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IMPLEMENTATION OF A GEOGRAPHIC INFORMATION SYSTEM IN MONITORING THE IMPLEMENTATION OF HOUSING CONSTRUCTION

Bukhori [1*], Aryati Indah Kusumastuti[1]

[1]) Civil Engineering Departement, Universitas Swadaya Gunung Jati, Cirebon.
[*]Corresponding Email: bukhoricrb@gmail.com
Number HP: 081802300447

ABSTRACT

Building the 864-unit housing complex was a significant construction undertaking. Within an implementation period of 18 months and a project area of approximately 34 hectares, this project demanded efficient management to control the time and budget that had been set. In achieving our objectives, effective strategies are crucial, requiring meticulous planning, seamless organization, adept management, and judicious resource allocation. The goal is to simplify project management by breaking it down into digestible tasks with time estimates and continuous monitoring. While tools like Primavera and MS Project provide temporal representations, they lack spatial monitoring within the project scope. This limitation impedes a holistic understanding of spatial dynamics crucial for comprehensive project management. Thus, the quest for a more encompassing approach persists, urging exploration of innovative avenues to bridge the gap between temporal representation and spatial comprehension within the project's framework. By integrating Geographic Information Systems (GIS), this project can gain additional benefits. GIS allows identifying data about the progress of construction tasks, and then presenting them in the form of maps. This not only visualizes overall progress graphically and geographically, but also makes it easy to extract useful summaries to support project decision making. With GIS, construction project monitoring not only becomes more efficient, but also more up-to-date and relevant to the scope of the project involving various dispersed structures. It is hoped that GIS integration can improve project management control and optimize the final results of the construction of the 864 housing complexes.

Keyword: *Monitoring Construction, Projects Construction, Monitoring Real-time, Geographic Information Systems (GIS).*

1. INTRODUCTION

Developer Trusmiland seeks to build 864 housing units in Pamengkang Village, Mundu District, Cirebon Regency along with various service facility buildings (Figure 2). This research aims to provide an easy-to-understand tool for project implementers and project owners to monitor work progress, considering the large and complex data that must be managed and the project's spatial coverage of 34 ha. Project managers continue to rely on traditional planning methods such as bar charts, Critical Path Method (CPM), and Program Evaluation and Review Technique (PERT) for project planning. However, these methods exhibit notable weaknesses in decision-making, primarily due to their failure to incorporate essential spatial aspects and data [1]. Gantt charts, a specific type of bar graph, present start and finish dates and progress ratios for project tasks. Despite their utility in tracking task progress, Gantt charts lack the ability to provide a spatial or geographic map for monitoring work tasks within specific locations [1]. Recognizing these limitations, Geographic Information Systems (GIS) emerge as a crucial tool. GIS not only fills the gap by offering accurate project information to project managers and stakeholders from diverse backgrounds but also enables visual monitoring of activities and cost flows at each project stage [2].GIS stands out as the preferred tool for meeting these needs, ensuring easy data identification and presentation through various thematic maps. This system facilitates the graphical representation of global construction progress, allowing for the extraction of specific information through simple attribute queries [2]. By combining spatial and temporal dimensions, GIS provides a comprehensive solution to enhance project management efficiency and decision-making processes.

2. LITERATURE REVIEW

2.1. Geographic Information Systems (GIS)

A Geographic Information System (GIS) comprises hardware, software, data, human expertise (brainware), organizations, and institutions employed for the purpose of gathering, storing, analyzing, and sharing information concerning specific areas on the Earth's surface [3]. GIS, an abbreviation for Geographic Information System, serves as a means of conveying information related to objects in the spatial context, presented in the form of regions and encapsulated as spatial information [4].

GIS possesses the capacity to link diverse data points at specific locations on Earth, amalgamate this information, conduct analyses, and ultimately derive conclusions. The data manipulated within GIS is spatial in nature, meaning it is geographically oriented and tied to specific locations with a defined coordinate system serving as a reference basis. Consequently, GIS applications are adept at addressing various inquiries, including those related to location, environmental conditions, trends, patterns, and modeling. It is this unique capability that sets GIS apart from other information systems, allowing it to provide comprehensive insights into spatial data and contribute to informed decision-making processes.

A Geographic Information System (GIS) is a comprehensive system that includes hardware, software, data, human expertise (brainware), as well as organizational and institutional components. It is employed for the purpose of gathering, storing, analyzing, and sharing information about specific areas on the Earth's surface [5]. GIS, also known as Geographic Information System, serves as a means of presenting information related to objects in the spatial context, represented as regions and encapsulated within spatial information [6].

