Pena Journal of Computer Science and Informatics 2, Issue 1 (2025) 35-46

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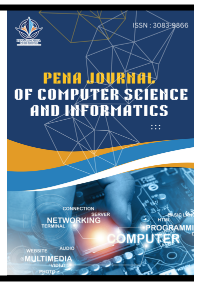
Pena Journal of Computer Science and Informatics

Journal homepage:
https://penacendekia.com.my/index.php/pjcsi/index
ISSN: 3083-9866



Modeling Simulation of Bridge Abutment Planning using Autodesk Revit Software with Building Information Modeling Technology

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ARTICLE INFO

Article history:
Received 15 July 2025
Received in revised form 14 August 2025
Accepted 10 September 2025
Available online 18 September 2025

Keywords:
Bridges planning; bridges abutments; Building Information Modeling; transportation infrastructure

ABSTRACT

A bridge is a structure that connects two sections of road separated by an obstacle. The bridge is a crucial piece of transportation infrastructure. Bridges facilitate the efficient and easy movement of people and goods. Bridges can also be used as symbols of a nation's advancement and as landmarks. This study focuses on the structure of the bridge's lower half, specifically the abutment. The abutment is the most significant section of the bridge structure since it directs loads from the upper structure to the earth or structure below. This research used Revit software version 2024.1 to model the bridge abutment. The Building Information Modeling (BIM) revolution has altered the construction industry by offering a unified building design, modeling, and simulation platform. Revit, one of the most prominent BIM software packages, has various modeling simulation features, such as energy analysis, structural analysis, and visual simulation. BIM enables professionals involved in the building lifecycle to work together better and make more informed decisions about building design, construction, and operation. This research aims to provide an overview of the simulation of bridge abutment modeling using Revit software. The method used in this research is to model the bridge abutment in 3D. The modeling data is sourced from research journals on the Cipeundeuy-Sukatini bridge, Indonesia. Bridge abutment modeling is done by creating drawings on template families. The result of this modeling simulation is to show the modeling from various views. The results of modeling bridge abutments using Autodesk Revit software are expected to be a reference in modeling more modern drawings.

1. Introduction

Because they foster social and economic growth, bridges are vital to the transportation system and are considered one of the most significant and essential infrastructures [1]. Bridges are crucial to

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https://doi.org/10.37934/pjcsi.2.1.3546

a nation's infrastructure because they shorten travel times and allow moving people and goods across borders [2]. Wood, stone, brick, concrete, steel, fiber-reinforced polymers, stainless steel, and combinations of these materials can all be used to build bridges. New bridge construction is still required, particularly for short-span bridges in emerging nations [3]. Adequate transportation infrastructure, including bridges, requires optimal technical and economic planning, design, execution, and operation to achieve these goals [4].

This article describes the use of BIM technology in bridge abutment planning. BIM is a collaborative tool utilized by individuals in the architectural, engineering, and construction (AEC) sector based on various software solutions. BIM involves changes to processes in addition to technology [5]. All segments of the construction business must stay abreast of current technological advancements and consistently make an effort to innovate and enhance technology within the sector.

It is widely known that interactions between the approach and abutment embankment fills can substantially impact the dynamic properties of bridges, leading to excessive deformation demands on substructural parts [6]. The abutment is the primary component of the support system that absorbs pressure and transmits it to the base. A precise assessment of a bridge's seismic performance must consider the actual behavior of the abutments, which are frequently modeled in structural calculations as linear spring-dashpot elements or as fixed limitations [7]. Strong bridge abutments are necessary to build a bridge that can support a variety of loads.

One tool for project management that can expedite project execution and save time is BIM technology [8]. BIM is beneficial, especially when building bridge abutments, and it is an efficient application. BIM facilitates understanding, participation, communication, and teamwork between relevant parties at every project stage to produce a high-quality result [9]. However, the application of BIM is currently only done by big companies. Technology has yet to be fully utilized in Indonesia's construction industry [10].

This paper primarily focuses on adopting BIM technology and simulating bridge planning, which will be used for future work scopes. It aims to implement BIM technology in bridge abutment design planning. This research also aims to improve efficiency and accuracy in the bridge abutment design and planning process and facilitate integration and collaboration between the parties involved in the construction project. As a result, this research will cover how to design bridge abutments using BIM-based Autodesk Revit software. This paper will help apply BIM technology in the future.

