Assessing the Effectiveness of Building and City Information Modeling (BIM&CIM) in Enhancing Drainage System Projects in the Philippines

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***Abstract*—The Philippines, a country geographically located in the Pacific Typhoon Belt, experiences an average of about 20 typhoons per year. When typhoons are experienced, and most especially when it is frequent, flooding is a hazard for the safety, health, and loss of possession. In the year 2024, the Philippines experienced floods in areas that previously had no flooding and are now devastated. Specifically, Tropical Storm Kristine has brought the most severe flooding at some areas in the Bicol region in 30 years. Many causes result in flooding; many of which are caused by pollution, some can be attributed to ineffective drainage systems and its maintenance, or even due to changes in weather patterns and intensity. In this research paper, the researchers aim to provide a possible path toward the improvement and development of drainage systems for developing cities using Building Information Modelling (BIM). Building Information Modelling is a group of software wherein planning, 3D modeling, simulations, and many other features can provide an efficient and effective project management tool. In conjunction with using this software, a process called Civil Information Modelling (CIM) will also be introduced, which will be a significant part of the urban planning process for such developing cities. Thus, with the help of Building Information Modelling (BIM) software and the Civil Information Modelling (CIM) process, the researchers aim to provide a possible path towards a solution to the flooding problems in the Philippines.**

Keywords—Drainage Systems, Building Information Modelling (BIM), Civil Information Modelling (CIM), Urban Planning

I. INTRODUCTION

The Philippines is a country that is prone to tropical cyclones, heavy rainfalls, and high intensities of wind. In recent years, 20 occurrences of typhoons on average have ravaged the country and all of its islands each year (PAGASA). Due to the frequent typhoons in the country, there is a need to provide a solution for a sustainable and effective drainage system that can handle the severity of the effects caused by typhoons experienced today. There is an idea that Filipinos are resilient people, coined from their resiliency, courage, and unity amid a calamity. However, this resiliency masks the real problem: the lack of effective drainage systems capable of withstanding the severity of typhoons, the lack of maintenance on existing drainage systems, and other flood control projects. Also, improper disposal of waste materials will only lead to more severe flooding in the coming years.

Many cases in the Philippines are flooded for the same reasons. May it be due to a lack of urban planning, unsafe settlements for homeowners, low-lying areas, and places close to a body of water that quickly rise. However, these are the same problems that make it difficult to find a path towards finding a solution to our already settled cities without any room for major changes. Towards economic development, the need for urban planning is second to none for a developing city.

A. Background of the Study

Building Information Modelling (BIM) is a construction management software capable of creating 3D models of a design, a landscape, etc. It is also capable of efficiently coordinating with the different members of the project. Using this construction management software is not new in the construction industry internationally, in fact, it is widely adopted by countries like Japan, the United States, Singapore, the United Kingdom, etc. [1]. Using Building Information Modelling (BIM) for developmental project planning and construction phases can reduce risks and improve efficiency overall. With the help of Civil Information Modelling (CIM), a process that makes urban planning a possibility, shall aid in implementing sustainable and effective systems.

The present situation of BIM in various countries has been the subject of several previous research. These also examine the reasons for using BIM technology, the difficulties encountered, and its determinants of success. The study written by Jones describes the broad acceptance and development of BIM in the UK [2]. The results indicate that while life cycle thinking and waste reduction are frequently disregarded, collaboration and the blending of product (software) and process innovation are the benefits that are most frequently reported, and according to the study of [3], Dubai Municipality (DM) became the first authority to command Building Information Modeling (BIM)

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implementation in UAE. Ever since, many businesses in Dubai have invested in BIM technology to secure their existence and seize new chances. The UAE's academic community is also gradually adopting BIM into its curriculum to facilitate this transformation.

On the other hand, the many building projects targeted at boosting and improving the infrastructure in various cities around the Philippines are evidence that the country's construction industry is expanding. In fact, it was anticipated that public infrastructure investment would reach a record high of $17.7 billion in 2017 [4]. A few architectural design firms in the Philippines began incorporating BIM technologies into their workflows in 2005, utilizing software like Revit, because of this, engineering and consulting organizations adopted the usage of BIM ideas to keep up with the industry's growing trends. Given these advancements, there is a growing need to educate both lean advocates and implementers about the capabilities of BIM and to educate BIM enthusiasts and users about lean concepts, methodologies, and tools. Thus, given that BIM adoption is becoming a more popular trend in the AE&C sector, the Philippine construction industry should be aware of it and prepared for it.

