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Application of 3D, 4D and 5D Building Information Modeling (BIM) in the Design of the Building Structure of the Archives Depot Building of the East Kutai Regency Secretariat

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Abstract: This section consists of single paragraph and about 250 words maximum. For research articles, abstracts should give a pertinent overview of the work. We strongly encourage authors to use the following style of structured abstracts, but without headings: The development of digital technology in the construction industry has driven the adoption of Building Information Modeling (BIM) as an integrated approach in designing and managing building projects. However, the use of BIM, especially 3D, 4D, and 5D models, is still not optimal in non-metropolitan areas such as East Kutai Regency due to low technical understanding among construction service providers and users. This research aims to develop a BIM implementation model that is in accordance with local needs, especially in the design of government building structures. Using a qualitative approach based on case studies and meta-synthesis techniques on secondary data from the East Kutai Regency Secretariat Archives Depot Building project, this study integrates various BIM software such as Autodesk Revit, Proisac BIM 4D, and Sofistik Reinforcement to build a model that is able to represent geometric information, implementation schedules, and cost estimates simultaneously. The results show that the integration of 3D, 4D, and 5D BIM results in a more accurate, efficient, and can be used as a reference for replication in similar projects. In addition to answering local problems, this research makes a practical contribution to the preparation of a BIM implementation framework based on software interoperability, as well as expanding academic discourse on the application of BIM in the regional construction environment. The implications include the potential to increase the efficiency of public projects through the digitization of planning, while encouraging the strengthening of technical capacity and information technology-based procurement policies at the regional level.

Keywords: Building Information Modeling (BIM); Sofistik Reinforcement; Sofistik Bimtools; Proisac BIM 4D; Quantity Take-off

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1. Introduction

The development of digital technology has revolutionized the global construction industry, especially with the advent of Building Information Modeling (BIM) which offers an integrated and multidimensional approach to the design, implementation, and management of building projects (Kurcjusz et al., 2024). BIM not only transforms the two-dimensional design paradigm into three-dimensional (3D), but also enables more accurate and efficient time modeling (4D) and cost estimation (5D) (Datta et al., 2023). This transformation is particularly relevant amid the increasing complexity of construction projects and the demands of cost and time efficiency in various countries, including Indonesia (Palensia et al., 2024). Although BIM has become the standard in developed countries such as the United Kingdom and Spain

(Pomares et al., 2017), its adoption in Indonesia is still in its early stages, especially in non-metropolitan areas such as East Kutai.

One of the main challenges in the implementation of BIM in Indonesia is the low digital literacy and lack of technical understanding among construction service providers and users, which results in the suboptimal use of this technology in local projects (Kurniawan & Suroso, 2023). In fact, previous research has shown that the application of BIM, especially 3D, 4D, and 5D models, is able to improve design accuracy, reduce conflicts at the construction stage, and significantly save project costs (Noviani et al., 2022; Saputra et al., 2025). This awareness of the implementation gap encourages the urgency for academic studies that not only map obstacles, but also develop BIM implementation models that are contextual to local conditions, such as in East Kutai Regency.

In a theoretical context, the meta-synthesis approach to BIM development refers to the integration of software such as Autodesk Revit for 3D models, Proisac BIM for 4D scheduling, and Sophistication Reinforcement as well as sophistication of Bimtools for the calculation of reinforcement and formwork volumes and 5D cost estimation (Zheng et al., 2023). This approach is based on the principles of interoperability and cross-disciplinary collaboration that are at the core of BIM systems (Patil & Dwivedi, 2025). In international case studies, BIM models have also been shown to be able to identify potential design clash detection, manage construction logistics, and produce more realistic cost estimates than conventional approaches (Chahrour et al., 2020; Li et al., 2021).

In 2021, Government Regulation No. 16 of 2021 was issued, which states that the use of BIM in building construction must be used in technology-intensive and capital-intensive building construction, with the classification of medium to super-tall buildings, it is mandatory to use BIM at least the fifth dimension of BIM (PP No. 16, 2021).

This study aims to develop a Building Information Modeling model based on Autodesk Revit software, Proisac BIM 4D, Sofistik Reinforcement, and Sofistik Bimtools in designing the building structure of the East Kutai Regency Secretariat Archives Depot. With a qualitative approach based on case studies and secondary data, the main question asked is: How to develop a BIM model for building construction planning? The formulation of these problems is the basis for exploring the application of BIM technology that is more systematic, adaptive, and in accordance with the needs of projects in the regions.

This article makes a significant contribution to academic discourse and construction practice by proposing a model for the application of 3D, 4D, and 5D BIM that is adapted to the local context in Indonesia, and based on complementary software integration to produce precise digital outputs. The novelty of this research lies in the use of a meta-synthesis approach in integrating BIM software for the needs of building structure design in areas with a low level of technology adoption, such as East Kutai (Jing & Alias, 2024), as well as encouraging the replication of similar models in building projects in other regions in Indonesia. The building is with the collaboration of Autodesk Revit software, Proisac BIM 4D, Sofistik Reinforcement and Sofistik Bimtools in the Design of the Building Structure of the Archives Depot Building of the East Kutai Regency Secretariat, and can also be used as a reference for accurate building design and can produce digital planning data.