GIS possesses the capability to link diverse data points at specific locations on Earth, amalgamate the information, analyze it, and ultimately arrive at conclusions [7]. The information processed in GIS is spatial data, meaning it is geographically oriented and associated with locations having a specific coordinate system, serving as a reference basis. Consequently, GIS applications are equipped to address a range of inquiries, including those related to location, environmental conditions, trends, patterns, and modeling [8]. This unique ability distinguishes GIS from other information systems, enabling it to provide comprehensive insights into spatial data and contributing to informed decision-making processes.

2.2. Monitoring and Evaluation

Monitoring is a descriptive assessment process designed to identify and/or measure the impact of ongoing activities without delving into questions of causality. [9]. In contrast, evaluation encompasses a series of activities that involve comparing the achievement of inputs, outputs, and outcomes against predefined plans and standards.

2.3. Project Overview

The ongoing construction of 864 houses unfolds in two distinct stages, with Figure 2 illustrating their distribution within the project area. Raja Sukses Propertindo employs a percentage completion contract, as outlined in Table 1, wherein the project is systematically broken down into 18 primary activities. Monthly invoicing is intricately linked to the progression of these activities, reflecting the evolving nature of the work. Noteworthy is Raja Sukses Propertindo's specific interest in delving beyond the overarching progress ratio for each activity. They are keen on a granular understanding, scrutinizing the

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progress for each activity at the level of individual houses. This meticulous approach stems from the agreement to transform the amassed work progress data into maps, offering Raja Sukses Propertindo a nuanced visual narrative of the construction's unfolding. The objective is to provide a lucid depiction of what is being built, precisely when and where, enabling Raja Sukses Propertindo to navigate the project's complexities with clarity and informed decision-making.

3. METHODOLOGY

3.1. Implementing GIS for Building Work Progress Monitoring

In recent years, there has been a swift advancement in the realm of civil engineering with the emergence of Geographic Information Systems (GIS). GIS is a computerized system designed for processing geographic-related information, encompassing tasks such as assembly, storage, manipulation, and display. It falls into a distinct category of information systems, characterized by four key components: computer systems, GIS software, human expertise, and data. GIS activities are broadly categorized into spatial and attribute data management, data display, exploration, analysis, and modeling [10]. Across various civil engineering disciplines, GIS has gained recognition as a valuable technology, evident in the growing number of articles within civil publications discussing its applications [11].

The integration of GIS into this project followed a three-fold process:
Step 1: Development of the geographic database (GDB);
Step 2: Modeling the alphanumeric database (ADB);
Step 3: Utilizing the primary functions of GIS for analysis and interpretation.

The project commences with the critical task of Geographic Database (GDB) modeling, serving as the technical cornerstone. This pivotal step entails the meticulous creation of a GDB model, incorporating diverse layers of information encompassing housing units, master plans, foundation and structural work, masonry, cement coating, floor and wall tiling, electrical connections, system installations, waterproofing, and more. The detailed methodology for this complex process is visually depicted in Figure 1, providing a comprehensive guide to the GDB creation. This initial phase lays the groundwork for a robust and informed approach to managing and analyzing spatial data throughout the project's lifecycle.

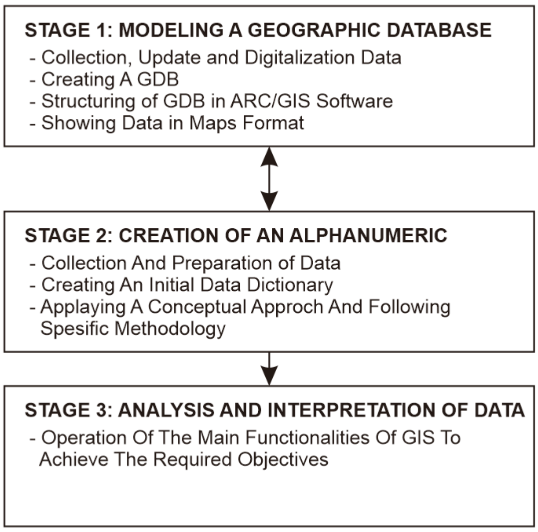

Figure 1. Methodology adopted for a geographic database modeling

The next phase involves the establishment of an Alphanumeric Database (ADB) intricately linked to the GDB. Employing the Merise1 method, ADB modeling breaks down the project into sequential phases, progressing from a broad overview to specific details, advocating a systemic approach. This method recommends utilizing the model across system analysis, design, and implementation phases. Essentially, the objective is to translate the real-world intricacies into a conceptual model comprehensible to machines. The initial step involves gathering and preparing data encompassing all project details, setting the foundation for a systematic and comprehensive integration of alphanumeric data within the database structure such as:

1. Enumeration of codes and numerical designations for different housing types.
2. Geographical positioning of housing units in Pamengkang Village, Mundu District.
3. Recognition of subcontractors and all teams, including details such as names, specializations, contract types, etc.
4. Identification of distinct implementation phases aligned with the contractual financial stipulations mutually agreed upon by the CC company and the client.
5. Allocation of housing units to subcontractors and CC teams based on their specialization and the ongoing construction stage.