B. Scope and Limitations

This study provides data on how Building Information Modelling (BIM) can improve the quality and efficiency of managing and constructing utility systems against flooding. The goal of this study is to examine BIM's effectiveness in comparison to other construction management software and processes presently used in the construction industry here in the Philippines. The study considered all of the respondents' opinions and insights about BIM's potential for improving efficiency during the planning phase of a project and the implementation stage of a project.

The data gathered in this research is only limited in scope to the insights and opinions of Engineers with knowledge and experience in using BIM software.

II. METHODOLOGY

A. Research Design

The study used a quantitative research method based on the correlational method, which involves looking for relationships between variables [5] [6] [7]. Quantitative research is concerned with quantifying and evaluating variables to get outcomes. It entails using and analyzing numerical data using specific statistical methodologies to verify pre-formed assumptions and theories and to answer questions such as who, what, when, when, where, how much, and how many [8] [9]. This approach was chosen since the study's goal was to conduct a questionnaire and form a general idea of the Engineers' opinions and insights about the efficacy of Building Information Modelling (BIM) compared to alternative construction management software being implemented in the Philippines. Specifically, the research focuses on the application of BIM and CIM and their benefits in designing and constructing drainage systems, evaluating their efficiency in improving planning, coordination, and overall project outcomes. The research phases, as well as the necessary instruments and objectives, are provided [10].

Phase 1: Define the role and impact of utilizing Building Information Modelling (BIM) in improving the efficiency and quality of work of the Underground Drainage Systems.

During the first phase of the thesis paper, the researchers colluded in gathering and understanding already accomplished research papers and/or literature connected to the paper's topic. During this phase, the researchers can define the Building Information Modelling, its uses, etc., for possible improvements in overall planning and the different phases in project development.

Phase 2: Define Civil Information Modelling (CIM) as a process and how this process will improve the design quality and product quality of the drainage systems.

During this phase of the research, the researchers will define the role, process, and possible benefits of implementing Civil Information Modelling (CIM), as a process, in conjunction with the software available in Building Information Modelling (BIM).

Phase 3: Find similar studies that researched the effectiveness of Building Information Modelling (BIM) in improving the efficiency of the designing process and its implementation.

During this phase, the researchers used a questionnaire from a similar research that had previously studied the effectiveness of Building Information Modelling (BIM). The questionnaire is revised to make the questions relevant here in the Philippines. It shall serve as a basis in constructing a structured questionnaire that is both relevant and applicable here in the Philippines.

Phase 4: Compare the planning phase and construction phase of Infrastructures made with Building Information Modelling as opposed to the traditional Philippine practices.

This is the data-gathering phase of the paper. The researchers hand out the questionnaires to the paper's target audience. Before the questionnaires are answered, the researchers will briefly introduce both traditional and BIM methods in project development to give the surveyee a brief understanding of what the research is about.

Phase 5: Compare and examine the responses of the participants about their evaluation of the subject matter

This phase is specifically for data interpretation. The researchers used descriptive analysis to compare and describe the answers/opinions made by the surveyees per question. The researchers shall interpret these general descriptions or opinions of qualified individuals to determine the consensus of the majority. From the interpretations made by the researchers, the researchers also verified these interpretations with a qualified expert in the field.

Phase 6: Create an analysis of the effectiveness of project development and project outcome utilizing Building Information Modelling (BIM)

With the validation from a qualified expert, the researchers composed an evaluation of the data, general descriptions, and interpretations. Hence, it concludes and explains the consensus made by the target audience.

B. Data Gathering Instruments

The questionnaire is also divided into three sections. The first section is the demographic profile, which includes the respondents' names, professions, years of experience in the field, their familiarity with Building Information Modeling (BIM), and which software they have used in drainage system projects. The second part will focus on the adoption, benefits, and challenges of BIM in drainage projects. The last part considers the perceptions and future of BIM in Drainage Systems, this section will gather expert opinions on BIM's potential in the Philippine construction industry.

C. Statistical Treatment Instruments

This study will conduct a Quantitative analysis with a Descriptive Statistics approach. To analyze the data in this study quantitatively, a descriptive statistics method will be utilized to furnish a comprehensive overview of the gathered information. Various statistical metrics will be applied to the questionnaire responses to characterize and summarize the essential aspects of the dataset. Metrics, including mean, median, mode, standard deviation, and range, will be computed for each pertinent variable outlined in the questionnaire. This approach aims to reveal the central tendencies, variabilities, and distribution patterns inherent in the dataset. Beyond providing a snapshot of participants' perspectives and experiences concerning Building Information Modeling (BIM), using descriptive statistics will facilitate systematic exploration of infrastructure design quality concerning flooding and typhoon-related constructions.