2. Materials and Methods

2.1. Research Location

This research was carried out on the Planning Project for the Development of the Archives Depot of the East Kutai Regency Secretariat which is located in the Bukit Pelangi Sangatta Government Center area.

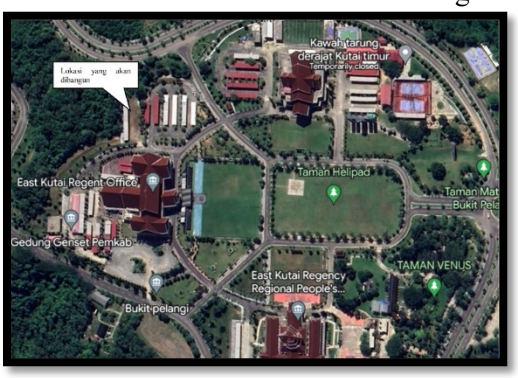

Figure 1. Research Location

2.2. Research Data

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In this study, secondary data from the Archives Depot Development Planning Project of the East Kutai Regency Secretariat was used. The data obtained is a plan drawing.

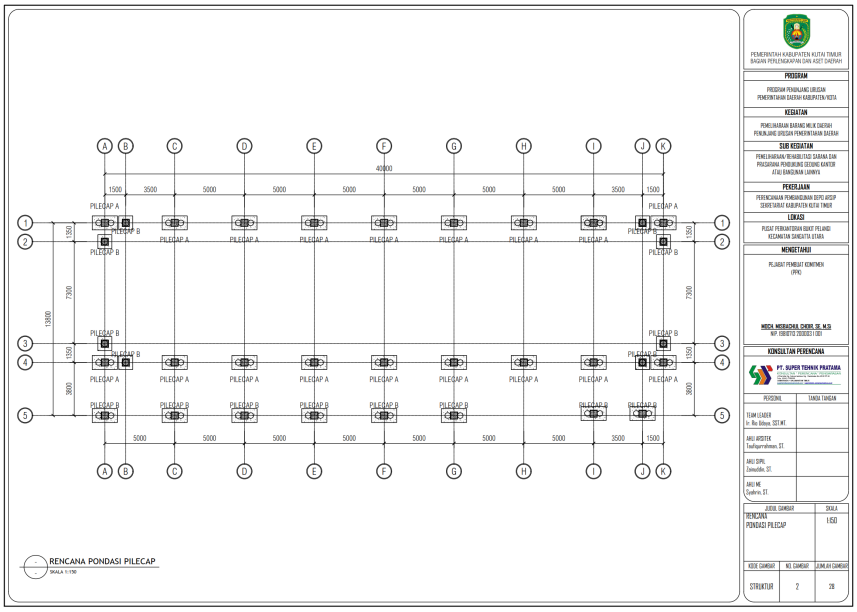

Figure 2. Pilecape Foundation Plan

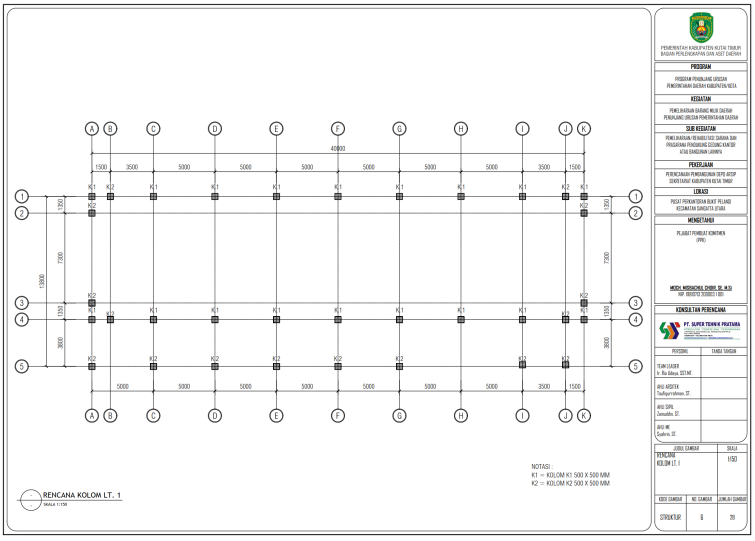

Figure 3. 1st Floor Column Plan

2.3. Research Stages

Secondary data processing is carried out through image modeling in the form of structural components using the Revit Structure 2025 program. 3D modeling is done by creating foundations, sloofs, columns, beams, and roofs. 4D modeling is carried out by adding a schedule from the 3D modeling that has been made (Ferry & Indrastuti, 2020).

