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The BIM Implementation for Preparing Mutual Check-0 (MC-0) Documents in the Building Development Project of Edusmart Soerojo Hospital Magelang

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ABSTRACT

The development of Building Information Modeling (BIM) technology in the construction sector has been a solution to the problem of preparing planning documents that often occur. It can lower the discrepancy between the value of the planning contract and the value of the building construction implementation contract. The BIM system defines the physical characteristics of a design model into information that can be implemented at several stages of construction work, one of which is Mutual Check 0 (MC-0). Preparing documents (MC-0) on construction projects aims to adjust planning documents in the form of analysis of work items, working drawings, and calculation of the volume of work that affects the contract value. In a short time, the parties involved in construction work, such as contractor service providers and supervisory consultants, need to check the planning volume to match the actual volume of work in the field. In the Edusmart Soerojo Hospital Magelang Building construction project, Building Information Modeling (BIM) is used to check the volume of work. This checking process is assisted by using the Autodesk Revit 2021 software. This study reviews the effectiveness of BIM in preparing documents (MC-0) using a comparative descriptive method, comparing the volume of work in contract documents with the actual volume in the field. This study's results show a difference between adding and reducing volume in the field. The addition occurred in earthworks and excavation, foundation structure, 1st-floor structure, 2nd-floor structure, roof floor structure, and Ground Water Tank (GWT) work. In contrast, the decrease occurred in the sloof understructure and roof work. The total volume obtained indicates a difference in the contract value of the structural work, which has increased by 9.47%. The initial planning contract value was IDR 5,569,152,785.40, an increase of IDR 527,623,004.49 to IDR 6,096,775,789.89.

1. Introduction

Technological aspects in construction are increasingly needed to produce more effective and efficient work, such as Building Information Modeling (BIM) technology. BIM is a digital representation of a facility's physical and functional characteristics. It enables shared knowledge of information resources as a reliable basis for decision-making in its project cycle, from initial conception to demolition [1]. BIM is also interpreted as a construction model that contains building information from all phases of the building's life cycle [2].

BIM technology has developed rapidly and become a new standard in architecture and construction. The BIM implementation policy at the Ministry of Public Works and Housing (PUPR) is also contained in the PUPR Regulation Number 22/PRT/M/2018, which requires the use of BIM in non-simple State Buildings for an area of over 2,000 m^2 and above two stories [3]. BIM technology needs a deeper understanding of its implementation so that, in the future, the implementation of all infrastructure at each stage can obtain the benefits of this BIM technology.

BIM changes the concept of conventional planning in the construction sector (Figure 1). Construction work using the BIM system is done by creating a 3D planning model. This model allows users to generate working drawings, planning evaluations, work volumes, and construction schedules to help the process of work stages to be more effective and efficient [4].

One of the potential implementations of BIM in construction projects is the MutualCheck-0 (MC-0) stage. It is a report of all work items to know every comparison in the volume of work contracts, technical studies, or

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calculations. The MC-0 document is based on the result of the supervisor's and contractor's investigation of the suitability between the existing work items in the plan and the existing volume conditions in the fieldwork [6]. MC-0 can minimize losses for all parties involved in construction work. In a state-building project, this document is vital to ensure the conformity of state treasury payments with the project being undertaken. The BIM system can assist in the preparation of MC-0 and reduce errors in the process of calculating the work volume.

