

The Effects of Design Change on the Completion Time of Universitas Multimedia Nusantara Tower 3 Construction Project

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Abstract

Project scheduling is the determination of the timing and sequence of operations in the project and their assembly to give the overall completion time. One of the benefits of project scheduling is to evaluate the effect of changes on the construction project. The objective of this research is to analyze the effects of design change on project completion time on the construction of Universitas Multimedia Nusantara Tower 3 project. There are five scopes of works that encounter changes, specifically are the work of façade, steel for canopy, landscape, mechanical-electrical, and structure-architecture-plumbing, which have total approved change orders value around 9.95% to the principal project contract. These change orders caused delay of project completion time from May 2017 to January 2018.

Keywords: Project planning, Design change, Completion time, Façade, Steel of canopy, Landscape, Mechanical electrical, Structure architecture plumbing

1 Introduction

Project management nowadays is regarded as a very high priority as all companies are involved in implementing new undertakings, innovations, and changes in bringing projects to a successful end [1]. Some activities that included in project management are project planning and project scheduling. These activities can bring project to success if the project itself can be done on scheduled.

Project planning is the process of choosing the one method and order of work to be adopted for a project from all the various ways and sequences in which it could be done [2]. Project planning serves as a foundation for several related functions, such as cost estimating, scheduling, project control, quality control, safety management, and others. Scheduling is the determination of the timing and sequence of operations in the project and their assembly to give

the overall completion time [2]. One of the benefits of project scheduling is to evaluate the effect of changes.

A change order is a legal document used to modify a construction contract. Change orders can be initiated by the owner or the contractor [3]. According to Yasin (2009), a change that is initiated by the owner is called change order, meanwhile a change that is initiated by the contractor is called change suggestion [4]. Change order effects to project's budget, schedule, or both. Change orders might happen either in planning phase or in construction phase. Change orders can result from any number of differences between what was expected and described in the contract documents and what was found in the field, or they can come from owner-requested changes that are within the scope of the original contract [3]. Change orders are almost inevitable. However, well-planned project may have few changes or could reduce changes.

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Related to above the phenomenon, this research is aimed to analyze the effects of change orders on project completion time on the construction of Universitas Multimedia Nusantara Tower 3 project, whether the change orders were initiated in planning phase or construction phase. This project is designed to achieve high performance and sustainability using the integration design process. The needs of the various building systems are considered from the very beginning of the process design and requires the key building professionals to work as a team even before the first drawing is made.

2 Literature Review

2.1 Change order initiator

A request for a change order can be initiated by any of the following:

1. The owner
2. The architect or other design consultant
3. Unforeseen conditions (i.e., soil conditions different from the submitted boring logs)
4. Municipal government requirements
5. Missing information as determined by RFIs (request for information)
6. Design discrepancies
7. Latent conditions
8. Potential coordination problems with owner-provided equipment
9. Acceleration to the schedule
10. Damage caused by insurance claims (hurricanes, tornados, earthquakes)
11. Changes to equipment or finishes that were initially specified but no longer manufactured.

Meanwhile processing change order begins with preparation for information of drawings and specification defining the new scope of work by the design team. This information is then reviewed by the construction management or general contractor's team [5]. The contractor estimates the cost of the change order and the impact on the schedule, if any. The owner approves, rejects, or negotiates the contractor's request. Once the owner approves such a request, he or she issues the change order [2].

2.2 Change order effect

A change order usually effects to project budget and

schedule [2]. Change Orders may and usually do affect existing items. According to Barrie & Paulson (1992), the effects of change order can be divided to direct-cost effect, extended time effect, and indirect-cost effect [4]. Change order effects more than one scope of work so it can cause cumulative effect [4].