The stages in this study are described as follows:

2.3.1. Grid and Elevation Modeling

The grid in Revit is a coordinate reference for modeling. The coordinate lines on the grid consist of X, Y and Z lines. Grids are used to simplify the process of placing building structural components and as a reinforcement axle point. The grid is created in the initial step in the edit menu selected grid. Once the properties dialog box appears, the X, Y and Z coordinates of the model will be generated according to ABD. Modification of the distance on the grid can be done by clicking on the grid you want to replace. As for making building elevation. To create an elevation to the Project Browser menu then select Elevation (East, North, South and West).

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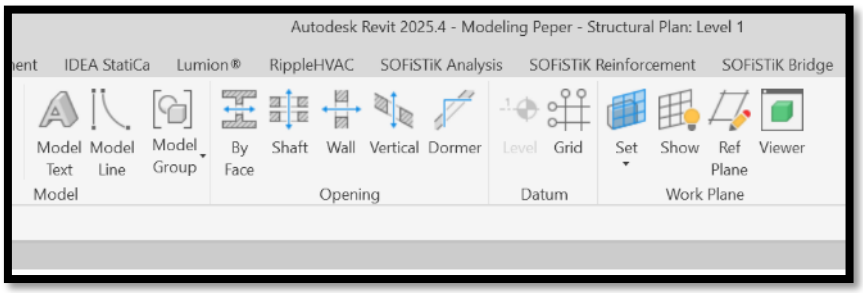

Figure 4. Grid

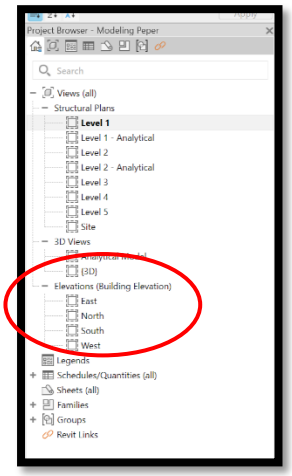

Figure 5. Elevation

2.3.2. Foundation Modeling

Foundation The first building structure is the foundation and piles. Pile foundation modeling begins by clicking on the structure menu and then isolated. After the properties box opens, the available foundation components in Revit will appear, and then the concrete foundation is selected. The foundation is laid according to the ABCD.

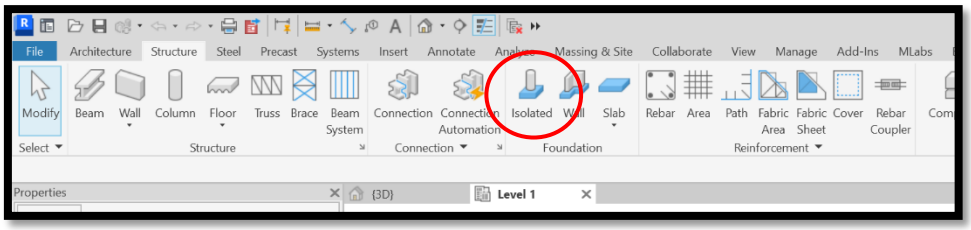

Figure 6. Isolated

2.3.3. Column Modeling

The next modeling of a building structure is called columns. The first step of column modeling is to select column on the Structure menu. The columns are placed on the grid according to the ABD drawing. The characteristics of a column can be changed by clicking on the column to the properties box and changing it in that properties box.

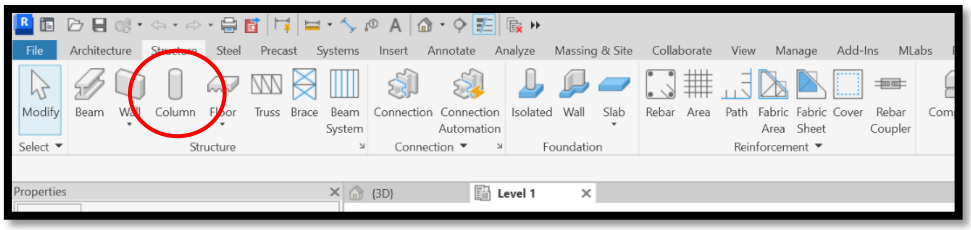

Figure 7. Colomn

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2.3.4. Beam Modeling

Beam modeling is done by clicking on the Structure menu and then the beam is selected. The beam is placed on the grid according to the ABD image by drawing a line from the end of one column to the next. The characteristics of the blocks can be changed by clicking on the blocks so that the properties box appears.