III. Results and Discussion

The first section of the survey focuses on General Information, which includes general questions regarding the respondents' background. This section aims to provide an overview of the respondent' professional background and their level of familiarity with Building Information Modeling (BIM) and City Information Modeling (CIM).

Among the 15 respondents, were engineers, project managers, and architects, all 15 respondents are familiar with or know Building Information Modeling (BIM), whereas only 4 respondents indicated familiarity with City Information Modeling (CIM). In addition to assessing familiarity, the survey also included a question about BIM and CIM software that respondents have used. The respondents were asked to select all the software they were familiar with, allowing for a broader understanding of their technical expertise.

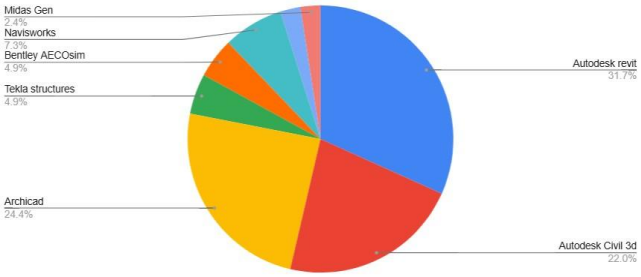

Fig. 1. Familiar BIM Software

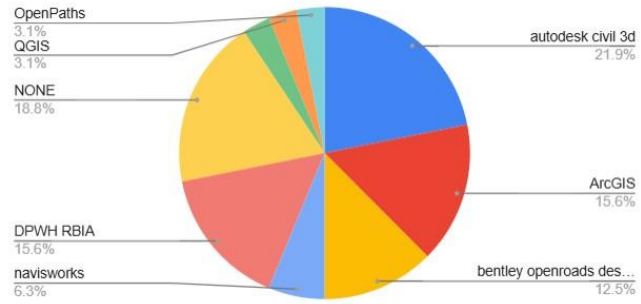

Fig. 2. Familiar CIM Software

To gain further insight into the respondents' background in software usage, the respondents were asked to list other software they had experience using. The figure below indicates the familiarity of the respondents in utilizing this software. The figure also indicated the percentage of respondents without prior experience in utilizing the software. The data gathered in this section provides valuable insights into the respondents' familiarity with BIM and CIM software, as well as their broader technical proficiency.

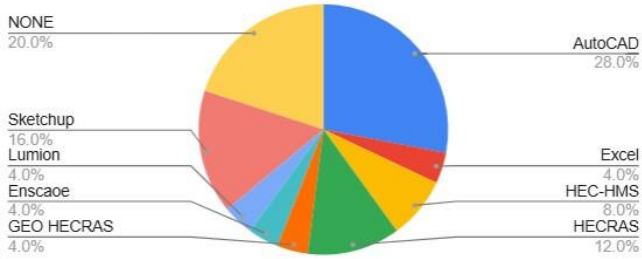

Fig. 3. Software Used by the Respondents

Based on the findings, none of the 15 respondents was able to use any of the BIM or CIM software in any of the projects they have worked on. Hence, the data also suggests that none of the respondents was able to use these kinds of software for drainage projects. Based on these findings, the data suggests that BIM and CIM software are not highly adapted to most projects in the Philippines.

In the second portion of Section II, the respondents were able to give their opinions on the benefits of BIM software in the grand scheme of the construction industry and specifically its benefits for drainage projects in the Philippines. The figure below shows the respondents' confidence level in the benefits this software will promote when implemented on Drainage Projects.

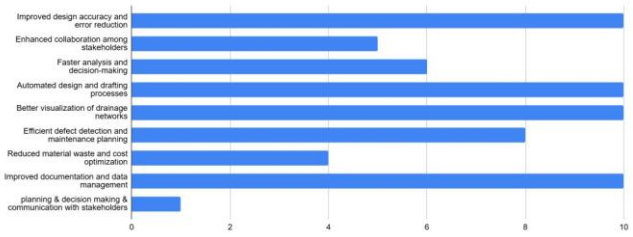

Fig. 4. Benefits of BIM in Designing and Implementing Drainage Projects

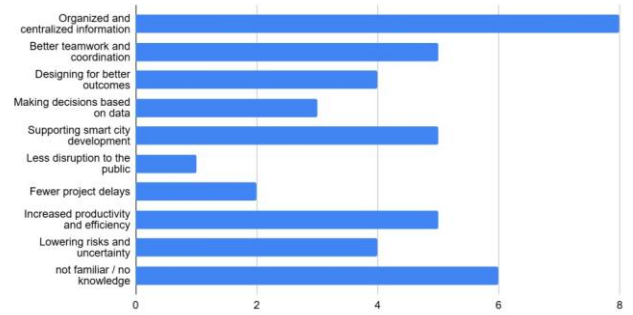

Fig. 5. Benefits of CIM in Designing and Implementing Drainage Projects

The next portion of Section II is about the challenges in the implementation of BIM and CIM in the Philippines. The figure below shows the respondents' issues with its implementation here in the Philippines, specifically for drainage projects.