3 Research Methodology

This study utilizes a descriptive method through a taxonomy analysis to describe and/or explain data or observation result. Those data are then analyzed with qualitative method that refers to Miles and Huberman theory [6]. They stated that activities in qualitative data analyzing are done in interactive and continuous process until the research is complete. This research begins by identifying changes in work items which are divided in scopes of works and calculated the cost of each item change. Furthermore, it is grouped based on the initiator of the change and analyzed against the implementation schedule. In addition, an interview is conducted with the project manager. The taxonomy and the interview result the cause-effect change order on the completion time of this project.

4 Results and Discussion

4.1 The description of the project

This research is conducted at Universitas Multimedia Nusantara Tower 3 project in Serpong, Tangerang. The tower is used for education and its support. This project is designed to achieve high performance and sustainability using the integration design process. The needs of the various building systems are considered from the very beginning of the process design and requires the key building professionals to work as a team even before the first drawing is made. The total area of the university is $\pm 80.000 \text{ m}^2$. This project consists of 2 main buildings, a podium (1 semi basement and 3 stories) and a tower from 4th floor up to 18th floor, 1 mezzanine story, and 1 roof top. The total area of the site is $\pm 7575 \text{ m}^2$ and the total area of the building is $\pm 45.642 \text{ m}^2$. The original contract duration is 409 days with start date on April 1st, 2016 and finish date on May 31st, 2017. The principal-project sum contract is about two hundred billion rupiahs.

In this project, the design changes happened in

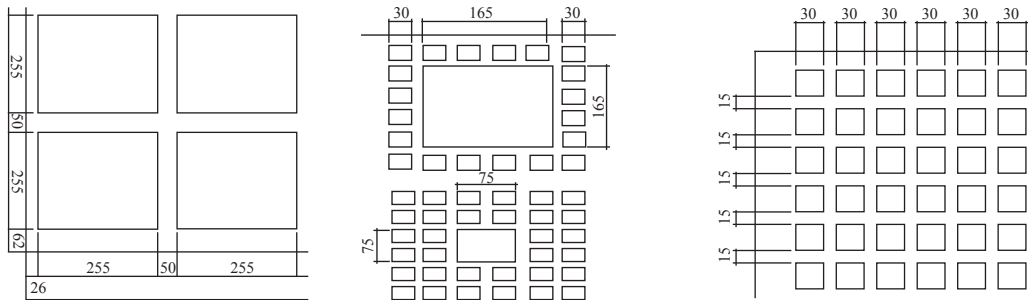


Figure 1: Square-form perforated façade design.

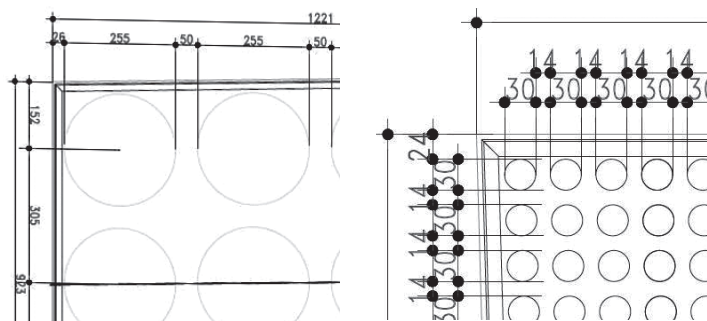


Figure 2: Circle-form perforated façade design.

five scope of works.

a. The work of Façade

Original duration 173 days (October 15th, 2016–April 7th, 2017). Amount of original contract Rp21,007,381,818.19. Approved change orders Rp856,857,209.19 (0.43% to the principal project contract). Amount of final contract Rp21,864,239,027.38

b. The work of steel for Canopy

Amount of original contract is zero. Approved change orders Rp4,009,643,410.59 (2.00% to the principal project contract).