2. Literature Review

2.1 Bridges Planning

Building bridges is one way to enhance transportation infrastructure. A bridge is a road transportation that joins two places separated by a barrier. It is an essential component of the transportation network system that will sustain a developing country in the long run [11]. Regulations modified to SNI 03-1725-1989 regarding guidelines for planning the loading of highway bridges govern the planning and execution of bridges [12].

A bridge is a structural building consisting of various key components. It is the most commonly used type of structure worldwide. Bridges are constructed to meet structural needs and aesthetic or beautiful requirements while keeping up with modern technologies [13]. They are still in use today, and their designs range from straightforward to quite intricate, with materials including steel, concrete, bamboo, and wood being utilized [14].

Every bridge constructed must provide high safety and comfort to its users so that undesirable events can be avoided [15]. To obtain this level of security, bridge planning is necessary, especially on the structure of the lower part of the bridge. To plan the strength of structures under bridges, it is necessary to calculate the loads, especially those caused by the dynamic action of the ground [16].

2.2 Bridges Abutments

The lower structure of the bridge includes abutments and foundations. The end of the bridge that holds the superstructure and channels it into the ground is called the abutment [17]. A strong bridge lower structure is planned to accommodate greater capacity and traffic loads [18]. Even in modern times, a building's foundation remains its most crucial component, particularly in the case of bridge construction. It is a load-bearing structure for the weight that the bridge itself is carrying and for establishing the location of the building structure above it in the form of abutment pillars [19].

Failure of bridge structures is often caused by failure of the substructure, which is responsible for transmitting the loads underground [20]. Because the bridge is essential to the community in the transportation system [21], it is necessary to plan the bridge construction carefully. Bridge abutments need to be constructed with consideration for the environment and aesthetics in addition to their compressive strength value [22].

As a result, the bridge abutment can contribute to the beauty and natural surroundings and serve as a support. Weather, soil, and the surrounding environment must also be considered while designing bridge abutments. A good abutment design is necessary to make the bridge safe and durable. A good bridge design will feature load analysis, design details, etc.

2.3 Building Information Modeling

In order to boost productivity, AEC (architecture, Engineering, Construction) actors in Indonesia must keep up with the swift advancements in construction technology that have occurred in this period of the business [23]. BIM technology is not limited to design; it can also compute a building drawing's volume and dimensions. In addition to applying to design, BIM can generate accurate and timely information [24]. Building Information Modeling (BIM) is a three-dimensional (3D) digital representation of the functional and physical attributes of building facilities that use parametric intelligence to change their position or proportion [25]. BIM has also been successfully used to design and construct bridges [26].

One area of construction for advancement in Indonesia is building roads and bridges. However, as the need for the construction sector has grown and contractor organizations in Indonesia have become more competitive, the country's BIM development picture has also significantly expanded [27]. The use of Revit software based on BIM technology is only carried out by large companies in Indonesia. The advantages of integration and interoperability in the BIM concept can be mainly applied to managing several projects that belong to a single stakeholder [28].

BIM is also being used in bridge projects in several countries. In 2015, FHWA contracted the National Institute of Building Sciences (NIBS) for a project titled Advances in Bridge Information Modeling [29]. Vietnam has also begun to implement BIM in a variety of projects. In 2016, the Vietnamese government established a BIM implementation law that required the completion of at least 20 BIM pilot projects between 2018 and 2020. These pilot project outcomes will be the foundation for countrywide BIM deployment in 2021 [30]. BIM is used not only for modeling but also by owners for facility management tasks such as maintenance and operations of bridge abutments [31].

3. Method

In this research, the method used is the design of abutments modeling in 3D. The data collected will be used to create a 3D model of the bridge abutment using Autodesk Revit software. This model will include structural details and features relevant to bridge abutments. The 3D model created will be analyzed and evaluated to determine how accurate and efficient this method is in producing bridge abutment design and planning. Implementing the BIM modeling method on the bridge abutment project will be carried out, and the results will be tested to determine how effective this method is in increasing efficiency and accuracy in the design and planning process.