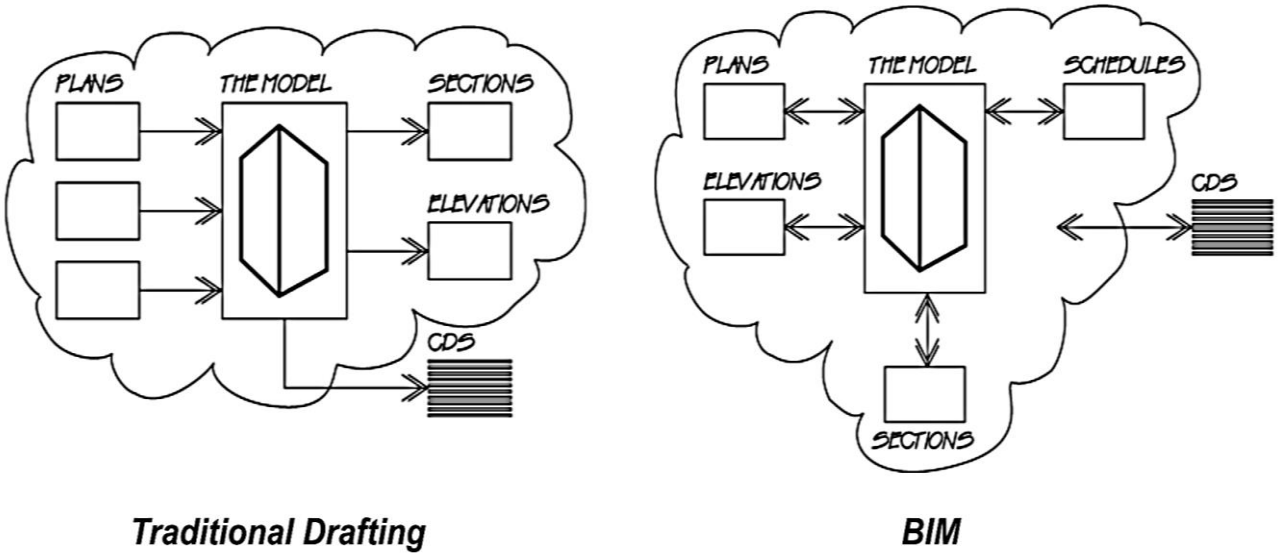

Figure 1. The difference in work procedure between the conventional model and BIM [5]

Research on BIM implementation within the construction world has been found in several journals. However, very few elaborate on the BIM implementation for preparing the MC-0 document in construction projects. A study links BIM with volume calculations entitled "The Implementation of Building Information Modeling (BIM) in Estimating the Volume of Structural and Architectural Work". This study explains the use of BIM in estimating work volume with an average volume gap of 5-6% compared to conventional volume calculations [7]. It is found that this study does not explicitly discuss the use of BIM in the MC-0 stage.

This study aims to determine the extent to which the efficiency of BIM implementation and the accuracy of the volume obtained at the stage of preparing the MC-0 document. In addition, this study also aims to determine the differences in the value of the conventional method work with the BIM method. The results of this study are expected to contribute to the development of BIM implementation awareness in the construction world.

2. Method

This study was conducted using a comparative descriptive method that compares two or more groups of variables to find out fundamental answers about cause and effect by analyzing the factors that cause certain phenomena [8]. In this study, the data variable being compared is between the volume calculation of the structural work, which is calculated manually based on the drawings in the contract document or the Detail Engineering Design (DED), and the calculation with the BIM system. The object of this construction work is the Edusmart Soerojo Hospital Building, a 3-story building with a total area of 3530.47 m2. The project is located on General Ahmad Yani Street No. 169, Magelang, Central Java, Indonesia. It is a Ministry of Health project supervised by the PUPR Service Office of Central Java Province.

Figure 2. The design plan of Edusmart Soerojo Hospital Building

Based on the criteria for this construction project, the Edusmart Soerojo Hospital Building (Figure 2) is classified as a non-simple building project that must adopt the BIM system because it has a total floor area of more than 2000 m^2 and the functional floors above two stories. Therefore, it is essential to study the BIM implementation that has been done on this project. In this study, the software used Autodesk Revit 2021. This software aims to assist the Architecture, Engineering, and Construction (AEC) field in creating high-quality buildings and infrastructure [9]. Like the BIM concept, Autodesk Revit software assists users in every stage of construction, starting from the planning, implementation, and evaluation to the maintenance stage. On this basis, this software was chosen to assist in the process of preparing the MC-0 document.

