

## Analysis of Construction Cost Estimation Ministry Regulation Year 2016 and Year 2022 for Construction Projects

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### ABSTRACT

*Cost is one of the three most crucial project management components, with the other two being Quality and Time. A Ministry Regulation regulates the calculation of construction work costs in detail in Indonesia. This Ministry Regulation has only undergone changes in 2022, which replaces and fixes several existing rules in the previous Regulation issued in 2016. For brevity, the two Regulations are shortened to regulation 2016 and regulation 2022. This study uses the two Regulations on two different Construction Projects to analyze the different cost calculation results caused by the regulation change. This change must be understood to continuously improve the Ministry Regulation regarding cost estimation. This research method observes each research project's working coefficient, calculates project cost using Regulation 2016 and Regulation 2022 and compares it with contractor/actual price. Based on the calculation, most results show that Regulation 2022 is closer to the actual cost than Regulation 2016. Still, there are some components that even Regulation 2022 must improve, such as floor plate formwork, Ceiling work, plasterwork, floor and coverings work, and other works which have a significant deviation, as can be seen on the paper. In conclusion, regulation 2022 can produce more accurate results, with regulation 2016 often giving a higher cost estimation than regulation 2022. For future research, it is best to analyze another type of construction infrastructure to gain more insight into other improvements.*

**Keywords:** *Construction Management, Cost Estimation, Ministry Regulations*

### Introduction

Indonesia is a developing country that continues to grow its infrastructure. Calculating the construction cost of buildings as closely as possible to its actual price is especially important, as poor cost estimate performance has caused project failure before[1]–[10]. Several estimates are needed based on the intended use and designation in construction practices. In the early stages of planning a periodic road maintenance project, such as during the preparation of the project budget, estimates are not possible based on the calculation of the quantity (volume) of work because the description and specifications of the work have not been prepared[11]. In Indonesia, the analysis of building construction is regulated by a Ministry Regulation. The current Ministry Regulation is the Regulation of The Minister of Public Works and Public Housing of The Republic of Indonesia Number 1 of 2022 Concerning Guidelines for Preparing Estimated Costs for Construction Work in The Field of Public Works and Public Housing, with the previous Regulation is the Regulation of the Minister of Public Works and Public Housing Number 28 of 2016 Concerning Guidelines for Analysis of Unit Prices for Public Works. Even though there will be a new regulation in 2022, to compare the previous and the current Regulation is essential to analyze the difference and accuracy between the two regulations. The analysis was performed because cost estimation is one of several primary factors in avoiding failures such as cost and schedule overruns[12]. This paper's purpose is to :

1. Analyze the difference between the cost estimation results and find the difference coefficient between Ministry Regulation by using the calculation of regulation 2016, regulation 2022, and Contractor Calculation/Actual (Field) Cost based on the project used for the research, and
2. Suggest a future improvement for Ministry Regulation using the calculation of regulation 2016, regulation 2022, and Contractor Calculation/Actual (Field) Cost based on the analysis.

Unit Price Analysis is a calculation used in cost estimation. Unit Price Analysis generally calculates the construction cost by multiplying the material, tools, and labor needed to complete work with the price of materials, tools, and delivery. To simplify the process of the calculations, the number of materials, tools, and labor needed to complete a work is represented by a number called a coefficient. Coefficients played a significant role in the work unit price analysis as these numbers used to be multiplied by the unit price of materials, tools, and labor costs that formed the work unit price[13]. Unit Prices will eventually use to create a

cost budget plan. Preparing a Cost Budget Plan before carrying out a construction job is essential. The planning must be carried out carefully and carefully so that construction cost control goes well [14].

Base Unit Price, shortened as BUP, is the price of the component unit of the work unit price per specific unit. There are also several terms relating to the BUP, and they are: Self-Estimated Price, shortened as SEP, is an estimate of the price of goods/services determined by a commitment-making official that has considered indirect costs, profits, and value-added tax. The Designer's Estimated Price, shortened as DEP, is the estimated cost of wk calculated professionally by the designer and used as a reference in figuring the Own Estimated Price[15]. There are several types of estimations, such as[16]:

1. Rough Estimation  
This estimate is an initial price estimate and is not too detailed. This estimate is needed by the project owner, which will then be used to decide whether the project idea will continue.
2. Early Estimation  
This estimate is more detailed than the previous estimate. This estimate is based on drawings, work plans, and requirements.
3. Detailed Estimation  
After receiving and studying the tender documents during the work explanation meeting, the contractor makes detailed estimations.
4. Actual Cost  
The price stated in the contract is a fixed cost for the project owner and is the final cost that will be incurred for the project.