c. The work of Landscape

Original duration 105 days (January 31st, 2017–May 15th, 2017). Amount of original contract Rp1,090,822,700.00. Approved change orders Rp64,254,225.00 (0.03% to the principal project contract). Amount of final contract Rp1,155,076,925.00

d. The work of Mechanical Electrical

Original duration 320 days (June 13th, 2016–May 15th, 2017). Amount of original contract Rp30,190,909,090.90. Approved change orders Rp3,400,965,100.00 (1.7% to the principal project contract). Amount of final contract Rp33,591,874,190.90

e. The work of Structure Architecture Plumbing

Original duration for Structure: 219 days (May 11th, 2016–December 31st, 2016). Original duration for Architecture Plumbing: 239 days (September 17th, 2016–May 15th, 2017). Amount of original contract Rp80,225,475,202.40. Approved change orders Rp11,562,437,416.69 (5.78% to the principal project contract). Amount of final contract Rp91,787,912,619.09

The total approved change orders is Rp19.894.157.361,47. (9,95% to the principal project contract).

4.2 Change order cause and effect analysis

The study of those scopes of work are then classified from the cause and the effect of change order.

4.2.1 The Work of Façade

In the work of façade, change orders were initiated by design discrepancies of perforated form, from square to circle which are shown in Figures 1 and 2.

Square-form perforated design has four difference types of size with the side's length of 225, 165, 75, and 30 mm. Meanwhile the circle-form perforated design

only has two difference types of size with the diameter's length of 225 and 30 mm. The total volume from the work of façade is about 12,995.64 m². Specified amount of panels for each perforated form are show in Tables 1 and 2.

Table 1: Amount of square form perforated aluminum panel

| Perforation Size | Perforated Side' Length | Panel's Amount |
|--------------------|-------------------------|----------------------|
| Big Perforation | 255 mm | 1,548 pieces |
| Medium Perforation | 165 and 75 mm | 5,326 pieces |
| Small Perforation | 30 mm | 3,551 pieces |
| Total | | 10,425 pieces |

Table 2: Amount of circle form perforated aluminum panel

| Perforation Size | Perforated Diameter's Length | Panel's Amount |
|-------------------|------------------------------|----------------------|
| Big Perforation | 255 mm | 2,322 pieces |
| Small Perforation | 30 mm | 8,103 pieces |
| Total | | 10,425 pieces |

This design discrepancies was caused by the owner when the contractor was installing mock-up on July 2nd, 2016. Meanwhile, the Work Order would be sign by both party on August 31st, 2016. In this Work Order, the façade installation will be started from October 15th, 2016. Beside the perforated form design discrepancies, the pattern of façade was also changed as shown in Figures 3 and 4.

The design discrepancies of perforated form and façade pattern caused the Architect's team to recreate for-construction drawing and contractor's team to create shopdrawing. This drawing process could not be continued due to owner's decision has to be made. The owner requested new pattern design to be presented and was agreed on November 22nd, 2016. This delay time affects the schedule of drawing and installation. The shop-drawing need 3 months to proceed from September 2016 to November 2016. Due to the waiting time from the owner, this work schedule was changed from November 2016 to January 2017.

When it is calculated with the same duration, the work of façade needs 173 days ≈ 6 months. So, the completion time of the work of façade is delayed approxiamtely to end of July 2017. The change in duration of the work of façade is shown in Figure 5.

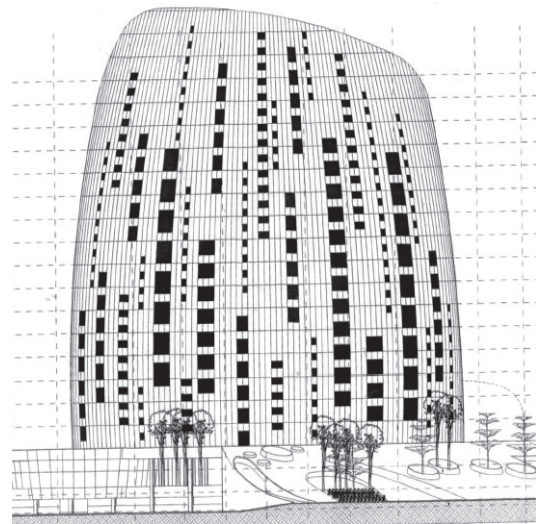


Figure 3: Old façade pattern design.