3. Results and Discussion

3.1 Structural Modeling Process

The initial stage of preparing the MC-0 document with the help of BIM technology is in the structural modelling with the Autodesk Revit 2021 software. The model work is adjusted to the DED drawings from the AutoCAD software. It ensures that the model on Autodesk Revit has dimensions and characteristics that match the planner's DED drawings. The work items carried out at the modelling stage is structural work. The modelling results of the Edusmart Soerojo Hospital Building are shown in Figure 3.

In addition to modeling concrete structural work, the details of the steel reinforcement modelled must refer to the DED drawings and the Bar Bending Schedule (BBS). The BBS document is used as a reference for iron cutting and bending based on the applicable standards. The planner prepared the details for reinforcement formation and length so that the detailed reinforcement structural models could be presented based on the rules contained in the document. Differences between the iron model and the DED images may affect the volume results' validity. The user should consider the model's suitability with the DED image. The detailed sample drawings of DED documents and Revit reinforcement models are presented in Figure 4 and Figure 5.

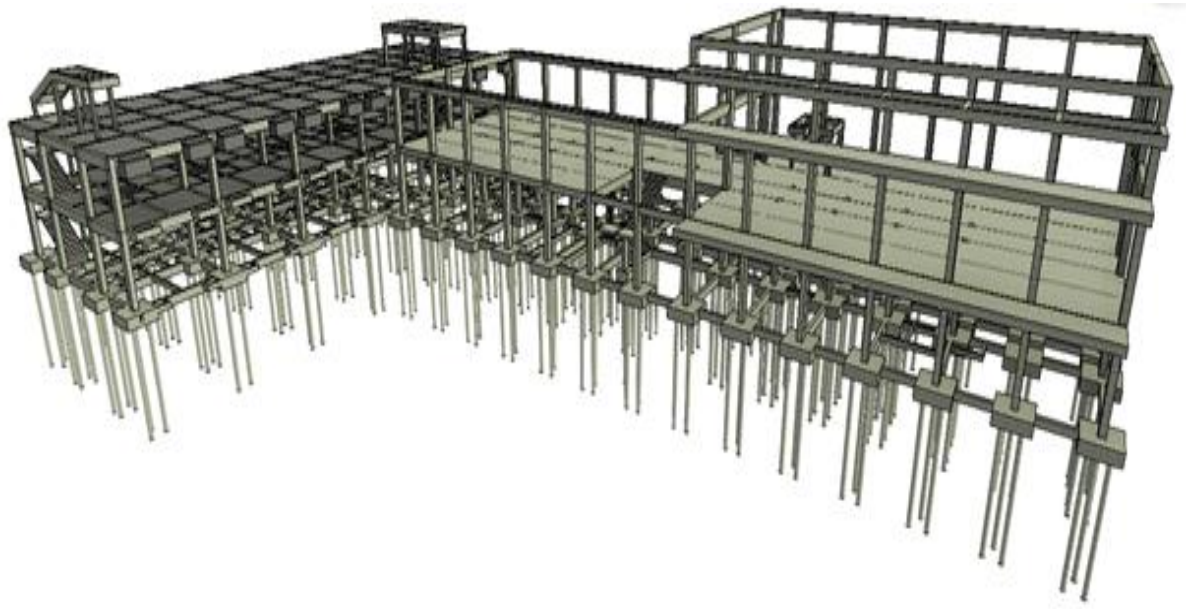

Figure 3. The structural model of Edusmart Soerojo Hospital Building Magelang

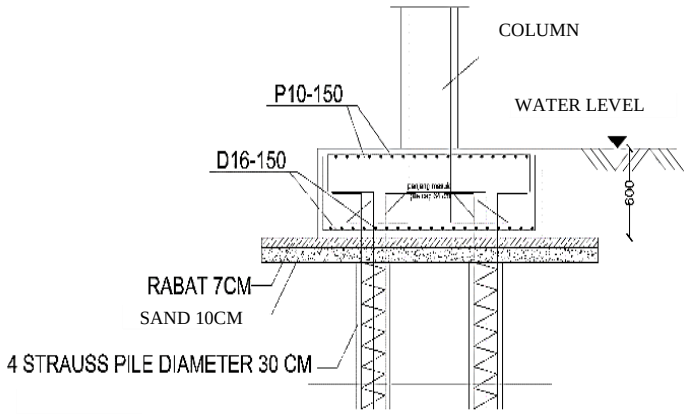

Figure 4. DED drawings of the reinforced concrete structures for borepile, pilecap and pedestal column foundations

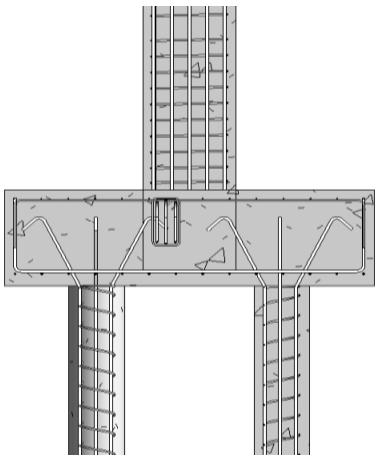

Figure 5. Model of the reinforced concrete structure of borepile, pilecap and pedestal column foundations

3.2 Clash Detection

In modelling building structures using the BIM system, users can apply the error detection process of the structural model that has been created. This stage helps the involved parties in the construction process to finding out earlier about potential design errors during the planning process. The clash detection results that can be obtained based on the DED images are in the main stair beam structure (Figure 6). The main stair beams in The