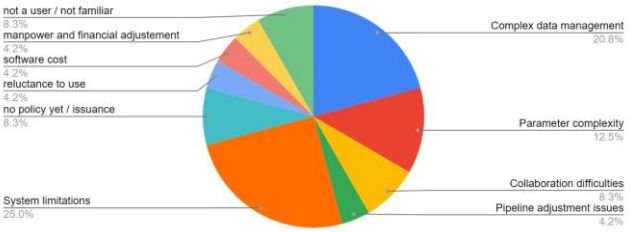

Fig. 6. Challenges in the Adoption of BIM

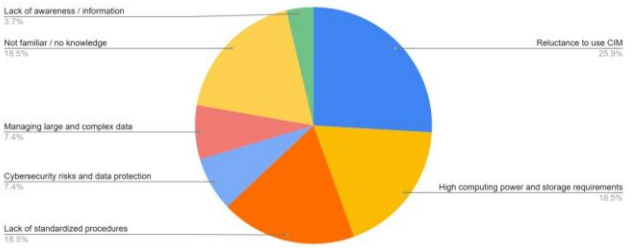

Fig. 7. Challenges in the Adoption of CIM

For the last part of Section II of the survey, the researchers gathered data from the respondents by measuring their confidence in BIM and CIM software for the given parameters. Based on the data, the respondents deemed that the effectiveness of BIM in design optimization, collaboration, and real-time data analysis is very high, with a mean score of 4.667, 4.2, and 4.267, respectively, out of a maximum score of 5. It was also determined that the most frequent ratings made by these same parameters were 5, 4 and 4, respectively. For the variability of the data sets, the computed standard deviation score for the same parameters was determined to be 0.48795, 1.01419, and 0.70373, respectively.

On the other hand, the effectiveness of CIM in design optimization, collaboration, and real-time data analysis was also very high, with a mean score of 4.727, 4.000, and 4.364, respectively, out of a maximum score of 5. It was also determined that the most frequent ratings made by these same parameters were 5, 4 and 5, respectively. Lastly, for the variability of the data sets, the computed standard deviation score for the same parameters was determined to be 0.46710, 0.61187, and 0.94081, respectively.

Section 3 of the survey presents the respondents' perceptions regarding Building Information Modeling (BIM) and City Information Modeling (CIM) and their perspectives on the future of these technologies in drainage system projects. Respondents were first asked what improvements should be made to encourage the wider adoption of BIM in drainage projects. The figure below shows the respondents' insight on what improvements are needed to be made before the adoption of this software.

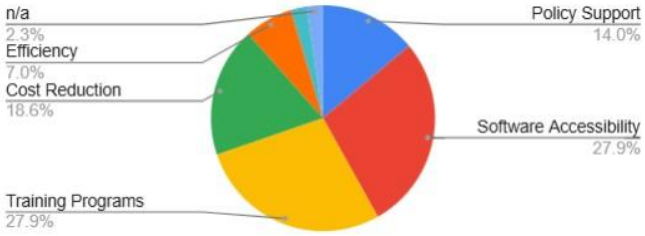

Fig. 8. Improvements to be Made Before the Adoption of BIM software

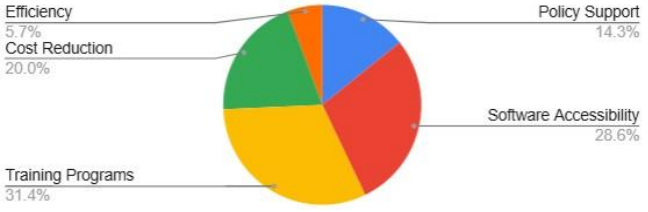

Fig. 9. Improvements to be Made Before the Adoption of CIM software

IV. Conclusion and Recommendations

A. Conclusions

Based on the findings, it indicates that BIM and CIM are good systems for better assisting the drainage system development in the Philippines. Project visualization, design optimization, and collaborative tools are some other advanced methods that could be employed for resolving the constant problems that already exist in the country with respect to flood management. With the use of digital models, project stakeholders can make informed decisions, with the goal of minimizing errors in construction through design and construction.

