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Proposal Methodology for Highways in Ecuador Experiences of Collaborative Work Using BIM

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Abstract:- In view of the need to apply a new collaborative method in road projects in Ecuador, it is proposed the use of effective tools and adequate planning in order to avoid the waste of time and resources that today is affecting public and private entities, a consultant and a constructor in each of the stages at the time of executing a project. The use of the BIM (Building Information Modeling) methodology contributes an added value to a project in terms of schedule and cost, because it is done in a collaborative environment with good planning techniques, teamwork skills and good communication skills. In the case of the present work, since there is no experience of the implementation of a collaborative planning system in highway projects in Ecuador, so we focused on the experience of South American and Spanish construction companies, using the qualitative research narrative design as a method for collecting data, with techniques such as focus groups and life stories to then be analyzed through the ATLAS TI. These were done in order to establish the methodological patterns being used by companies to minimize or eliminate unconnected processes and activities, as well as to increase the use of construction standards and techniques to simplify construction projects. The BIM method has been adopted progressively in different countries in the last ten years because of obligatory standards that regulate the execution of engineering projects. As these norms are not yet mandatory in Ecuador, our objective was to show the advantages of the implementation of a collaborative management tools along the life cycle of a project.

Keywords:- *BIM; Methodology; Roads; Construction; Maintenance.*

I. INTRODUCTION

In Ecuador at the present time highway construction projects are mainly addressed by giving priority to 2D drawings or plans. This generates offline elements and a large number of files with little collaboration and the need for many man/hours of work. In this context, our aim was to simplify the reality of a road project by generating the documentary graphic information used to represent the design as a control and transfer tool. The procedure for verifying the technical specifications and Ecuadorian standards in this type of model is also difficult and prone to errors [1] [2].

It is thus necessary to automate the verification of each of the stages within the project life cycle, this being desirable in the public and private sphere to save time and money in terms of administrative personnel. To achieve this, it is indispensable to use a standard format for data exchange, since its inapplicability slows down progress in the collaborative field [2]

The automatic control of compliance with the regulations and specifications has been widely developed in the architectural field [4] However, several difficulties have also arisen, mainly the constant changes in building regulations that make it necessary to update the compliance criteria [1]. There are in fact many computer programs that could be interpreted, but human interaction and interpretation are still necessary because it is not possible to automate all the fields involved [6]. It is even essential to establish the regulations and the level at which they should be met. In Highway projects, design decisions can have consequences in terms of safety, functionality, operability, and costs. Although Ecuador's roads have numerous regulations they are easy to apply. It would thus be more effective to identify the regulations that could be automated for their respective application.

This is why it is necessary to identify how technological innovation implemented in other countries can influence the planning of a road project, as well as determine whether it is possible to identify applicable tools within the BIM methodology, which ensures that the effective tool is selected for integrated project management and if the BIM application can be applied to the technical, social and cultural needs of professionals and companies in the field of highway construction.

The alternative BIM solution (Building Information Modeling) is a construction computer model that, with the help of platforms and digital tools, interacts in an environment or ecosystem that is interconnected and linked to workflows. The aim is to develop a virtual pre-construction model that contains all the information and processes, as well as a network of complex interactions within a single model based on the principle of efficient information management [3]

This paper proposes a qualitative method as an alternative solution based on data collected from previous highway projects that implemented BIM management. This

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data is then compared to the system used in Ecuador and to propose a methodological procedure for road construction projects [5].

There are several existing software programs that can be used to verify the standards applied in road construction processes and optimize documents by adopting the latest technological updates. The BIM method is proposed to automate the processes to improve construction processes and highway maintenance.

II. METHODOLOGY

Since there are no obligatory norms in Ecuador for the use of BIM tools due to the lack of statistical data to demonstrate its effectiveness, we focused on the experience of construction companies in Latin America and Spain using focus groups and interviews with professionals in our qualitative research to collect the data. The qualitative data analysis was supported by ATLAS TI software.

Discussion groups were held with professionals from the road construction industry who use BIM technology for their work. In this context, the relevance of the obligation to use BIM in their bidding processes is due to the fact that it is also used for administrative and management processes. We counted on the collaboration of five professionals, two from Europe, from Spain (one from the Murcia Highway Demarcation Department, the Spanish Ministry of Development, and one from the VIC Group SL, Universitat Politècnica de València. There were also three from South America (one from the Argentine BRT (Benito Rogio Transport), Railway Specialist, one from Brazil VLT Carioca, Project Director, and one from the Chilean BIM Consultant LATAM). All five professionals have worked in various disciplines in a BIM environment and were experienced in the implementation of road projects.