This research also uses Mendeley software as a citation. This research also uses international and national journal searches through Google Scholar as a literature reference. Using Google Scholar makes finding international and national standard literature sources easier. This research is expected to contribute to developing BIM technology and improve efficiency and accuracy in bridge abutments' design and planning process. Data collection as a reference for bridge simulation was taken from data in the journal "Analysis of abutment safety factors against landslides on the Cipeundeuy bridge-Sukatani, Indonesia [32]”.

4. Results and Discussion

4.1 Abutment Data and Overviews

Before performing a modeling simulation, the author searches for data references. The author can use the data as a reference to create an accurate abutment modeling simulation. The author will simulate the gathered data using the Autodesk Revit software. The abutment's data can be found in (Table 1) below:

Table 1
Data of abutments

Bridge Abutment	
Description	Specification
Construction Type	Reinforced Concrete K250
Height (H)	7.00 m
Width (B)	4.00 m
Length (L)	11.00 m

After gathering data references, the author depicts the data in 2D and describes its dimensions. The data obtained and drawn in 2D will be a better reference when drawing in 3D. The author used Autodesk Revit Version 2024.1 software to model the bridge abutment. The data obtained will be simulated in 3D modeling.

4.2 Modeling Stage

The author makes use of template families in Revit modeling. Individual items in template families, which are standalone portions, can be imported into the template model later. The goal of modeling bridge abutments with Revit templates is to make them easier to adapt if the bridge abutment design changes. Furthermore, template families can ensure that the picture modeling design is consistent, lowering the possibility of errors during modeling. As a result, the picture below will walk the modeler through the many stages of modeling bridge abutments with Autodesk Revit 2024.1. The initial stage of bridge abutment modeling simulation can be seen in Figure 1 below.

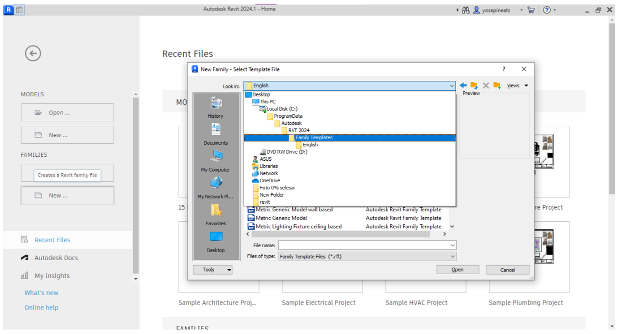

Fig. 1. Revit template selection

The author began modeling with the left perspective as a reference. First, the author enters the families section and selects new. Then, the author selects the library from the family templates, the English folder, and finally, the Metric Generic Model file, then clicks open. After clicking new, the Revit sheet will look like Figure 2 below:

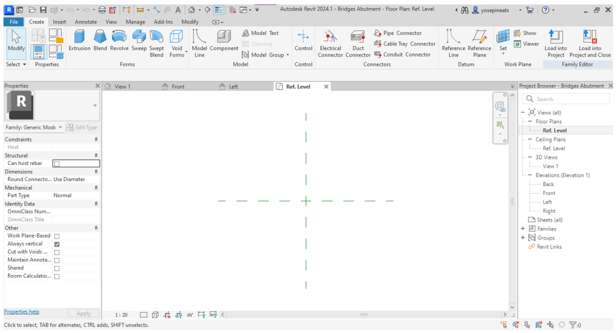

Fig. 2. Modeling sheet view

The figure above is a drawing sheet in Revit after clicking open on template families. The title bar is a Revit feature that appears in the yellow box. The green box has a ribbon bar with numerous tabs and panels in Revit. The red box represents the properties area, the purple box represents the viewport part, the blue box represents the project browser section and the black box represents the display settings portion in Revit. Figure 3 below shows an advanced stage of bridge abutment modeling.

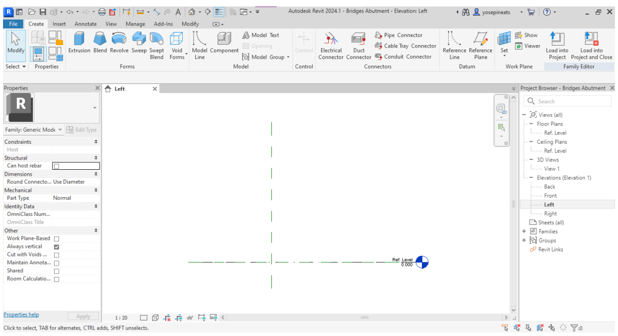

Fig. 3. Modeling on the left elevation

The figure above is a drawing sheet in Revit after clicking open on template families. The author will then do the modeling, and the left view will serve as the modeling reference. The modeler can model the bridge from any perspective. However, the author chose the left view as the first modeling worksheet. The following Figure 4 depicts the next stage.