However, various factors have been hindering progress in standardizing BIM and CIM. The adoption of BIM and CIM

in mainstream engineering and construction has been hindered by limited technical expertise, financial barriers, and the absence of robust policy frameworks. Another factor that keeps many construction practitioners from realizing the potential benefits that BIM and CIM hold for construction is the lack of sufficient knowledge and training on their proper utilization.

One of the main lessons from the study is that adopting BIM and CIM should be a gradual and well-planned process. To make the transition from traditional methods smoother, it's important to take the following key steps:

1. Government-led Initiatives
2. Training Programs Across All Sectors
3. Pilot Studies and Case Demonstrations
4. Cost Reduction Strategies
5. Enhancing Collaboration Between Public and Private Sector

B. Recommendations

Future researchers are encouraged to explore the integration of BIM and CIM in drainage system projects on a larger scale, considering real-world applications and local case studies. Further studies can assess the cost-effectiveness, implementation challenges, and policy implications to support wider adoption.

For industry professionals and policymakers, investing in software accessibility, training programs, and policy support is crucial to maximizing the benefits of BIM and CIM. Collaboration among engineers, architects, and government agencies is recommended to enhance design accuracy, efficiency, and flood resilience through data-driven solutions.

To further assess the role of BIM in drainage system projects, respondents were asked whether BIM should be required in such projects. The majority (13 respondents) answered “Yes”, citing reasoning such as improved design efficiency, enhanced workflow and data management, increased accuracy, better visualization, and more reliable database-driven analysis. The respondents also highlighted the importance of BIM in reducing project costs, improving scheduling, enhancing post-construction data management, and integrating advanced clash detection capabilities. Furthermore, some respondents emphasized that BIM aligns with global construction trends and enhances flood resilience through data-driven simulations. However, one respondent opposed requiring BIM, arguing that while BIM is efficient, drainage systems can still be modeled using any stand-alone software.

Regarding CIM, respondents were similarly asked whether it should be required for drainage system projects. Eight respondents supported its mandatory implementation, citing benefits such as improved efficiency, enhanced workflow, large-scale data analysis, better coordination, increased design accuracy, and integration of urban-scale data for flood management and infrastructure planning. Some respondents noted that CIM can enhance resilience against climate change and contribute to efficient city-wide drainage system design. However, two respondents stated that they were unfamiliar with CIM and required further study to determine its effectiveness, while one respondent suggested that its adoption should depend on its ability to address flooding issues in city planning. One respondent opposed its requirement, while four answered "N/A."

The researchers included a portion of Section III in determining their opinions on the initiatives needed for the wide-scale adoption of BIM and CIM software in the Philippines. Most of the initiatives required the private sector and the government to take initiatives towards the adoption of BIM and CIM. In addition, some respondents mentioned the need to establish standard procedures and policies. It is also widely known that BIM and CIM software cost a lot since they require not just one entity in a project to make it work. The primary selling point of this software is its improved collaboration and communication with different entities.

In the later portions of Section III, the researchers required the respondents to rate and explain their stance on the likelihood of BIM or CIM adoption being prevalent in 5 years. Based on the data for the possibility of BIM adoption in 5 years here in the Philippines, the respondents were unsure if BIM adoption will come in the near future.

Based on the responses, there are underlying problems in the adoption of BIM in the next 5 years since policy development for its adoption is still in its early stages within DPWH. Although most of the respondents were aware of BIM, most of them had little to no training and experience with such software. Other reasons included cost and lack of proper equipment.

On the other hand, CIM adoption is also deemed to have slow progress. Since most of the Engineers had little to no knowledge of CIM, it can be considered to that it would take longer for CIM methodologies to be implemented here in the Philippines. With a mean score of 3.231 out of 5, the respondents do not feel confident about the wide-scale adoption of CIM methodologies in the Philippines.

In the last part of the survey, the researchers gathered additional comments from the respondents. The majority of the feedback emphasized that BIM and CIM have the potential to significantly enhance engineering design processes, particularly in the development of drainage systems. However, several respondents expressed concerns regarding the implementation of these technologies, as neither BIM nor CIM is currently utilized in their respective workplaces.

Notably, some respondents suggested conducting a pilot study to evaluate the impact of BIM and CIM on design processes, as well as a proof-of-concept study to further justify their necessity. Additionally, concerns were raised regarding the cost implications associated with the adoption of these technologies. Beyond discussions on

implementation and benefits, respondents also expressed a strong willingness to learn and integrate BIM and CIM into their professional practices.

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