We also addressed railway projects because of the similarity of the processes. We used the ZOOM virtual platform as the forum the individual interviews and group discussions. We highlighted the relationship of information, consistency of information and application consistency in road projects. We also counted on the professional experience of Ecuadorian experts in the field of road construction during the last 50 years. This part was focused mainly on the difficulty of converting a project from paper and ink to digital tools. For this purpose, information was collected from 14 companies and 6 legal experts or consortiums with wide experience in road projects in Ecuador. Information was collected on the companies' interdisciplinary experience in the development of projects and their planning strategies.

The data collected was analyzed on ATLAS.TI software, starting from the primary contact with the document, preparing the document, the analysis, and the analytical interpretation. The information was grouped into categories such as: the application of the qualitative method, ideas, concepts, and abbreviated interpretations of the quotations, thus obtaining a final result of a combined process between an ambiguous stimulus and the interpretation of the receiver, recording this procedure with an analysis matrix (see Fig. 1).

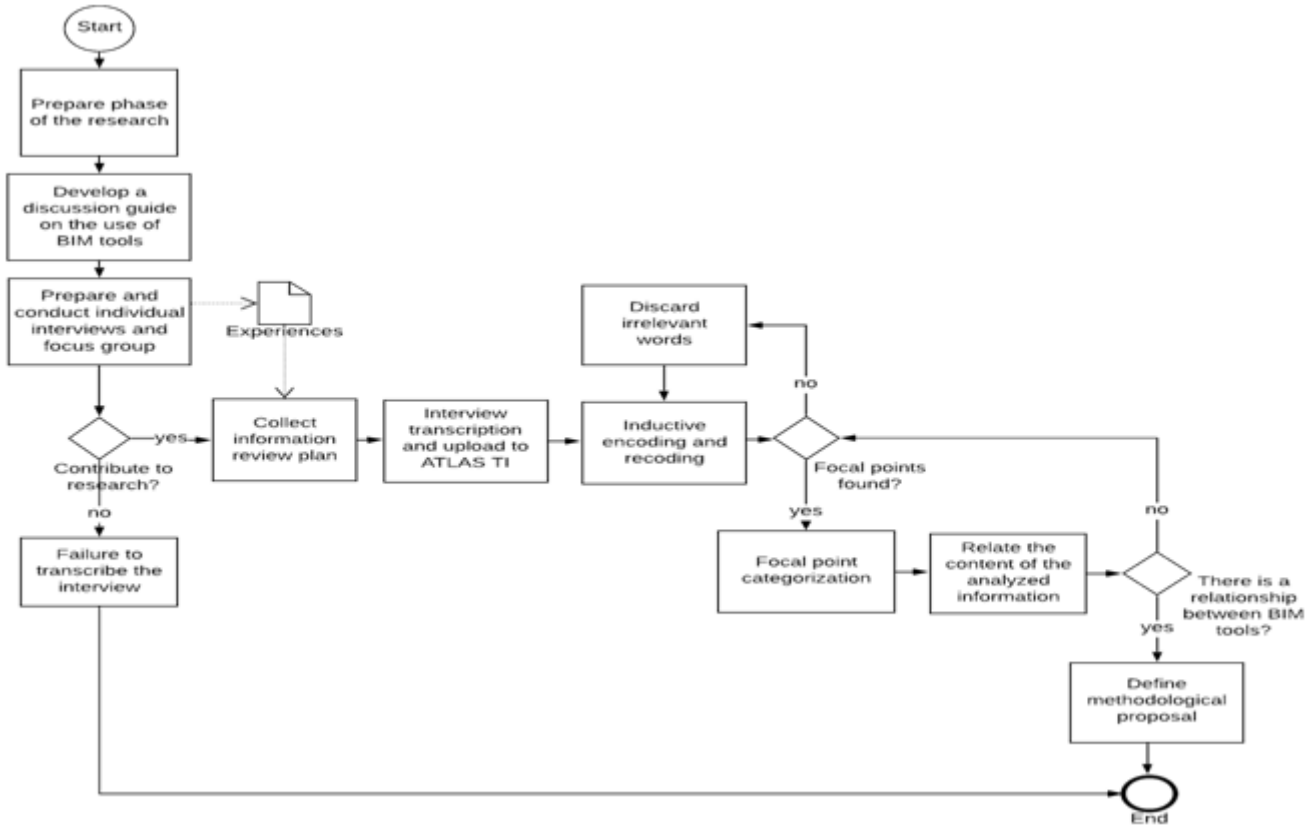

Fig. 1. The process followed to propose a BIM methodology on road projects in Ecuador

III. RESULTS AND DISCUSSION

A. Analysis of BIM Platforms and Tools

After interpreting the experts' information on the use of BIM it was found that there are several platforms and tools available for digital data processing. We therefore start with an analysis of the most widely used BIM platforms and tools.