Compiling a project budget plan is based on analyzing each constituent component (materials, wages, and equipment) for each work item contained in the project. The results of the component analysis will eventually produce a work unit price per item which forms the basis for determining the estimated value of the overall project implementation cost by converting it into the total volume for each item of work in question[17].

Regarding previous research, there are several previous research used in this paper as references and comparisons. A previous study comparing regulation 2016 and the Indonesian National Standards resulted in regulation 2016 having higher costs, mainly because the latter didn't calculate the overhead cost[18]. Another reference that compares cost estimation between several methods resulted in the cost calculation from the contractor's calculation results has the lowest value. The Indonesian National Standards method has the effect that is closest to the contractor's estimate, with a difference of 8.99%. The difference between the Indonesian Standard Methods and BOW methods is 27%[19]. A paper comparing regulation 2016 against regulation 2022 in soil excavation cost shows the cost of regulation 2022 is below regulation 2016 for a project started in 2018[20]. Previous research [21] , which compares the cost calculation between regulation 2016 against contractor calculation in 2019, shows that the analysis in this study indicates that the Ministry Regulation has a higher value than the actual in the field. This is due to the comparison of significant labor coefficients. Another research shows that regulation 2016 is more efficient in the budget than the offering calculation[22].

Regarding the urgency of this research and paper: the use of Regulation 2016 and Regulation 2022, respectively, is widespread across Indonesia as it is the base rule of calculation cost estimation for infrastructure projects. To pay as close to the actual cost, we can estimate the more we can avoid loss of profit. Evaluating price correctly is essential to become a reliable estimator or a reliable builder (owners or contractors). That is why the improvement of Regulation 2022 is vital for future cost estimation in Indonesia. The earlier we know what to improve, the faster we can improve it.

Compared to previous research, this paper will compare the Indonesian ministry regulation on cost estimation (regulation 2016 and regulation 2022) against contractor calculation. This comparison will show the difference between regulation 2016 and 2022 and the contractor calculation. This comparison will be able to offer the accuracy of regulations 2016 and 2022 and will be able to inform what part of the Regulation could be improved.

## **Research Methods**

Using the cost estimation rules and calculation in regulation 2016, regulation 2022, and the analysis of contractors, the cost of two projects was compared, not against each project but between the cost calculation results using regulation 2016, regulation 2022, and contractor calculation.

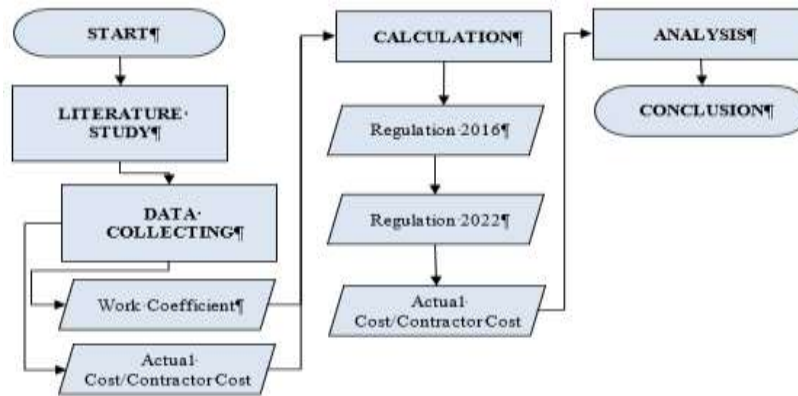


Figure 1. Research Flow Chart

### Regulation 2016 And Regulation 2022

Work unit price analysis in this research will use the reference of 2 ministry guides, which are: "Peraturan Menteri Pekerjaan Umum dan Perumahan Rakyat Nomor 1 Tahun 2022 tentang Pedoman Penyusunan Perkiraan Biaya Pekerjaan Konstruksi Bidang Pekerjaan Umum dan Perumahan Rakyat" (regulation 2022) and "Peraturan Menteri Pekerjaan Umum dan Perumahan Rakyat Nomor 28/PRT/M/2016 Tahun 2016 tentang Pedoman Analisis Harga Satuan Pekerjaan Bidang Pekerjaan Umum" (Regulation 2016). In both regulations, it is stated that the calculated work unit price is a sum of direct costs and indirect costs. Direct costs are the amount needed for materials, tools, and labor. At the same time, indirect costs are general costs and profits, where general costs can be broken into service costs and accident costs. The allowed profit limit ranges from 10 to % of direct costs[23].