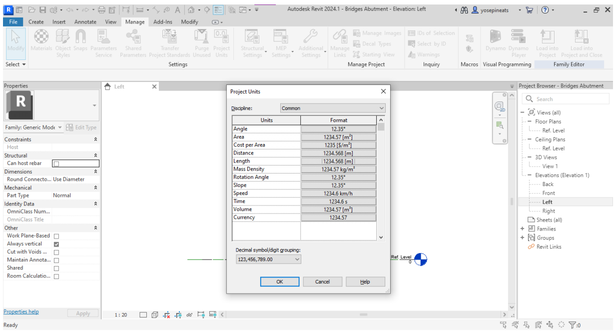

Fig. 4. Modeling unit assignment

Before beginning the modeling, the author determines the meter unit on the Revit drawing page. The author changed the unit for the Distance and Length sections to meters. To change the unit, open the manage menu in the tabs area and click the project units section. To change the unit, click the U and N keys alternately on the keyboard. Figure 5 below depicts the next step in modeling the bridge abutment.

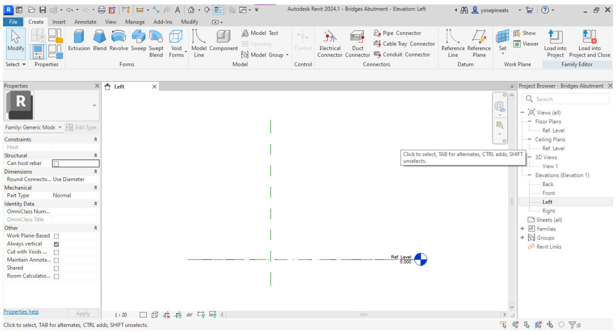

Fig. 5. Reference line drawing

The author then employs a reference line in the create bar to assist in the bridge abutment modeling line drawing. Reference lines are essential for guiding the placement and alignment of model pieces. They are also used as a guide for modeling Revit families that may be reused. Reference lines help ensure that families are established correctly and consistently. Figure 6 shows the following processes in modeling the bridge abutment.

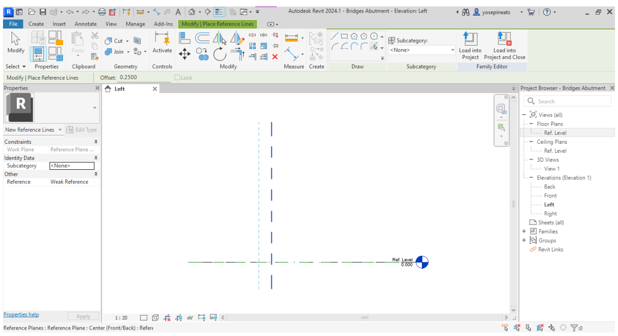

Fig. 6. Initial overview of the reference line

The author then creates a reference line by modifying the abutment's measurements to the information gathered. The author's pick lines, indicated by the red box, make it simpler to offset the lines. The offset tool, represented by the yellow box, establishes parallel pieces at a specific distance based on the available dimensions. In contrast, the blue box exemplifies how the author can move a line away from the reference level. Figure 7 below shows the subsequent step.

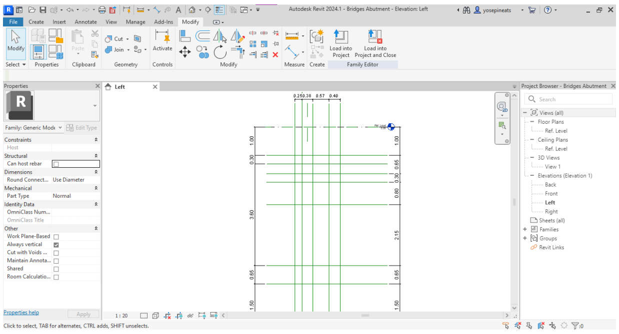

Fig. 7. Reference line and abutment dimensions

The figure above is the result of the previous modeling step. The author draws a reference line to make it easier to do the next modeling stage. The author also makes dimensions on the bridge abutment to make it easier if there is a size error. The author clicks the letters D and I alternately on the keyboard to make dimensions. Dimensions can also be made by clicking on the part in the red box. It can also be done by clicking the annotate bar and then clicking the aligned feature. In Figure 8, further steps in modeling the bridge abutment are shown.