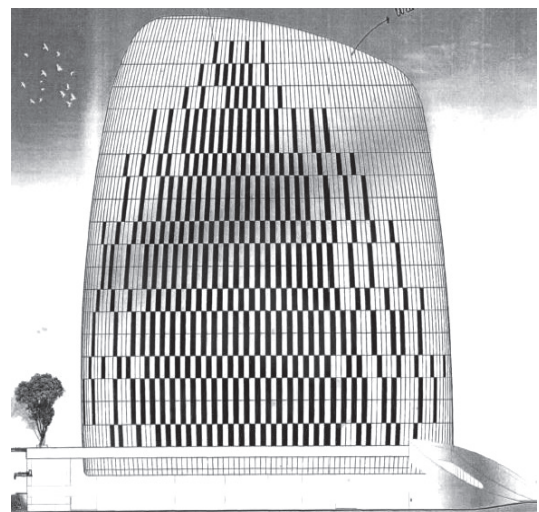


Figure 4: New façade pattern design.

| Year | 2016 | | | 2017 | | | | | | |
|------------------|------|-----|-----|------|-----|-----|-----|-----|-----|-----|
| Month | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul |
| Planned Duration | | | | | | | | | | |
| Actual Duration | | | | | | | | | | |

Figure 5: Completion duration of the work of façade.

Apart from perforated form and façade pattern design discrepancies, there are 4 change orders which are classified into Table 3.

Table 3: Change order of the work of façade

| Item | Change Order Value | Change Order Causes* |
|---------------------------------------|--------------------------|----------------------|
| Guest lounge grid | Rp 85,592,903.22 | 1, 2 |
| Aluminum perforated sheet waste claim | Rp (227,821,819.64) | 1, 3 |
| Window wall and curtain wall | Rp 1,471,473,572.93 | 1, 2, 3 |
| Door and aluminum window | Rp (472,387,447.32) | 1, 2 |
| Total | Rp 856,857,209.19 | |

*Table information:

1. The owner
2. Design discrepancies
3. Missing information as determined by RFIs (request for information)

4.2.2 The Work of Steel for Canopy

In the work of steel for canopy change order occurred by structure design discrepancies from concrete material to steel and aluminum material as shown in Figures 6 and 7 [7], [8].

This scope of work addition was initiated by design discrepancies from the owner. From July 20th, 2016, the work of canopy was delayed. The owner requested to the architecture’s team to redesign the canopy using steel and aluminum material. On November 22nd, 2016, the owner issued Site Instruction for additional work of canopy using steel material for 44,062.91 kg and this work will be start at the end of May 2017.

According to Guidance on Building Construction Materials and Civil Engineering Section 4: Work Unit Price Analysis Filed of Cipta Karya [9]–[11] for installing one kg of steel roof-truss, 0.06 man-day construction welder is needed. The available construction welders on the field are 11 men so in one day there is $11 \div 0.06 = 183.33$ kg steel roof-truss installed. The total duration needed for the work of steel for canopy are $44,062.91 \div 183.33 = 240.35 \approx 241$ days ≈ 8 months. By using this calculation, the work of steel for canopy is estimated can be done in the end of January 2018. After those steel are installed, this work is then continued with installing aluminum perforated sheet for 925.46 m². The change in duration of the work of steel for canopy is shown in Figure 8.



Figure 6: Front-view of canopy.

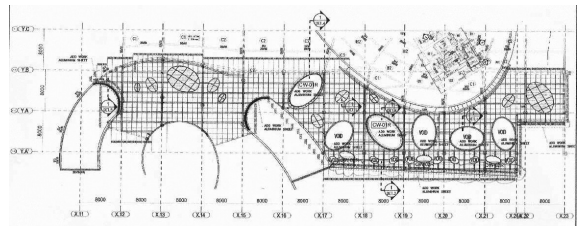


Figure 7: Top-view of canopy.

| Year | 2017 | | | | | | | | | 2018 |
|------------------|------|-----|-----|-----|-----|-----|-----|-----|-----|------|
| Month | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | |
| Planned Duration | | | | | | | | | | |
| Actual Duration | | | | | | | | | | |

Figure 8: Completion duration of the work of steel for canopy.