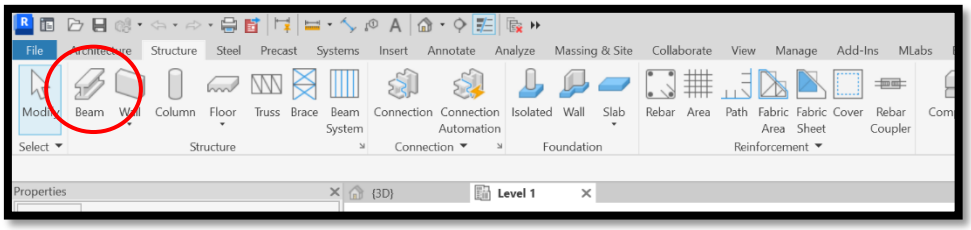

Figure 8. Beam

2.3.5. Plate Modeling

The first step in modeling the slab is on the Structure menu selected Floor. The starting point of the floor plate is selected and then followed by the other corner points of the plate until it returns to the starting point. The characteristics of the plates can be changed by the way the plates are clicked so that the properties box appears.

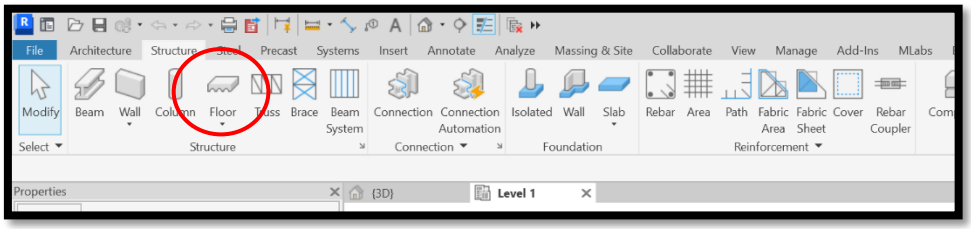

Figure 9. Plate

2.3.6. Reinforcement Modeling

Reinforcement modeling begins by creating a section on the object to be modeled the rebar, then go to the structure menu and then select rebar. After that, a cast rebar sketch will appear.

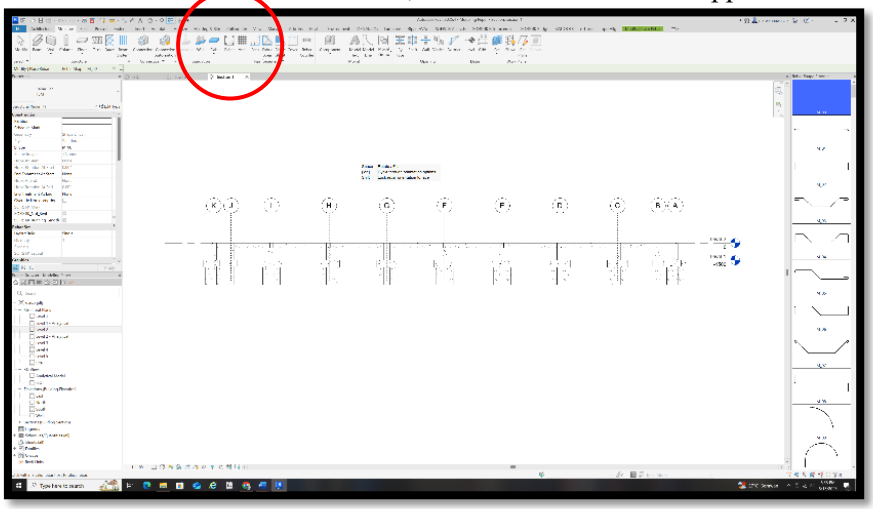

Figure 10. Reinforcement

3. Results

3.1. 3D Modeling Results

Building structural items are modeled using Autodesk Revit, including foundation structures, beams, columns and plates. The following are the results of modeling building structures in BIM systems in 3D form:

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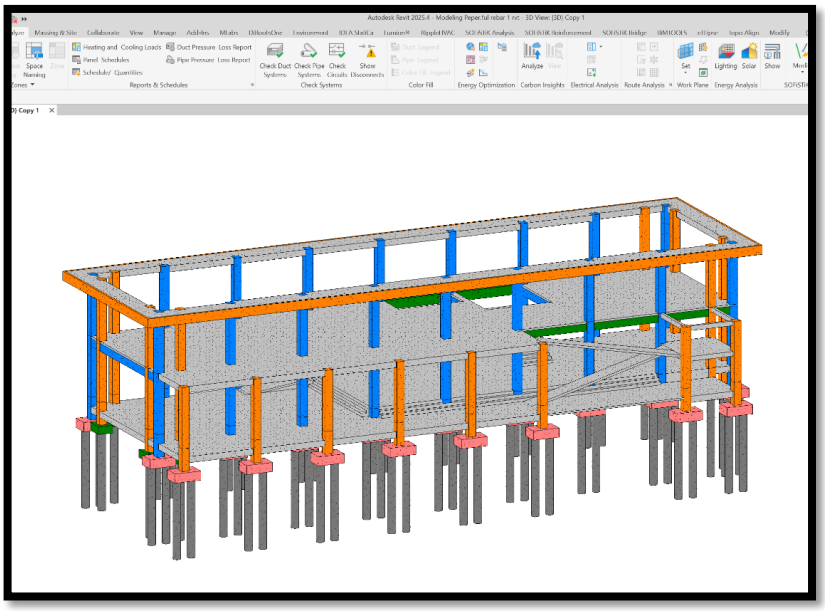

Figure 11. Building Structure Modeling Results

From the 3D model, the details of the structural reinforcement are then carried out, so that the information on the structure of the building is entered into the BIM model. The following are the results of detailing the structural reinforcement in a 3D model integrated with BIM.