### Data Collecting

Data collection was done by gathering primary and secondary data. These data were collected on two separate projects. The projects are A thirty-three-floor apartment in Tangerang Area and a Two-Story Housing Project in Cikupa

The primary data was through observation and direct survey to find the productivity of each work that was analyzed. Secondary data are project plan, volume data, cost data (available and allowed to be given), and schedule[24]–[28].

Some of the data acquired is the coefficient for the workforce and the equipment and material coefficient. After the primary and secondary data have been gathered, the cost can be calculated. Although in this paper, not all components of the structure (the Apartment building and the Housing Project) are calculated. This is because of the limitation of the allowed data collection for both primary and secondary data on both locations and the time limitation for this research. Direct data from the field is often called preliminary data, and documented data is called secondary data[29].

### Project Cost Calculation and Comparison

The project cost calculation was done using Regulation 2016 and Regulation 2022 for the two-project mentioned before: an apartment project in the Tangerang area and a two-story housing project in Cikupa.

Cost Estimation is implemented at a given time using available project data and information. In several cases, estimators could predict the cost of a project with limited resources [21][30]. In this research, the cost estimation using regulation 2016 and regulation 2022 is compared against the contractor cost/actual cost to analyze the difference between the two Regulations and determine what improvements the future Regulation could have. For comparison, this research compares the work productivity on both regulations and the actual productivity on project location. It reaches the cost estimation on both regulations and the actual cost of the project location. The following section will discuss the results of this analysis.

## RESULTS AND DISCUSSION

This paper will compare the results between the cost calculation coefficient used in regulation 2016 and regulation 2022 against the actual work coefficient in the field. By comparing the coefficient, we can better understand why each calculation's results can be different, what to be wary of when calculating project cost in

the future, and what improvement we can implement for future regulations (or just for future calculations). The cost calculation in this Result is based on regulation 2016 [31] and Regulation 2022 [32].

### ***Coefficients Analysis for Observable Works***

Data gathering through observation and survey was done to gather the coefficient and the productivity of the actual field works. In this paper, several comparisons for the coefficient will be shown, starting from the Two-Story House Project in Cikupa and then the Apartment project in Tangerang. The coefficient determination and calculations are based on previous research [33] analyzing the time and cost of other works.

For the Two-Story Housing Project in Cikupa, from the observation, survey, and theoretical data of regulation 2016 and regulation 2022, attached are several works that were able to be observed directly[20], [34], [35]:

**Table 1.** Coefficient Difference in Brick Wall Works (Observed at Two-Story House Project in Cikupa)

Description	Unit	Coefficients		
		Regulation 2022	Regulation 2016	Observation*
Worker	person-day	0,3	0,3	0,212
Handyman		0,1	0,1	0,212
Handyman Head		0,01	0,01	-
Foreman		0,015	0,015	0,018
Brick	pcs	70	70	58
Portland Cement	kg	9,68	9,68	13,054
Sand	m <sup>3</sup>	0,045	0,045	0,0369

*\*Observation value will be used in the contractor calculation because this paper aims to compare regulation 2016 and regulation 2022 against the actual cost (or the closest to the actual price)*

**Table 2.** Coefficient Difference in Light Brick Wall Works

Description	Unit	Coefficients		
		Regulation 2022	Regulation 2016	Observation*
Worker	person-day	0,671	0,671	0,267
Handyman		0,13	1,3	0,267
Handyman Head		0,013	0,13	-
Foreman		0,003	0,003	0,025
Light Brick	pcs	8,4	8,4	8,4
Ready Use Mortar	kg	0,063	0,063	1,508

*\*Observation value will be used in the contractor calculation because this paper aims to compare regulation 2016 and regulation 2022 against the actual cost (or the closest to the actual price)*

For the Apartment Project in Tangerang, from the observation, survey, and theoretical data of regulation 2016 and regulation 2022, attached is the ready mix works that were able to be observed directly:

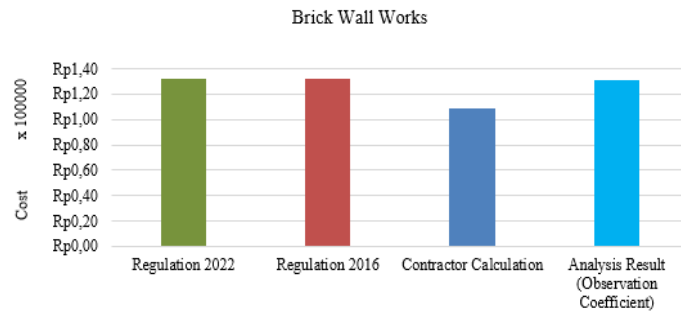
**Table 3.** Coefficient Difference in Ready Mix Concrete Works (Observed at Apartment Project in Tangerang)