This process makes the Raja Sukses Propertindo Company face many and various complicated situations that require good and fast data management. Accumulating substantial daily data is imperative for a singular house undergoing construction. It is evident that the construction of each house involves the participation of nine teams and subcontractors. The raw and extensive data from this process requires systematic organization, effective management, and thorough cleaning. Following this, the refined data is utilized to establish an alphanumeric database, employing Microsoft Excel for the purpose, as illustrated in Figure 3.

Continuous updating of the database (DB) is crucial in the chosen methodology; hence, this project adopts a closed methodology to ensure regular updates. The third and concluding step involves employing the primary functions of GIS to guarantee effective management, scheduling, and monitoring of construction work. Numerous tasks have been accomplished as part of this process:

1. Monitor work progress on a monthly, weekly and daily basis;
2. Carry out permanent monitoring of worker performance;
3. Ensure detailed work schedule with daily updates;
4. Monitor the subcontractors' performance and issue their invoices based on the advancement of their work;

As depicted in Figures 4 and 5, the status of work progress activities in each house is visually represented with distinct colors. This monthly geographic map provides a comprehensive overview of the work progress status for houses within specific zones. This visual representation facilitates a straightforward evaluation and summarization of the work completed for each activity, consequently informing the monthly invoicing process outlined in Table 1.

Table 1. Percentage of activity value

Number of Contract	Job description	Percentage value
1	Planning Design	2,50%
2	Road preparation and paving work	1,00%
3	Excavation work	2,00%
4	Backfill Work	2,00%
5	Foundation work	10,00%
6	Concrete structural work	24,00%
7	Masonry work	9,00%
8	Ceramic tile work	3,00%
9	Exterior and interior wall plastering	7,00%
10	Painting Work	6,00%
11	Highway and car port work	8,00%

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Number of Contract	Job description	Percentage value
12	Windows, PVC and doors	9,00%
13	Interior painting	2,00%
14	Exterior painting	3,00%
15	Sewer and clean water piping	2,50%
16	Electric extension	3,50%
17	Electrical accessories	2,50%
18	Sanitary equipment and accessories	3,00%
TOTAL		100,00%

3.2. RESEARCH SITES

The research location is in Pamengkang Village, Mundu District, Cirebon Regency..

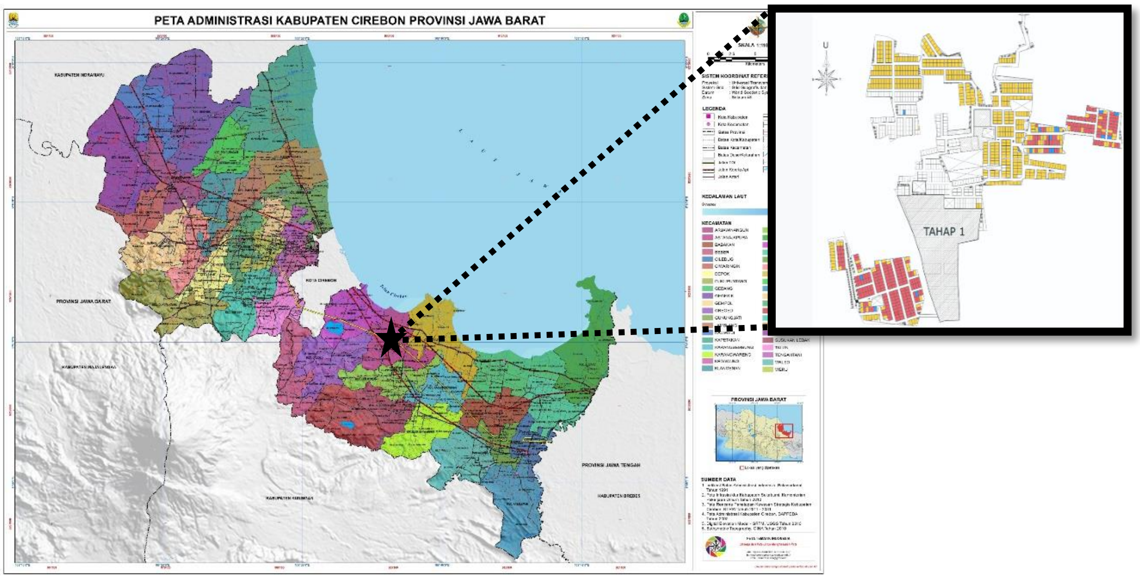

Figure 2. Site location

4. RESULTS AND DISCUSSION

Implementation of a Geographic Information System (GIS) in monitoring housing construction implementation provides results by integrating geographic information and construction implementation data, this system makes it easy to holistically monitor housing projects. Real-time monitoring results Offer a precise representation of the advancement in construction, enabling project managers to promptly identify potential issues and implement corrective measures.