Edusmart Soerojo Hospital Building, designed by the planners, experienced a design clash, so it needs several adjustments. The follow-up solution for a design error like this is to carry out a technical justification. This certainly can affect the value of the structured contract implemented in the field. Therefore, in preparing the MC-0 document, supervisors and contractors need to examine the DED drawings to ensure the costs caused by technical changes can be accommodated appropriately.

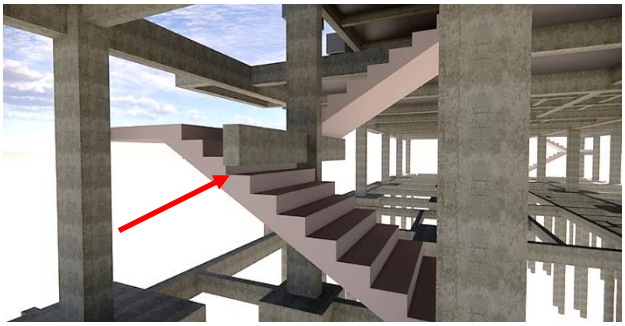

Figure 6. Clash design of ladder beam structure

3.3 Budget contract analysis

Modelling on the Autodesk Revit 2021 software has output in the form of detailed information. The volume structure model is one of the information data that can be obtained in this BIM system. The volume output data known in the Revit software is then exported in the form of an excel file for comparison with the volume from the planner based on the AutoCAD DED drawings. This volume comparison is carried out for each structural work item in the budget plan (RAB) document. Changes in work volume will influence the contract value or Build of Quantity (BOQ) of the building project.

Grouping of job descriptions is carried out to find out changes in the contract value in the Edusmart building structure work, which is included in the structural work criteria. The description of the work consists of earthworks and excavation, foundation structure work, substructure, and sloof work, 1st & 2nd-floor structure work, roof floor, ground water tank (GWT) structure work, and roofing work. The classification of job descriptions contains many work items; for example, floor structure work consists of scaffolding, formwork, metal work, and casting work. In one job description, it is possible to have an addition or reduction in the contract's value. The volume of each work item influences the grouping of work descriptions. The changes in the amount of reinforcement in beams or columns can affect the current contract value on floor work and other structural work. Table 1 presents the addition of contract values based on volume changes with the BIM method from Autodesk Revit 2021.

