Clash detection analysis with BIM-based software on midrise building construction project

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Abstract. The goal of this research is to conduct clash detection analysis using BIM-based software for construction of mid-rise building using the BIM technology. The research method implemented in this study is analysis of clash detection using building information modeling (BIM) software for structural, architectural, and MEP of mid-rise building in Jakarta. The result of this thesis is BIM-based 3D construction modelling, the analysis of clash detection which detected namely 104 clashes within overall models, and the estimate analysis of change in construction cost due to clash resolves with result of nearly 1% change of cost and quantity within structural, and MEP model.

Keywords: clash, detection, BIM, midrise, construction

1. Introduction

70% cost of the building construction is being committed in the design stage; hence Integration of multidisciplinary expertise is important throughout the building construction process. BIM is an essential factor for an integrated project management due to its ability in giving all parties that involves in the project an access for the most updated information of the building which previously being done traditionally. Therefore, practical way of utilizing BIM is rather necessary in SME as well as other large commercial or construction project [1]. Building Information Modelling (BIM) is known as an advance technology that supports construction design & process. It allows entire parties to involve throughout design until construction process, even to the building maintenance. In construction project management, BIM can be utilized to increase the necessary cost-effective construction. When problem arise and project turns into a more complex one, BIM can perform as a tool to help in the decision process [2] including cost estimation. Cost estimating holds an important role in establishing a construction project. Cost estimation is an activity of estimating all of the cost needed for each work in a construction project so that the total cost of a project is identified. It is necessary to check the cost estimated by the project management against experiential data and against the subjective knowledge of management professional[3].

Clash happens when two elements interfering in the same zone. Clash can be geometrical, or overlapping schedules, as well as design changes. There are three types of clash:
1. Hard Clash two elements overlapping in the same space.
2. Soft Clash: geometrical or distance tolerance of components towards other components.
3. 4D/Workflow Clash: clash that effects workflow & schedules [3].

2. Methodology

2.1. Data Collection
The data is obtained from the source, in this study data source is the contractor of the project, are details of the project planning, such as project location, for-construction drawings, & bill of quantities. For-construction drawings of structure, architecture, and MEP are the main data needed for this study. Figure 1 shows one of the for-construction drawings used in this study.

2.2. Data Analysis
Analysis of the obtained-data will be carried out in several stages, namely:

a. 3D BIM-based modelling of Structure, Architecture, & MEP using Revit 2020
b. Clash Detection using Naviswork Manage 2020
c. Clash Clustering
d. Clash Resolving
e. Quantity takes-off & Analysis
f. Cost Analysis

3. Result and Discussion

3.1. BIM-based 3D Modelling
The results of 3D modelling using BIM-based Software Revit 2020 is carried out based on Autodesk Revit user manual and in accordance standards of LOD (Level of Development). In this study LOD 300 is implemented. Results of the modelling are as follows Figure 2 – 4.
3.2. Clash Detection Analysis
Clash analysis using clash detection tools is done by comparing two component models, namely between structural & architecture, structure & MEP, and MEP & architecture. Elaboration of the analysis are as follows Figure 5 – 7.

a. Clash detected between structural and architectural components are 30 clashes.

Figure 2. BIM-based 3-dimensional model of structural components

Figure 3. BIM-based 3-dimensional model of architectural components (acoustic ceiling)

Figure 4. BIM-based 3-dimensional model of MEP components (HVAC) - duct, fcu, and fittings

Figure 5. Clash detection analysis between structural & architectural components
b. Clash detected between structural and MEP components are 61 clashes

![Figure 6. Clash detection analysis between structural & MEP components](image)

Based on the results of the clash detection tests above, it was found that the clash between the structural & MEP component has the largest number of clash and the lowest number of clashes is found in the clash between the structural and architectural component. Figure 8 shows a comparison chart of the results of clash between one test and another.

![Figure 8. Clash detection test result comparison](image)

c. Clash detected between MEP and architectural components are 13 clashes

![Figure 7. Clash detection analysis between MEP & architectural components](image)
3.3. Clash Clustering

Clash classification is done to facilitate the following process of analysis, for instance remodeling (resolve) and the quantity & cost analysis. The classification process is done using the same software that is used to analyze the clash detection, namely Naviswork Manage 2020.

The result of Classification are as follows:

a. Clash analysis of structural & MEP elements are classified according to structural components, namely columns, beams and floor plates. Result of the clustering is the tendency of clashes found on level 1A with 50 clashes between beam and HVAC components. Figure 9 shown Clash Detection between Structural & MEP Components were clustered based on Structural Components.

![Figure 9](image)

**Figure 9** Clash detection between structural & MEP components were clustered based on structural components

b. Clash analysis of structural & architectural components are classified according to structural components, namely columns, beams and floor plates. Result of the clustering is the tendency of clashes found on level 3 with 20 clashes between column and ceiling. Figure 10 shown clash Detection between Structural & Architectural Components were clustered based on Structural Components.

![Figure 10](image)

**Figure 10** Clash detection between structural & architectural components were clustered based on structural components
c. Clash analysis of architectural & MEP elements are classified according to MEP components, namely Duct, FCU/AHU, & fitting. Result of the clustering is the tendency of clashes found on level B1 with 8 clashes between duct and ceiling (shown Figure 11).