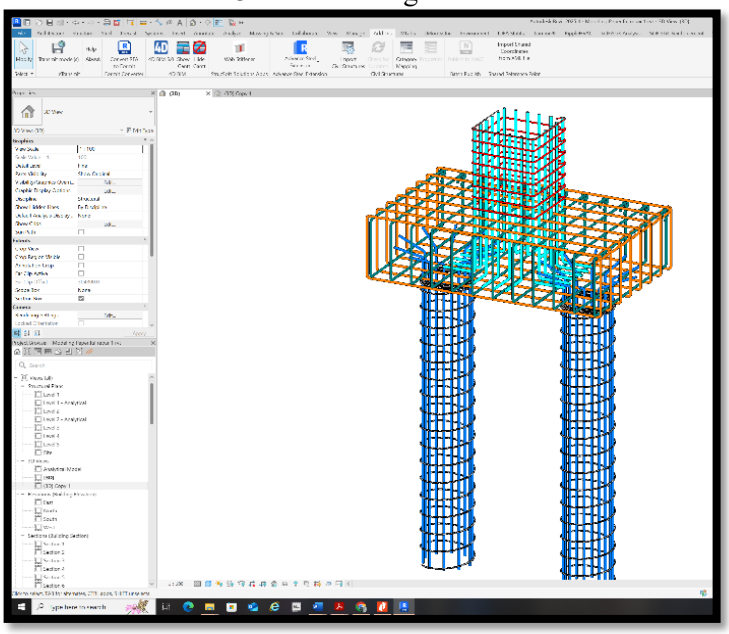

Figure 12. Results of Detailing Reinforcement Foundation Structure

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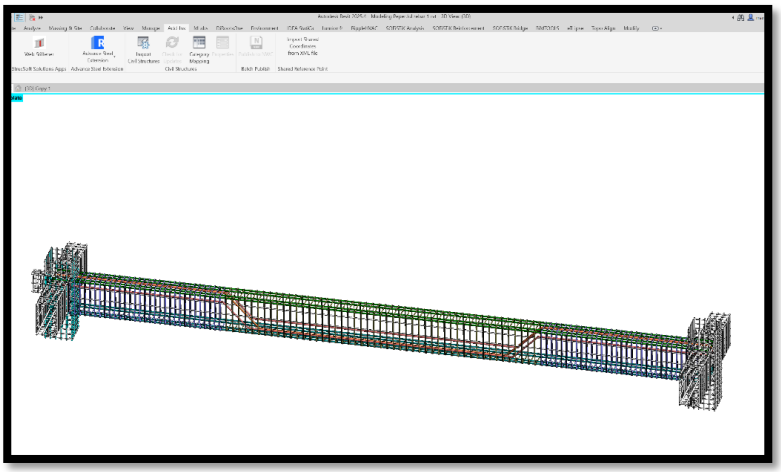

Figure 13. Results of Beam Reinforcement Detailing

With the completion of the 3D modeling of the building structure, the volume of work for each element of the structure has been automatically calculated such as foundations, beams, columns, floor plates, the volume of reinforcement is calculated with the help of the Sofistik Reinforcement plug-in and formwork is calculated with the help of Sofistik Bimtools. The following image shows an example of the volume of work results using Autodesk Revit.