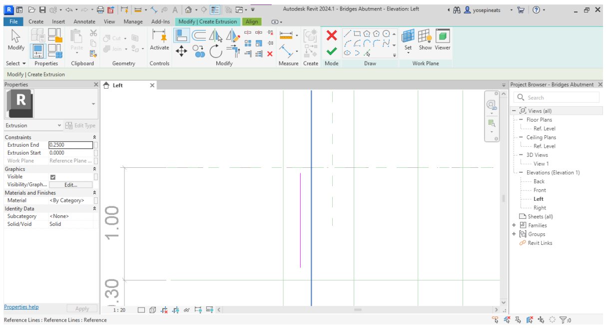

Fig. 8. Extrusion line

The figure above is a further stage after the author makes a reference line. Then, the author makes the abutment modeling line like the line in the green box. The author uses the create bar, selects extrusion, picks lines like the image in the red box, and starts to line the back wall on one part of the bridge abutment modeling. The following modeling step can be seen in Figure 9 below.

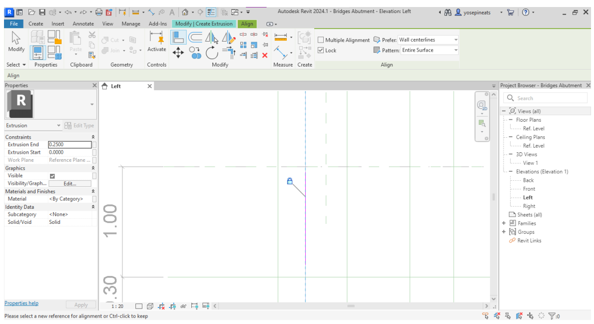

Fig. 9. Extrusion line locking

The figure above shows an overview of the next stage in modeling. After the author makes a line using extrusion, the author unites the line on the reference line and the extrusion line by clicking align in the blue box. After that, the author clicks the reference and extrusion lines. The author can block the image as in the green circle if the two lines are united. The author did this step in the abutment section, which he wanted to model similarly. The bridge abutment has several parts, including the back wall, breast wall, wing wall, approach slab, bearing support, bridge pillar, and corbel. Then for the next step can be seen in Figure 10 below.

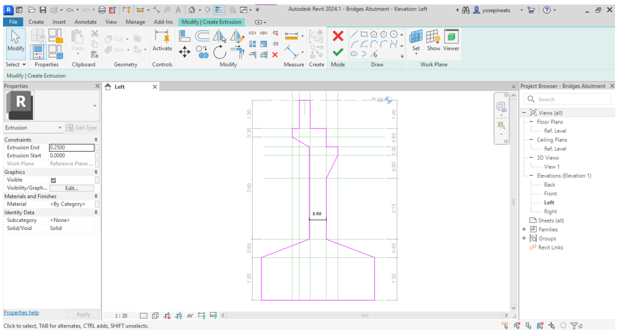

Fig. 10. Final overview of extrusion line

The figure above shows the result of modeling the bridge abutment using extrusion. The author also shows the dimensions of the bridge abutment parts. The author also shows the dimensions of the bridge abutment parts. These dimensions are used so the author can change the drawing size if there is a size error. After the image modeling, the author clicks the check mark on the blue box. The modeling results can be seen in Figure 11 below.

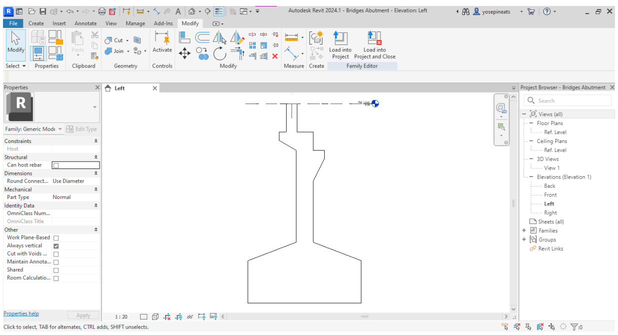

Fig. 11. Final image of bridge model in left view

The figure above is the result of bridge abutment modeling. The author first removes the reference line to show precise abutment modeling results. The Modeler can delete the reference line by selecting it and then clicking delete on the keyboard. The picture above is abutment modeling, which is still 2D. The next step can be seen in Figure 12 below.