4.2.3 The Work of Landscape

In the work of landscape, there are 3 change orders for work items which are classified into Table 4.

Table 4: Change order of the work of landscape

| Item | Change Order Value | Change Order Cause* |
|---------------------------------------|-------------------------|---------------------|
| Fertile soil addition | Rp 8,928,000.00 | 3 |
| Bush and grass addition | Rp 48,806,225.00 | 1, 2, 3 |
| Plant relocation and bamboo pile work | Rp 6,520,000.00 | 1, 2 |
| Total | Rp 64,254,225.00 | |

*Table information:

1. The owner
2. Design discrepancies
3. Missing information as determined by RFIs (request for information)

There is no difference between planned duration and actual duration of the work of landscape.

4.2.4 The Work of Mechanical Electrical

In the work of Mechanical Electrical, there are seven sub-work that encountered change orders, those are Motor Vehicle Air Conditioning (MVAC), firefighting, chiller, electrical, electronic, lift, and Sewage Treatment Plant (STP). The total numbers of change orders in the work of mechanical electrical are 16 work items which are classified into Table 5.

Table 5: Change order of the work of mechanical electrical

| Description | Change Order Value | Change Order Cause* |
|--|----------------------------|---------------------|
| Hydrant relocation | Rp 74,788,500.00 | 1, 2 |
| Ducting design discrepancies | Rp 365,533,670.00 | 1, 2 |
| Pipe and valve installation | Rp 522,357,570.00 | 1, 2 |
| Power cable procurement | Rp 123,256,090.00 | 1, 2, 3 |
| Air conditioning cancellation | Rp (65,158,580.00) | 1, 2 |
| Firefighting and MVAC provisional work | Rp (23,718,877.00) | 1, 2, 3 |
| Chiller sequencing unit provisional work | Rp 255,000,000.00 | 3 |
| Electric panel work | Rp (44,962,525.00) | 1, 2 |
| Lamp and electric socket work | Rp 748,745,850.00 | 1, 2, 3 |
| Transformer and Neutral Grounding Resistor Procurement | Rp 743,747,003.00 | 1, 2 |
| Cable installation discrepancies | Rp 47,781,670.00 | 1, 2, 3 |
| Fire alarm and sound system installation | Rp 39,502,850.00 | 1, 2 |
| Panel and pressure fan relocation | Rp 7,276,700.00 | 1, 2 |
| As-built and contract drawing discrepancies | Rp (76,951,821.00) | 1, 2, 3 |
| Passenger lift installation | Rp 681,079,000.00 | 3 |
| Sewage treatment plant piping work | Rp 2,688,000.00 | 3 |
| Total | Rp 3,400,965,100.00 | |

*Table information:
 1. The owner
 2. Design discrepancies
 3. Missing information as determined by RFIs (request for information)

There is no difference between planned duration and actual duration of the work of mechanical electrical.

4.2.5 The Work of Structure Architecture Plumbing

In the work of structure architecture plumbing, there are 22 work items that encounter change orders. Those work items are then classified into Table 6.