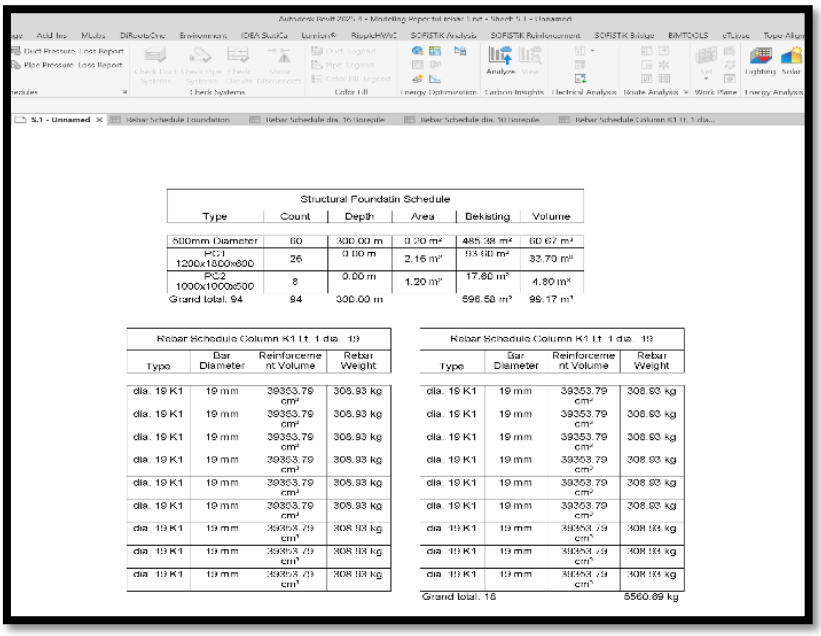

Figure 14. Work Volume Calculation Results

3.2. BIM 4D Results

The results of this study were compiled based on a qualitative approach of a case study with meta-synthesis techniques on secondary data from the construction project of the East Kutai Regency Secretariat Archives Depot Building and relevant scientific literature. The results of the analysis are divided into three main dimensions of BIM: 3D (Geometric Modeling), 4D (Time Planning), and 5D (Cost Estimation), and are focused on the effectiveness of software integration and the reliability of building structure planning outputs.

4D modeling, for project schedules Proisac BIM is used by input work items. Activity and activity view in Autodesk Revit and 4D Gantt model graphs generated from Proisac BIM. It also allows construction simulations to be animated. Several viewpoints are assigned according to the activity and attached to each related activity. With this method, construction simulations can be run. Figure 15 shows a Prisac BIM composite model that includes structural information with a Gantt chart generated by linking schedules.

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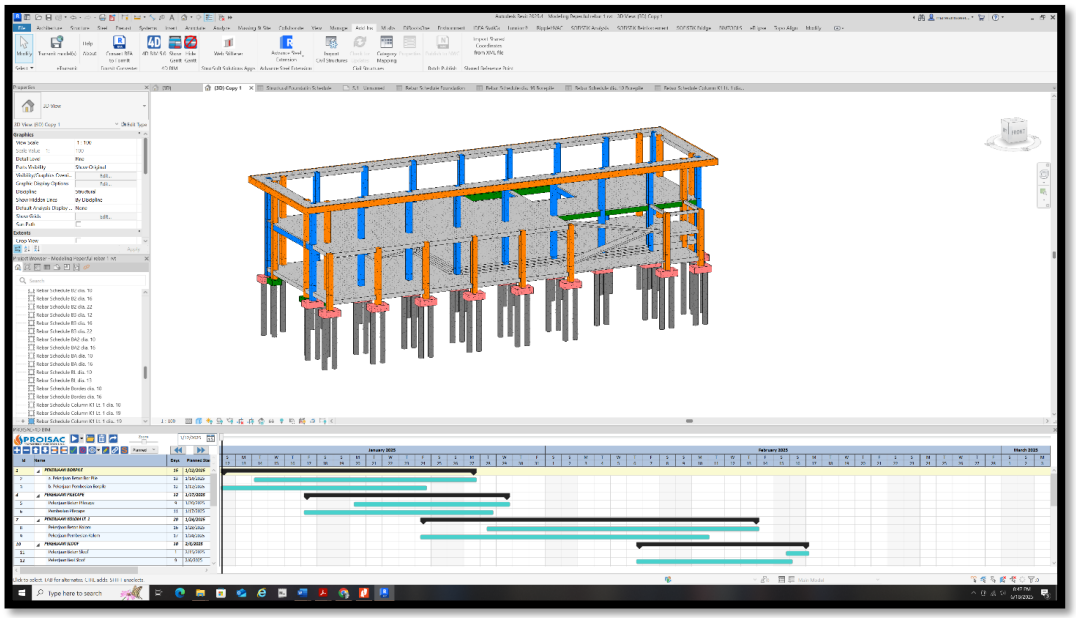

Figure 15. The relationship between 3D Modeling and Proisac BIM 4D

Figure 14 shows the relationship between 3D modeling and Proisac BIM 4D by integrating it with the activity schedule which is then used to integrate the results of the model visualization with the scheduling of project activities so that it is said to be 4D modeling. The 4D model will show a clear picture of the progress of the work by entering date data according to the project schedule. The results of the project visualization can be seen in Figure 16.