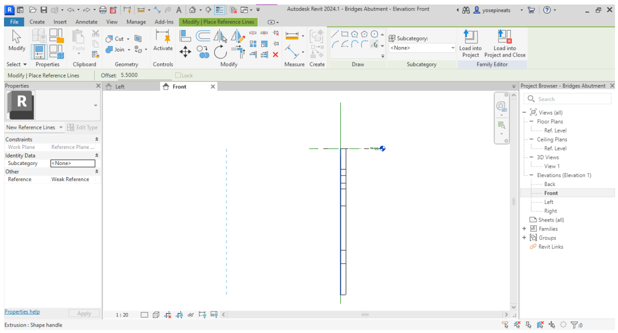

Fig. 12. Front view of modeling

Then, to see the modeling of the image on the front, the author clicks on the front in the project browser. The author then creates a new reference line to make it easier to create image dimensions. The way to make it is by clicking the reference line in the middle, then the author clicks pick lines in the black box, then offsets (orange box) the line along 5.5 m on the left and right. So, the total length of the bridge modeling abutment is 11 m. The next step can be seen in Figure 13 below.

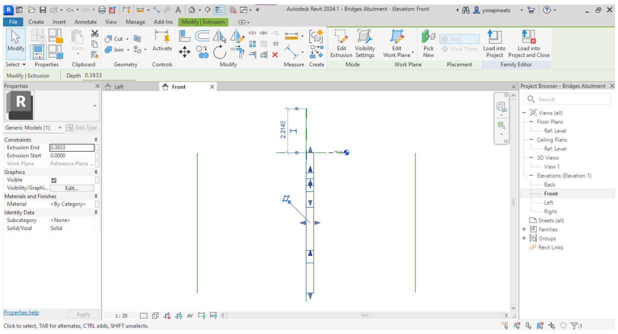

Fig. 13. Line drawing to create modeling length

The figure above is the next step in modeling the front of the abutment. To get an abutment length of 11 m, The author draws the picture to the left-right side according to the direction of the reference line. This method can be done by pulling the part in the red circle according to the direction of the reference line. For modeling, the bridge abutment in the front view can be seen in Figure 14 below.

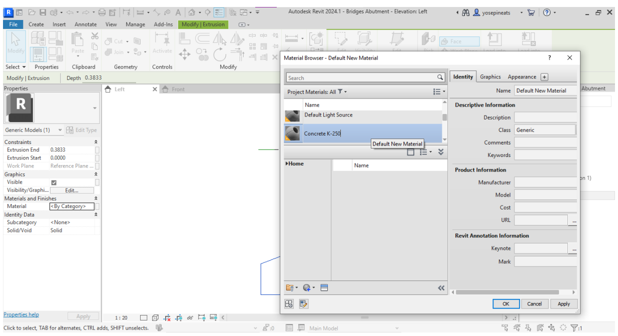

Fig. 14. Material type selection

The next step is for the author to choose the type of material used in the abutment modeling. The author first selects the material section in the properties in the red box to select the modeling material. Next, the author creates a new material by clicking on the blue box and right-clicking on the mouse or touchpad to rename Concrete K-250. After that, the author renames the material as in the green box. The next step can be seen in Figure 15 below.