Table 1. Addition of contract value

Work description	Previous contract value (IDR)	Addition of contrac value (IDR
Soil and Quarry	409,295,851.00	42,029,201.47
Foundation Structure	777,839,424.00	153,135,124.79
Bottom and Sloof Structure	382,759,067.00	91,883,840.22
1st Floor Structure	1,671,703,935.20	472,327,505.12
2nd Floor Structure	1,332,072,724.10	272,652,510.02
Roof Floor Structure	65,065,965.60	122,861,533.23
GWT structure	137,196,502.00	31,288,795.24
Roof Work	793,219,316.50	170,191,908.44
Total	5,569,152,785.40	1,356,370,418.53

Based on Table 1, it can be obtained that the additional contract value for structural work reaches IDR 1,356,370,418.53. The most significant added value is found in the 1st-floor structure work with IDR 472,327,505.12. Meanwhile, the minor addition was in the GWT structure work, IDR 31,288,795.24. This change was due to the calculation of the planners' reinforcing bars, which did not include a calculation of the iron joints overlapping. Another calculation that does not include overlap is iron columns and beams with a length of more than 12 m. Following the rules of the Indonesian National Standard (SNI) 2847: 2019 [10], the connection of iron columns and beams with a length of more than 12 m need to increase the distribution length by 40d [10]. Generally, the additions are due to changes in the technical specifications of the steel reinforcement. The structural design prepared by the planner regulates several reinforcement formations using plain iron reinforcement types.

Meanwhile, SNI requires that reinforcement, which functions for all structural work, must use deformed iron [10]. On this basis, the supervisor and contractor service

providers propose technical changes to the ironwork to comply with applicable standards. This change affects the specific gravity of the iron unit resulting in a significant addition of weight. In addition to the contract value, the items from the job description also experience a decrease in volume. It lowers the value of the contract. The reduced contract value is presented in Table 2.

Table 2. Contract Value Reduction

Work description	Previous contract value (IDR)	Addition of contract value (IDR)
Soil and Quarry	409,295,851.00	542,438.93
Foundation Structure	777,839,424.00	49,817,549.82
Bottom and Sloof Structure	382,759,067.00	178,273,707.76
1st Floor Structure	1,671,703,935.20	118,774,510.42
2nd Floor Structure	1,332,072,724.10	249,131,465.04
Roof Floor Structure	65,065,965.60	24,589,836.57
GWT structure	137,196,502.00	4,215,029.99
Roof Work	793,219,316.50	203,402,875.52
Total	5,569,152,785.40	828,747,414.04

The results in Table 2 show that the contract value reduction for structural work is IDR 828,747,414.04. The enormous reduction value is found in the 2nd-floor structure work, IDR 249,131,465.04. The most negligible reduction is found in earthworks and excavations with IDR 542,438.93. The decrease in contract value generally occurs due to an error in the manual calculation. At the same time, the volume obtained from the results of Autodesk Revit is smaller than the initial contract volume based on the proposed plan. In line with the function of the MC-0 document, the volume of work on the Edusmart building is more valid than the actual volume in the field after re-checking using the BIM system. The Edusmart Soerojo Hospital building project is one of the government's projects, so if the supervisor and contractor do not reduce the value of this contract, then the excess contract value can be found in an audit finding by the Financial Supervisory Agency (BPK). If this happens, the contractor demands to make a refund.

To find out the actual value of the calculation result of MC-0, a recapitulation and summing up of the original contract value, the contract reduction value, and the additional contract value should be done. The sum result is the real value of the Build of Quantity (BoQ) for structural work for the Edusmart Soerojo Hospital building. Data on changes in MC-0 contract values are presented in Table 3.