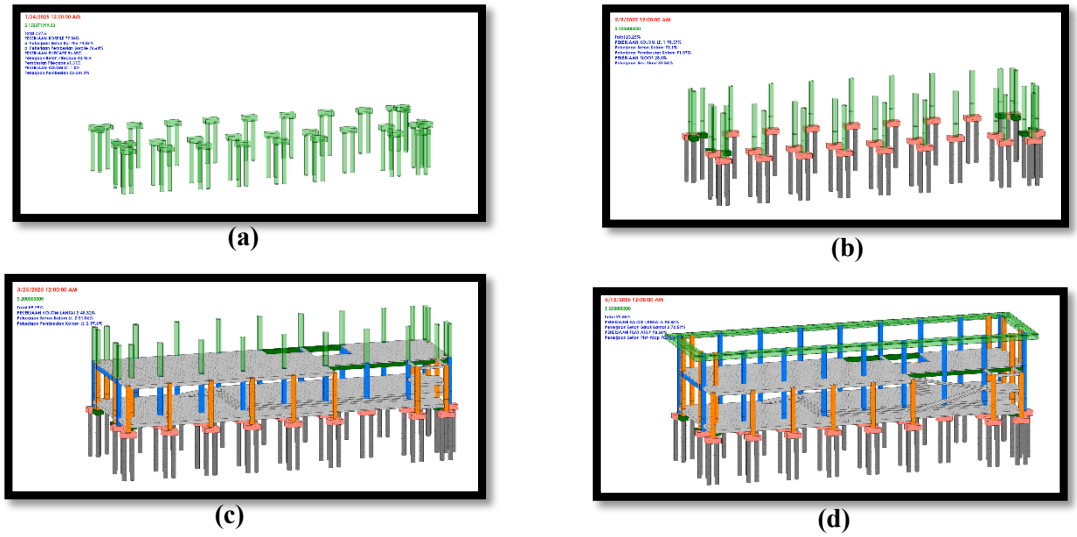

Figure 16. Project Visualization Results with Proisac BIM

3.3. BIM 5D results

BIM 5D is the process of adding costs to a 3D model (Smith, 2014). Building information modeling in the 5th dimension (5D) is defined as estimating modeling or calculation of a 3D model in the form of output and output from volume and integration between work scheduling visualizations (4D). This modeling allows for the creation of cost budget estimates and eliminates potential errors in the price amount. The 5D model occurs because of the combination and communication in the 3D model that is integrated into the 4D model and has visualized the progress of the work data from time to time, so that the information inputted is in the form of cost and specification tracking to support construction activities to be more controlled on the basis of the BIM model. The base used to do 5D modeling uses the same 3D model used for 4D modeling, this can cut time in the planning process (Soleh & Saputro, 2023). The results of the 5D model can be seen in figure 17.

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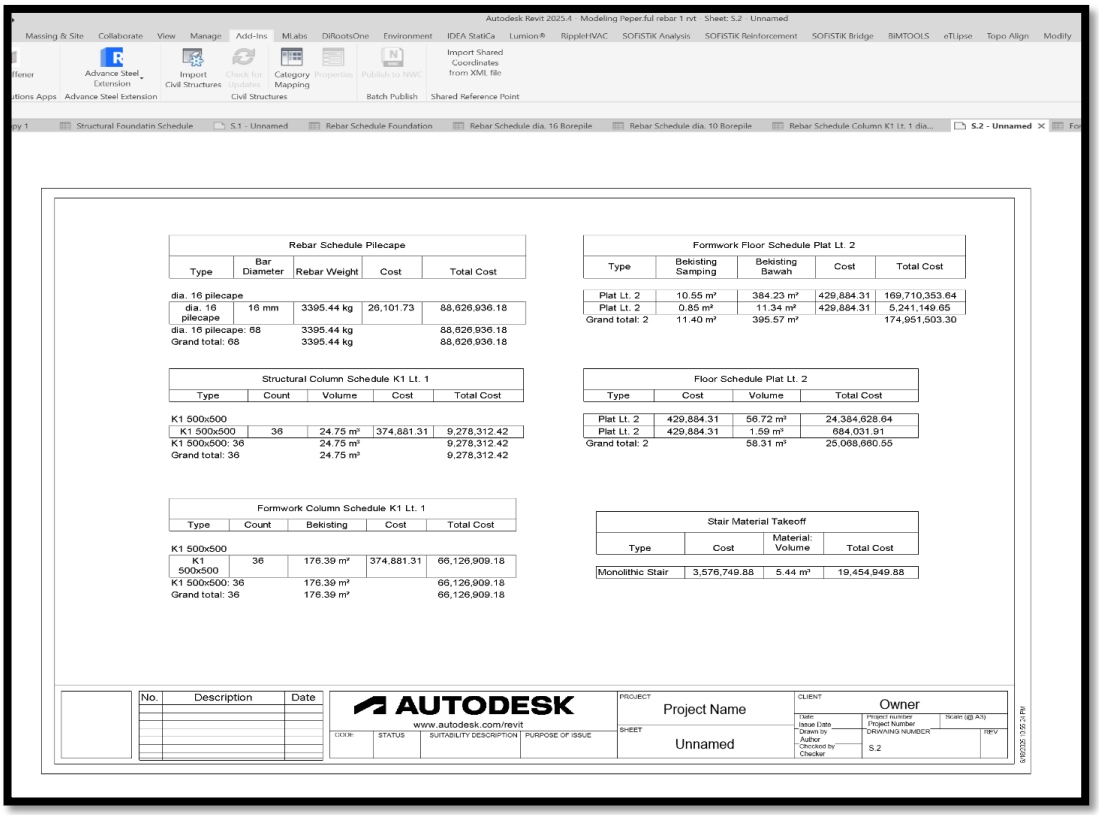