Illustrated in Figures 4 and 5, distinct colors signify the work progress in individual houses on a monthly geographic map within designated zones. This visualization facilitates a straightforward assessment and summarization of completed tasks for each activity, streamlining the monthly invoicing process detailed in Table 1. The clear depiction allows project managers to promptly evaluate construction progress, identify potential issues, and make informed decisions, ensuring effective project management.

Employing GIS in residential construction yields numerous advantages, enhancing efficiency, accuracy, and overall project management. The application provides valuable insights and streamlines various aspects of the construction process. First, real-time monitoring allows early detection of potential obstacles and problems that could affect the project. This directly contributes to controlling construction time and costs. Second, the integration of geographic information simplifies spatial analysis, enabling the identification of critical zones that require more attention. This helps in more focused resource planning and management strategies.

In addition, the system's intuitive interface also opens up opportunities for active participation from related parties, such as owners, contractors and subcontractors. This involvement can speed up the decision-making process and increase overall project transparency. However, GIS implementation also brings challenges. Therefore, mitigation measures need to be implemented to ensure the long-term success of these systems.

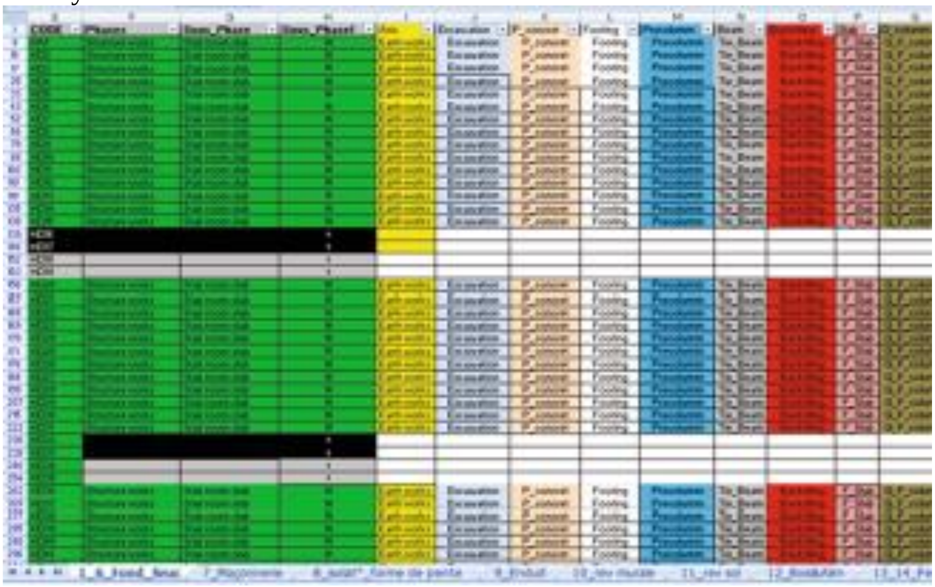

Figure 3. Extract of an alphanumeric database

Work Progress Area D
Date: 05/07/2022

1	Road preparation and paving work	100%
2	Excavation work	100%
3	Backfill Work	100%
4	Foundation work	100%
5	Concrete structural work	100%
6	Masonry work	100%
7	Ceramic tile work	0%
8	Exterior and interior wall plastering	100%
9	Painting Work	0%
10	Highway and car port work	25%
11	Windows, PVC and doors	20%
12	Interior painting	0%
13	Exterior painting	0%
14	Sewer and clean water piping	0%
15	Electric extension	0%
16	Electrical accessories	0%
17	Sanitary equipment and accessories	50%

Figure 4. Monitoring of works progress (Area D)**CITATION AND REFERENCE**

5. CONCLUSION

The study concludes that GIS serves as a valuable complement to project scheduling tools like Microsoft Project and Primavera. It acts as a visualization tool for construction schedules, aiding less-experienced users and enhancing project understanding by depicting the specifics of what, when, and where construction activities are occurring.

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