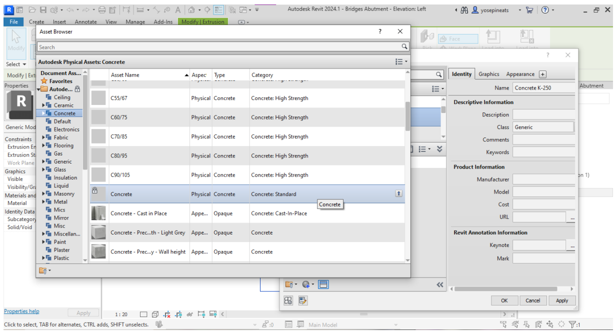

Fig. 15. Bridge abutment modeling material type

The figure above is a further stage of making abutment material. The author uses K-250 concrete with a compressive strength of 250 kg/cm2, equivalent to 20,75 MPa. This type of material defines the modeling building's visual appearance and physical properties. To select the type of material, click on the section in the red box, then select concrete in the Autodesk folder. If the modeler is still undecided on choosing the type of material, the modeler can click apply to see the material description on the building model. Details of the type of building material can be seen in the identity, graphics, appearance, and physical sections. After doing various methods, the building model and the type of material will appear.

4.3 3D View of Abutment Model

Revit 3D is a part of BIM that allows Architecture, Engineering, and Construction (AEC) professionals to build and manage 3D modeling of buildings and infrastructure. Using 3D Revit, stakeholders in a project can visualize the design realistically so that stakeholders can understand the design properly. 3D in Revit can improve project efficiency, productivity, and quality. Modeling bridge abutments in 3D can be seen in pictures 17 below.

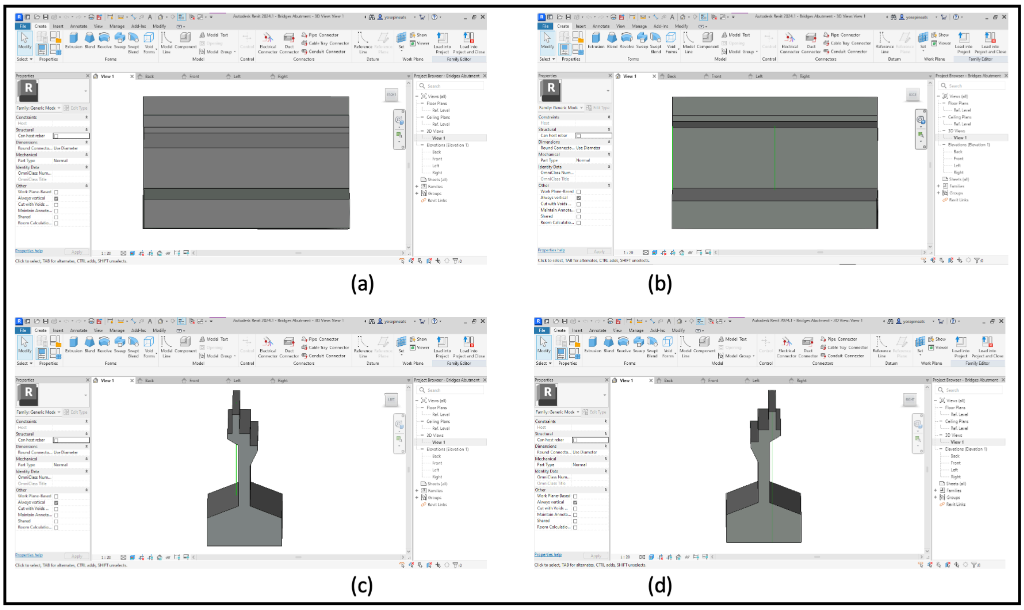

Fig. 17. Front elevations (a) Back elevations (b) Left elevations (c) Right elevations (d)

Figures 17 show four views of modeling in 3D. The 3D shape of the modeling has similarities with the model in the elevations project browser. The author rotates the 3D image by using the shift menu on the keyboard and simultaneously pressing the right side of the keyboard touchpad. Therefore, the author displayed only 3D due to the bridge modeling simulation. Elevations in the project browser are a form of modeling in 2D. Therefore, using Revit has an excellent impact on the construction field, allowing each design to be more detailed.

4. Conclusions

This paper contains a bridge abutment design modeling simulation to increase modeling efficiency in the construction world. By simulating the modeling, modeling using Revit software is very helpful, and it is easy to load various models. Ultimately, BIM in 3D makes it easier for construction actors to model and visualize models in natural form. The bridge abutment modeling simulation process is relatively easy to do. The author obtained bridge data with a height of 7 m, width of 4 m, and length of 11 m. Modeling is done by making a reference line as a modeling reference and then using extrusion as a part that models the abutment. In addition, selecting material types is easy to do, and various types of materials are needed. Loading dimensions on the model is easy and feels more efficient and fast.

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