1) BIM Platforms

The "BIM Creation Tool" or "BIM Authoring Tool" is a central BIM information generator and compiler that contains functions to maintain the integrity of a model based on parametric and object-based modeling capabilities. It can be used to develop or create digital and data-rich graphic BIM content during the design of the BIM models' virtual construction process. Information can be created from the geometry of walls, columns, ducts, valves, pipes, and others. These tools must have the ability to embed information in the model.

The parametric capacity of a platform refers to creating a 3d model which automatically generates views such as plans, elevations, cross-sections, and planning tables (drawings are not a set of manually coordinated lines that enclose and represent spaces, but an interactive representation of the model)

Working on a BIM platform ensures that a change in one view will propagate to all the other model views. All the information is parametric and therefore interconnected. As modifications are made to the plant components, these changes appear dynamically in elevation and cross-section, keeping the views consistent.

Changes and modifications are bi-directional, translating into considerable productivity improvements, highly coordinated documentation, and reduced errors. The components added to the model have the ability to link, receive, or export sets of attributes with information on structural material, acoustic data, technical data and similar to other applications and/or models.

The most common platforms used are Allplan, AutoDesk Revit, Tekla Structures, Bentley AECOsim, ArchiCAD, and Vectorworks.

Each one has its specific characteristics, strengths, and weaknesses; Autodesk Revit is one of the most widely used BIM platforms because it has a set of 3 different specific functions according to the area involved: e.g. Architecture, Structure, and MEP (Mechanical, Electrical, and Plumbing). These BIM designs modeled in Revit Architecture, Structure, and MEP are synonymous and linked together.

Although the platforms work similarly, each one has its own idiosyncrasies. There is not necessarily a single piece of software that works for all projects, all companies or all design team members.

2) BIM Tools

These include all the applications capable of transmitting, receiving, and processing information from BIM models within a BIM workflow in association with BIM platforms. In other words, they are used to analyze the model components or data generated on a BIM platform, but not for its creation.

The analysis is based on the attributes incorporated in the model in an appropriate manner, for which values are set and adjusted to suit the needs of a project.

Examples of BIM Tools:

a) *BIM visualization tools:* These tools allow the visualization and navigation of BIM models, and have the ability to review, mark, annotator, measure, and others, depending on the viewer. The most common include: Autodesk Design Review, Autodesk Navisworks Freedom, Solibri Anywhere, and Tekla BIMsight.
b) *Conceptual Design Tools:* Rhino, SketchUp, and Autodesk Formit conceptual or surface design tools are used in the conceptual design phase of a project where generic masses are created to have a morphological, versatile, and flexible approach to the formal model and to be able to carry out qualitative, quantitative, cost, solar impact, and energy efficiency analyses, among others. *The reason why BIM creation tools are not used for conceptual modeling in the early stages of the project is that they restrict design exploration and have limited capabilities in dealing with complex conceptual models, so alternative tools are used instead. While some BIM platforms have built-in mass creation functions to overcome this weakness, they do not offer as much flexibility as the specific tools.*
c) *Energy Analysis Tools:* these tools can design sustainably based on the building's performance, analyzing factors such as natural light, shadows, thermal comfort, energy use, and natural ventilation, among others. Examples include: Ladybug, Autodesk Insight, Sefaira, and Graphisoft ECODESIGNER.
d) These tools can perform a wide range of advanced structural analysis, such as static, modal, seismic, spectral, and other analysis types. After determining the structure's response to the different forces acting on them, these tools allow us to dimension and design structural members such as beams, columns, walls, etc. The most commonly used structural analysis tools include: Autodesk Robot Structural Analysis, CYPECAD, Staad Pro, SAP2000 and ETABS.
e) *Construction Simulation Tools or 4D Modeling (4D Scheduling):* These use the visualization method in the project schedule, resources, quantities, and project phase are incorporated.