Table 3. Recapitulation and Contact Value Based on MC-0

Work description	Previous contract value (IDR) (a)	Addition of contract value (IDR) (b)	Contract addition (IDR) (c)	MC-0 document (a-b+c=d) (IDR.) (d)	Change percentage (d/a*100) (%)	Explanation
Soil and Quarry	409,295,851.00	542,438.93	42,029,201.47	450,782,613.54	1.10	Increased
Foundation Structure	777,839,424.00	49,817,549.82	153,135,124.79	881,156,998.97	1.13	Increased
Bottom and Sloof Structure	382,759,067.00	178,273,707.76	91,883,840.22	296,369,199.47	-0.77	Decreased
1st Floor Structure	1,671,703,935.20	118,774,510.42	472,327,505.12	2,025,256,929.90	1.21	Increased
2nd Floor Structure	1,332,072,724.10	249,131,465.04	272,652,510.02	1,355,593,769.08	1.02	Increased
Roof Floor Structure	65,065,965.60	24,589,836.57	131,102,172.43	163,337,662.27	2.51	Increased
GWT structure	137,196,502.00	4,215,029.99	31,288,795.24	164,270,267.25	1.20	Increased
Roof Work	793,219,316.50	203,402,875.52	170,191,908.44	760,008,349.42	-0.96	Decreased
Total	5,569,152,785.40	828,747,414.04	1,356,370,418.53	6,096,775,789.89	9.47	Decreased

Based on these data, the percentage change in the contract value of each structural work description can be seen as shown in Figure 7.

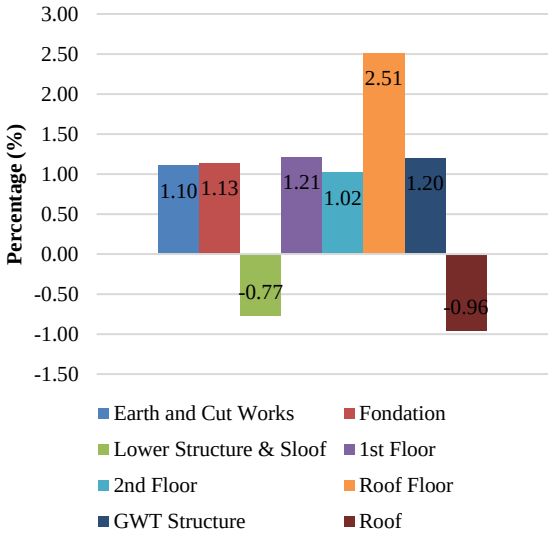

Figure 7. Percentage of changes in the value of structural work contracts

Roof floor work has the highest percentage of added contract value compared to other works (2.51%) from the original contract. It happened because there was a change in the specifications of the roof parapet walls, which originally used masonry walls to cast concrete walls. Models based on the Autodesk Revit software have been adapted to changes in design specifications (Figure 8). These changes affect the calculation of work volume and load.

