflow.pdf.

[9] M. Tamayo, “El proceso de la investigacion,” *El Proceso la Investig. Científica*, p. 256, 1994.

[10] J. Arroyo, D. Rendón, G. Flor, and S. Guerrini, “Application Of BIM 5D Methodology In The Construction Of A Children ’ s Park,” in *THE EIGHTEENTH LACCEI INTERNATIONAL MULTI-CONFERENCE FOR ENGINEERING, EDUCATION CARIBBEAN CONFERENCE FOR ENGINEERING AND TECHNOLOGY*, 2020, p. 11, [Online]. Available: http://laccei.org/LACCEI2020-VirtualEdition/full_papers/FP57.pdf.

[11] O. Zwikael and J. R. Smyrk, *Project management : a benefit realisation approach*. 2019.

[12] J. Xu, “Research on Application of BIM 5D Technology in Central Grand Project,” *Procedia Eng.*,

vol. 174, pp. 600–610, 2017, doi: 10.1016/j.proeng.2017.01.194.

[13] J. Teizer, O. Golovina, S. Embers, and M. Wolf, “A Serious Gaming approach to integrate BIM, IoT, and Lean Construction in Construction Education,” in *Construction Research Congress 2020*, 2020, vol. 2023, no. 1994, pp. 21–30.

[14] J. Arroyo, P. Alarcón, G. Flor, and N. Chamorro, “Propuesta de programación para la construcción del CPL Esmeraldas mediante el Método de la Cadena de Trabajo,” in *Proceedings of the LACCEI international Multi-conference for Engineering, Education and Technology*, 2019, vol. 2019-July, no. January, doi: 10.18687/LACCEI2019.1.1.379.

[15] A. Polanco, “Avances Tecnológicos en proyectos de ingeniería y construcción. Un enfoque integrado VDC, BIM, APD y Lean,” *Univ. Chile*, no. 1, pp. 43–58, 2020, [Online]. Available: https://www.uchile.cl/documentos/avances-tecnologicos-en-proyectos-de-ingenieria-y-construccion-un-enfoque-integrado-vdc-bim-ipd-y-lean_157519_2_2732.pdf.

[16] J. Arroyo-Orozco and D. Rendón-González, “Aplicación De La Metodología BIM 5D En La ‘Planta De Tratamiento De Agua Potable Para La Parroquia La Aurora,’” in *Proceedings of the LACCEI international Multi-conference for Engineering, Education and Technology*, 2021, vol. 2021-July, pp. 1–11, [Online]. Available: https://www.laccei.org/LACCEI2021-VirtualEdition/full_papers/FP186.pdf.