In general terms, the 4D models are essentially 3D models with time associations where the latter represent the fourth dimension. Each component within the model is linked to the schedule data in this way. When the GAND diagram is animated, the construction simulation is developed, allowing the detection of incorrect or inconsistent schedules, closed sequences, and resource allocation problems, among others.

These tools can also add animations such as machine movements, cranes, and workers. Some examples are: VIGO OFFICE, SYNCHRO, and Navisworks.

Other types of tool include those used in cost estimation without the 5D model, those used in the generation of specifications, those used in class detection analysis, among others. It should be noted that many of these tools can be considered BIM tools only to the extent that they support a BIM workflow.

B. Interpreting the Results

After the corresponding analysis of the platforms and tools most used by the experts for developing a project, we now consider the applied specialties, which are necessary to generate a BIM environment (BIM ecosystem). This is a set of BIM interconnected applications linked to workflows to support multiple lines of information and processes in a project or an organization, thus forming a network of complex interactions.

BIM environments cover the various platforms, tools, servers, libraries, and processes within the project or organization. Having a well-established and configured BIM environment thus allows you to connect various processes applied by both internal and external teams between organizations, thus obtaining maximum efficiency of the set of applications that need to be used.

With all these definitions and examples taken from the experts' experience in large road projects, they all agreed that "BIM tools not only accept models created by BIM platforms but can also accept CAD models. In a BIM process with stable interoperability conditions there is no loss of information. In contrast, if we do not use BIM creation tools in a traditional process there will always be a loss of data that must be returned to the application that performs the desired analysis, which translates into redundant efforts, lost time and reduced productivity.

The local experience has shown that the use of digital tools has intensified in the last 20 years and has improved the industry's production and manufacturing processes, and is not widely taken advantage of at present. The current use of digital tools is limited by the fact that public entities do not invest in systems that help improve the processes due to the high cost of software licenses.

Of the local construction experts consulted on BIM tools and platforms, only 6% had the knowledge and the opportunity to work within a BIM environment, 53% had used a single BIM tool but have not worked within a BIM environment, while the remaining 41% were not familiar with BIM tools and only use AutoCAD 2D. The professionals who handle BIM tools outside a BIM environment do so only with the aim of modeling and obtaining data from the attribute tables and enter the data manually, due to ignorance of the tool and a limited vision and .

The fundamental base of BIM technology is in the preliminary project phase, where it is fundamental to have a clear idea of the plan of execution. This is where the biggest investment is in resources and involves between 50 and 75% of the time. This initial investment will generate and effectively develop the work process in the planning and execution stages. The processes carried out on AutoCAD are not very collaborative and are not reliable, and require 125% more time than BIM, and generate limited confidence at the time of execution because adjustments are still being made to the design (see Fig. 2).

Fig. 2. Adaptation to BIM methodology

BIM has been involved in public contracts all around the world since 2014, using electronic systems in processes, services, and supplies. BIM standardization will gradually be incorporated into the public sector, and is currently mandatory in some countries, as well as the BIM Guidelines. Isolated public and private initiatives are gaining strength and Ecuador is practically isolated from this new visual information concept.

Productivity in the construction sector seeks to optimize the production factors by maximizing production through technical progress (see Fig. 3).

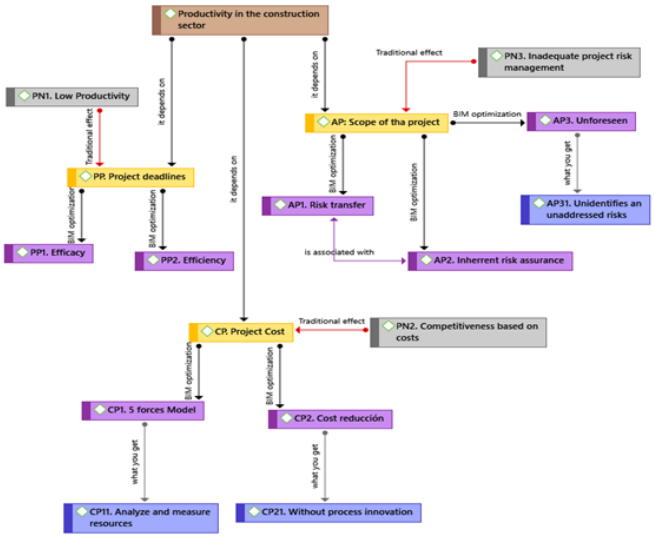

Fig. 3. Productivity in the construction sector

The project execution can be optimized in the management stages (see Fig. 4).