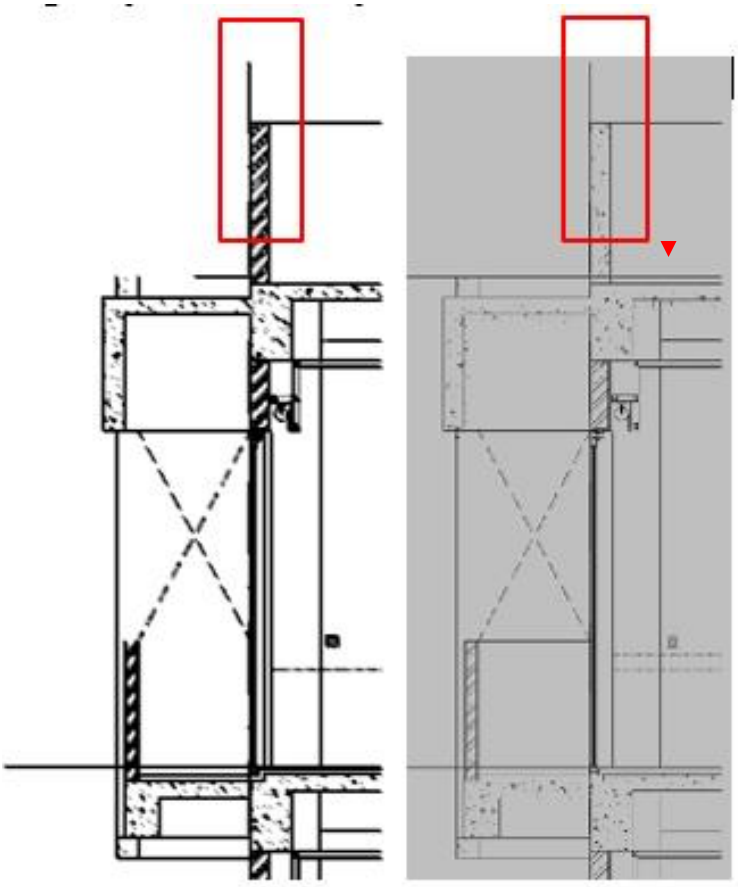

Figure 8. Changes in specifications for the parapet walls of the roof floor of the Edusmart Soerojo Hospital Building

The contract value decreased in roofing work, with a percentage value of -0.96%, and understructure and sloof work, -0.77%. The overall results obtained from Table 2 show that the MC-0 contract has increased by 9.47% with a final value of IDR 6,096,775,789.89. The graph of the addition work value is shown in Figure 9.

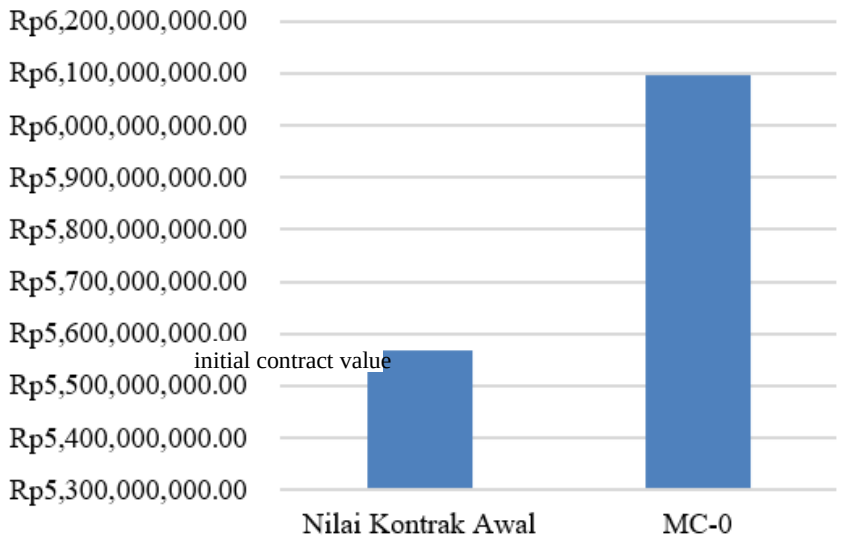

Figure 9. The specifications changes for the parapet walls of the roof floor in the Edusmart Soerojo Hospital Building

4.

5. Conclusion

Based on the previous analysis, it can be concluded that: (1) the use of the BIM system in the preparation of mutual check-0 (MC-0) documents helps to accelerate the volume checking process; (2) the documents compiled are closer to the real work volume in the field and minimize the errors in calculation; (3) the results of the comparison between calculations DED with MC-0 shows an addition in the contract value of 9.47%. The addition occurred in earthworks and excavation, foundation structure, 1st-floor structure, 2nd-floor structure, roof floor structure, and ground water tank (GWT) work. In contrast, the decrease occurred in the sloof understructure and roof work. The original structural work planning contract value was IDR 5,569,152,785.40, with an increase of IDR 527,623,004.49 to become IDR 6,096,775,789.89.

Acknowledgement

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