![Figure 11](image-url)

**Figure 11** Clash detection between architectural & MEP components were clustered based on MEP components

### 3.4. Clash Resolve Analysis

**Table 1. Options of structural clash resolve**

| Clash Description | Change Subject | Change Type | Changed Attributes | Spatial Dependencies | Analytical Dependencies | Change Impact |
|-------------------|----------------|-------------|--------------------|-----------------------|-------------------------|---------------|
| Structural Component & Ceiling | Column Size | MOD | Geometry | CNT | ADT | STR | Client’s Objective |
| Ceiling & HVAC | Beam Size | MOD | Geometry | CNT | ADT | STR | Cost |
| Drop Panel Layout | MOD | SPL | Geometry | ADT | STR | ARC | Cost |
| | | | Position | ELC | OP | | Time |

Source: [5]

**Table 2. Structural clash resolves option index**

| No. | Clash Resolve Option (CRn) | Description | SD | AD | CI | Option Index |
|-----|----------------------------|-------------|----|----|----|-------------|
| 1   | CS -1                      | Column size | 1  | 1  | 1  | 3           |
| 2   | CS-2                       | Beam Size   | 1  | 1  | 0  | 2           |
| 3   | CS-3                       | Drop Panel Layout | 1  | 0  | 0  | 1           |
Table 3. Structural clash resolves

| Before Clash Resolve | After Clash Resolve |
|----------------------|---------------------|
| ![Image A]           | ![Image B]          |
| ![Image C]           | ![Image D]          |

a. Architectural Clash Resolve

Table 4. Options of architectural clash resolves

| Clash Description                  | Change Subject | Change Type | Changed Attributes | Spatial Dependencies | Analytical Dependencies | Change Impact       |
|-----------------------------------|----------------|-------------|--------------------|-----------------------|-------------------------|---------------------|
| Structural Component & Ceiling    | Ceiling Existance | DEL         |                    |                       |                         | Client’s Objective |
| Ceiling & HVAC                    | Ceiling Height  | MOD         | Geometry           | CNT, ADT              | ARC, ELC, OPR, MEC      | Client’s Objective |
| Drop Ceiling Layout               | MOD, SPL        | Geometry    | Position           | ADT                  | STR                    | Cost, Time, Client’s Objective |

Table 5. Architectural clash resolves option index

| No. | Clash Resolve Option (CRn) | Description          | SD | AD | CI | Option Index |
|-----|----------------------------|----------------------|----|----|----|--------------|
| 1   | CS -1                      | Ceiling Existence    | 1  | 1  | 1  | 3            |
| 2   | CS-2                       | Ceiling Height       | 1  | 0  | 1  | 2            |
| 3   | CS-3                       | Drop Ceiling Layout  | 1  | 0  | 0  | 1            |

Table 6. Architectural clash resolve

| Before Clash Resolve | After Clash Resolve |
|----------------------|---------------------|
| ![Image E]           | ![Image F]          |
| ![Image G]           | ![Image H]          |
b. MEP Clash Resolve

### Table 7. Options of MEP clash resolve

| Clash Description | Change Subject | Change Type | Spatial Dependencies | Analytical Dependencies | Change Impact | LOP |
|-------------------|----------------|-------------|----------------------|-------------------------|---------------|-----|
| Duct Existance    | DEL            | -           | -                    |                         | Client’s Objective | EXT |
| Ceiling & HVAC    | MOD: Geometry  | CNT         | ARC                  |                         | Cost           |     |
| HVAC & Beam       | ADT            | -           | OPR                  |                         |               |     |
| Duct Size         | MOD: Geometry  | ADT         | ARC                  |                         | Client’s Objective | REG |
|                   |                |             | MEC                  |                         | Cost           |     |
| Duct Inclination  | MOD: Geometry  | CNT         | ARC                  |                         | Cost           | REG |
| SPL: Position     |                |             | MEC                  |                         | Time           |     |
|                   |                |             | ELC                  |                         | Client’s Objective |     |
|                   |                |             | OPR                  |                         |               |     |

### Table 8. MEP clash resolve option index

| No. | Clash Resolve (CRn) | Description | SD | AD | CI | LOP | Option Index |
|-----|---------------------|-------------|----|----|----|-----|--------------|
| 1   | CS-1                | Duct Existance | 1  | 1  | 1  | 3   |              |
| 2   | CS-2                | Duct Size    | 1  | 0  | 1  | 2   |              |
| 3   | CS-3                | Duct Inclination | 1  | 0  | 0  | 1   |              |

### Table 9. Architectural clash resolve

3.5. Quantity Takes-off

In completing the clash solution there are a number of error and clash solutions that cause changes in the quantity of material used, which can affect the change in costs needed in the construction. Changes in material quantities or units that occur in the model will be elaborated and discussed in the sub-chapters presented in this analysis and are presented based on the categories of causes of clashes that can be seen in Figure 12 – 14.

![Figure 1](image1.png)  
**Figure 1** Change in quantities of structural components

![Figure 13](image2.png)  
**Figure 13.** Change in quantities of MEP components
3.6. Cost Analysis

Based on the analysis of clash detection and its completion, the structural components experience changes in the volume of concrete material so that the column affects the material costs. Cost changes of 1.14 percent of the initial cost of concrete material for column construction. Difference in cost of about Rp. 6,590,366. This is due to changes in floor height at level 1A which results in changes in the volume of concrete material.

4. Conclusion & Suggestion

In the study of clash detection with Building Information Modelling based technology application, the following conclusions can be obtained:

- Integration of 3D models is required in the construction planning to have better visualization; hence pointless errors can be prevented as to reduce the risk of cost overruns in the construction phase;
- Clash detection tool identified design errors on the design of structural, architectural, and MEP model with overall 104 clash detected in this study. Most clash are detected on Level 1A for the clash between structural component and HVAC Component, around 50 clashes (the whole floor) caused by low floor – floor height.
- Change in cost and quantity is expected due to clash resolves of the structural with more than 1% change, architectural with nearly 15% change, and MEP with nearly 0.5% change model.
- Lack in multidisciplinary coordination between contractor and consultants is the main culprit of the detected clash.
- Due to the amount of change both in quantity, it is expected that the change in time is considered none.

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