Table 6: Change order of the work of structure architecture plumbing

| Item | Change Order Value | Change Order Cause* |
|--|-----------------------------|---------------------|
| Provisional and Prime-Cost rate | Rp (1,557,126,981.10) | 1, 3 |
| Cut and Fill work | Rp 388,003,350.00 | 1, 2, 3 |
| Rebar and casting work | Rp 2,504,176,918.52 | 1, 2, 3 |
| Concrete breaking work | Rp 307,130,177.14 | 1, 2, 3 |
| Plafond design discrepancies | Rp 1,385,848,657.03 | 1, 2 |
| Pump and sump pit design discrepancies | Rp 304,626,040.00 | 1, 2 |
| Floor drain and gutter installation | Rp 278,481,687.00 | 1, 2, 3 |
| Floor work and finishing | Rp 756,614,302.79 | 1, 2, 3 |
| Grand master key and hotel room electronic key procurement | Rp 28,364,072.00 | 1 |
| Glass reinforced concrete panel addition | Rp 737,535,400.00 | 1, 2 |
| Piping installation and design discrepancies | Rp 360,033,262.00 | 1, 2, 3 |
| Road and ramp work | Rp 538,871,713.85 | 1, 2, 3 |
| Masonry and finishing | Rp 396,863,041.60 | 1, 2, 3 |
| Andesit, granite, and split procurement | Rp 521,200,354.86 | 1, 2 |
| Door and window installation | Rp 675,772,320.12 | 1, 2 |
| Steel stair and railing procurement | Rp 167,943,790.00 | 1, 2 |
| Kitchen and hotel room finishing | Rp 882,292,585.60 | 1, 2 |
| Painting work | Rp 160,204,478.10 | 1, 2, 3 |
| Lift interior and pit lift work | Rp 394,409,994.72 | 1, 2 |
| Bench construction | Rp 640,747,621.95 | 1, 2 |
| Lamp box procurement | Rp 147,999,999.93 | 1, 2 |
| Annex room work | Rp 374,143,690.60 | 1, 2 |
| Total | Rp 10,394,136,476.71 | |

*Table information:
 1. The owner
 2. Design discrepancies
 3. Missing information as determined by RFIs (request for information)

There is no difference between planned duration and actual duration of the work of structure, architecture, and plumbing.

5 Discussion and Recommendation

The change of duration in the work of façade was occurred in the planning phase of perforated form and façade pattern, not in the installation phase of façade. This change was initiated by the owner so the contractor has to wait the decision to be made. In this situation, the owner cannot make decisions alone regarding the purpose of high performance sustainable building design, where subjective decisions are taken after objective decisions have been considered. They took several months to make a final decision. This change affects façade installation time which can be started on early February 2017 and be finished on April 2017, then delayed 4 months from the original schedule. So the completion time for the work of façade finished at the end of July 2017. This work of façade has change order value around 4.08% to the amount of original contract.

The change of duration in the work of steel for canopy was caused by design discrepancies from concrete material to steel and aluminum perforated sheet material on May 2017. The concrete has been installed and then disassembled. This is related to the sunlight that can be absorbed. This change affect the completion time for canopy, delayed 8 months and is estimated to be done in the end of January 2018.

In the work of landscape, mechanical electrical, and structure architecture plumbing, the change orders that occurred do not affect the completion time. From the site manager's information, these 3 scope of works have finished 100% to the end of May 2017. The completion time of these works have done in May 15th, 2017. The value of change orders to the amount of original contract are 5.89% for the work of landscape, 11.26% for the work of mechanical electrical, and 14.41% for the work of structure architecture plumbing. Those values are coming from material price discrepancies and miscalculated volume between what is stated in contract and what is found in field. The volume addition to the work items and material discrepancies do not affect the completion time because the decision is taken directly.

Overall, change orders that occurred in this project were initiated by the owner, design discrepancies, and missing information as determined by RFIs (request for information). The bigger percentage value of change orders to the amount of original contract that

occurred in the construction phase do not affect the completion time. There are other factors that caused the project does not finish on schedule. In this project, those factors came from the owner as described above

6 Conclusions

From the result and discussion that have been done, it can be concluded that:

- a. The total approved change orders value is around 9.95% to the principal project contract.
- b. The completion time of Universitas Multimedia Nusantara Tower 3 project delayed from May 2017 to January 2018.
- c. The main design change is material design discrepancies for canopy from concrete to steel and aluminum perforated sheet, which initiated by the owner.

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