Figure 17. BIM 5D results

4. Discussion

The results of the study show that the development and integration of 3D, 4D, and 5D Building Information Modeling (BIM) models in the structural design project of the Archives Depot Building in East Kutai is able to meet the main goal of the research, which is to create an accurate and integrated digital model in terms of shape visualization, time estimation, and construction cost calculation. These findings directly answer the formulation of problems related to the low understanding of construction service providers and users regarding BIM technology, by demonstrating the effectiveness of the use of software such as Autodesk Revit, Proisac BIM 4D, and Sophistication in supporting overall project structural planning.

Theoretically, these results are in line with the conceptual framework that places BIM as a collaborative tool in the design and management of multidimensional digital data-driven projects. 3D BIM provides the basis for geometric visualization that can be linked to scheduling (4D) and cost calculation (5D), thus creating an integrated simulation of the entire project cycle (Lee & Kim, 2020). This approach reinforces the argument that multidimensional BIM integration not only improves technical accuracy, but also strengthens the interconnectedness between aspects of design, time, and budget in a single digital ecosystem (Datta et al., 2023).

The results of this study are also in line with the findings of previous studies that show the effectiveness of BIM in improving project efficiency. For example, the implementation of 4D/5D scheduling is reported to be able to reduce project delays by up to 50% and result in significant cost savings (Muhammad et al., 2023). Another study in Peru showed that shortcomings in 4D and 5D BIM are often related to a lack of training and high software prices, which confirms the importance of integrative and contextual approaches such as those in this study (Pacheco et al., 2024). In addition, the approach used in this study has been able to overcome the problem of conflict design as shown in the BIM 5D project of the Patimban pier structure, where digital simulation is able to significantly reduce field revisions (Palensia et al., 2024).

The scientific contribution of this article lies in the incorporation of the synthesis of BIM methods and software adapted to the context of structural planning of government buildings in developing regions. This expands the scope of the literature that has been dominated by case studies on large-scale projects in urban or international areas. The development model offered also encourages replication in small-medium scale projects with local resource adjustments, as well as reinforcing the paradigm of software interoperability in digital project management (Sharma et al., 2017).

However, this study has a number of limitations. First, the use of secondary data from a single case study project can limit the generalization of findings to projects of different complexity. Second, BIM performance evaluation does not include long-term operational dimensions such as building maintenance (6D). Third, the limitation of local resources in the use of advanced BIM software can affect implementation in locations with low technical capacity (Jeong, 2022).

The implications of these findings for further research include the development of multi-case studies in different regions of Indonesia to evaluate variations in the effectiveness of locally-based BIM models. For practitioners, these results demonstrate the importance of cross-software training and the preparation of 3D, 4D, and 5D BIM operational standards at the local government level. Meanwhile, for policymakers, a public procurement policy is needed that requires the integration of BIM in the planning of state construction projects, especially in digital-based procurement to support project accountability and transparency (Basir et al., 2023).

5. Conclusions

This study successfully shows that the application of 3D, 4D, and 5D Building Information Modeling (BIM) models in an integrated manner in the design of the building structure of the East Kutai Regency Secretariat Archives Depot Building is able to answer the need for precise, efficient, and adaptive digital planning to the local context. Through a qualitative approach of case studies and meta-synthesis techniques to secondary data, it was found that the use of software such as Autodesk Revit, Proisac BIM 4D, Sofistik Reinforcement and Sofistik Bimtools is able to produce accurate geometric modeling, realistic scheduling simulations, and comprehensive cost estimation. The developed model not only represents the physical shape of the building, but also integrates time and cost information simultaneously, thus supporting data-driven decision-making in the construction planning process.

Theoretically, this article expands the discourse on the multidimensional integration of BIM with a case-study-based methodological approach that focuses on the context of medium-scale projects in non-metropolitan areas. The findings of this study also make a practical contribution to improving the technical capacity of construction service providers and users in the regions, through the preparation of an adaptive and replicative BIM implementation framework. In addition, the incorporation of software in a single structural modeling ecosystem provides a concrete picture of the interoperability of digital systems in public sector construction projects, which have been limited in application at the regional level.

For future development, it is recommended to expand the study to various regions with different project characteristics to test the external validity of the proposed BIM model. Further research can also be directed at the integration of additional dimensions such as 6D and 7D BIM to support sustainability management and long-term operationalization of buildings. On the policy side, regulatory support and technological infrastructure are needed to enable wider adoption of BIM in the national construction sector, including technical training and digital-based procurement incentives for local government institutions.

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