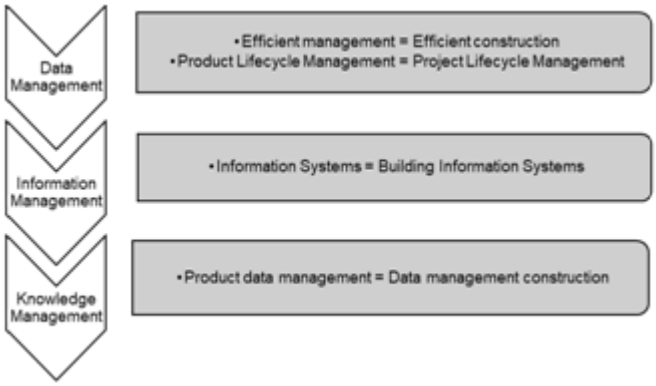

Fig. 4. Construction Manufacturing

From the results obtained, it can be established that we must clearly define the potential value of BIM in projects by laying down general BIM implementation goals, once measurable and realistic goals have been defined by the company and the project, specific uses can be identified that have a direct relationship with these goals. The guide defines it as a "unique task or procedure in a project that can benefit from the integration of BIM in the process".

Table1 represents some of the most common BIM uses incorporated into a project and the stage in which it should be integrated.

BIM uses in the stages of a project

BIM Uses	Stages of a project			
	Planning	***Design***	***Construction***	***Operation***
Modeling of existing conditions	X	X	X	X
Cost Estimates	X	X	X	X
4D Modeling	X	X	X	
Spatial Programming	X	X		
Site Analysis	X	X		
Design Reviews	X	X		
Design Authorship		X		
Energy analysis		X		
Structural analysis		X		
LEED Evaluation		X		
3D Coordination		X	X	
Digital Manufacturing			X	
Asset Management				X

This BIM will depend on the size, complexity, and characteristics of the project, as well as the skills of the participants and to certain extent the BIM capacity, as well as its maturity level in the organization. The team must identify and prioritize appropriate uses that are beneficial to the project and can help achieve the proposed goals, for example these could include the following:

- Reducing the duration of the Schedule.
- More efficient installation of MEP systems.
- Reduction of change orders.
- Improve project quality.

IV. CONCLUSIONS

Technological development is undoubtedly contributing to the progress of humanity in the context of construction management in highway projects. BIM can reduce material losses, facilitate project monitoring, and raise profitability. The success of large construction companies is largely due to the planning method they use, with BIM concept being the best option in most of them. The planning of a BIM methodological proposal therefore depends on the special requirements and needs of each project. The interoperability of BIM tools has an effective, fast, reliable, and collaborative implementation plan in a company's work processes.

Although there are BIM tools for engineers is limited in the case of the application in highways. Furthermore, despite packets covering a road project from its visualization, concept, energy analysis, structural analysis, and modeling, there are still specialties that cannot work within this collaborative environment as geology, hydraulics, and others. The need to enrich this collaborative environment is that the specialties of civil projects in highway analysis may have worked in environments where design is mostly strengthened since it is the essential stage within a project that develops with BIM.

The recommendation made within the stages of a project does not indicate the application for highways. Instead, it covers a general scope of the project due to the limited tools for developing roads. In this context, it represents that professionals' inroads have different demands and a new workflow, so it should seek to open the experience of BIM use in new areas associated with the construction. Hence, the

collaborative environment that represents this tool generates more advantages in managing a road project.

The expression "collaborative" is the key to road projects. It implies that the professionals who are involved can communicate, transparency, responsibility, commitment, and production; that which would represent to improve the useful constructive techniques, to strengthen the skills in the teamwork and to be good communicators; that is why the BIM tool would reinforce this area of the engineering.

Accordingly, the collaborative environment is essential for developing a strategy based on a digital tool such as BIM. Then, it is so important to grow together with professionals who can cover specific areas of this work environment since it is not relevant the individual growth but rather promote community growth within the road builders of Ecuador.

As for further work, we pretend to get involved in-depth in our initial proposal study and to optimize resources within the projects I develop; as well as establishing a production line of work that effectively manage the data, information, and knowledge so that as you experience a BIM methodology can have the know-how that serves as a reference to road builders in Ecuador and be a reference within the production processes and work management.

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