Component	Coefficient		
	Regulation 2022	Regulation 2016	Observation*
Worker	0.400	1.000	1.233
Woodworker	0.100	0.250	0.379
Handyman	0.040	0.025	0.093
Foreman	0.010	0.100	0.122
Ready Mix Concrete	1.020	1.020	1.010
Concrete Pump	0.120	0.120	0.010

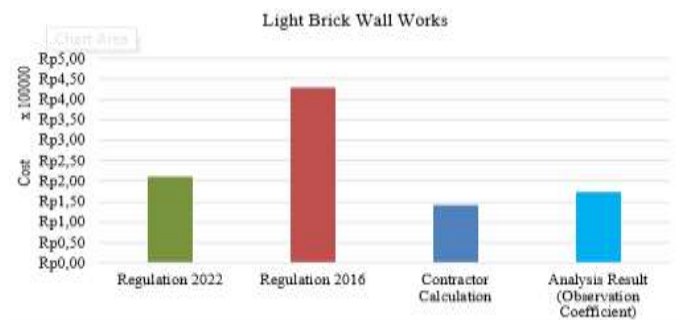
*\*Observation value will be used in the contractor calculation because this paper aims to compare regulation 2016 and regulation 2022 against the actual cost (or the closest to the actual price)*

### ***Cost Calculation for Observed Works***

After the coefficient for several works was found, each cost can be compared. The first comparison is the Two-Story Housing Project in Cikupa.



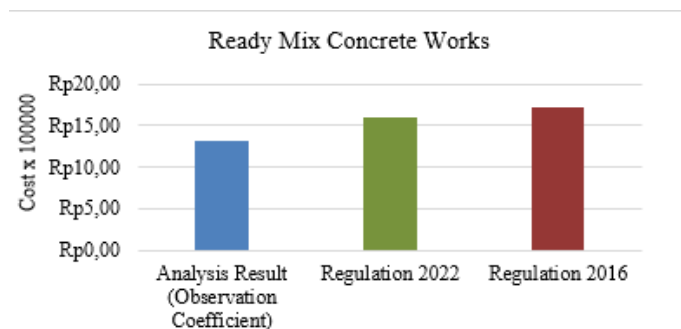
**Figure 2.** Brick Wall Works for a Two-Story House Project in Cikupa



**Figure 3.** Light Brick Wall Works Two-Story House Project in Cikupa.

For the two-story house project in Cikupa, Figures 2 and 3 show the difference for each calculation method. In Figure 2, we can see that the Result closely resembles each other for all the calculation, with the observation/analysis calculation being the closest to the contractor calculation/actual cost. In Figure 3, we see that regulation 2022 is the most comparable to contractor calculation compared to regulation 2016. But the analysis results through observation are still close to the contractor calculation/actual cost.

For the apartment project in the Tangerang region, the graphic can be seen in Figure 3. As you can see, regulation 2022 is closer to the analysis result (observation coefficient) than regulation 2016. For all three figures (Figures 2, 3, and 4), we can see that regulation 2022 is the closest for the two works. Even then, in Figure 1, regulation 2022 is still close to the Result of regulation 2016 and cost analysis through observation. To better understand the difference between regulation 2022 and regulation 2016, the cost of several sections of the two projects was also calculated (the housing project is calculated for one two-story house, and the apartment project is calculated on the structural works for basement floor 2 through the 33rd floor). These sections were compared against the contractor/actual cost against regulation 2016 and regulation 2022.



**Figure 4.** Ready Mix Concrete Works for Apartment Building Project in Tangerang

**Cost Calculation Comparison**

After comparing the coefficient and cost of observed works, the comparison is for the price of some project results.

**Cost Calculation Comparison for The Two-Story House Project**

The cost calculation for the two-story housing project is the cost for a single two-story house. Below in table 4, table 5, and table 6 is the comparison.

**Table 4.** Cost Calculation Based on the Contractor/ Actual Cost Calculation for Two Story House Project

<b>Work Description</b>	<b>Cost</b>
Preparation Works	Rp. 1.469.418,50
Soil Works	Rp. 1.787.417,50
Foundation Works	Rp. 382.912,20
Concrete Works	Rp. 189.200.024,01
Steel and Aluminium Works	Rp. 11.200.387,00
Wall Works	Rp. 44.137.052,22
Plaster Works	Rp. 70.553.922,12
Floor and Wall Covering Works	Rp. 44.170.431,91
Ceiling Works	Rp. 11.833.250,00
Roof Works	Rp. 5.536.784,00
Wood Works	Rp. 1.096.722,00
Door and Window Works	Rp. 76.734.418,20
Paint Works	Rp. 13.259.097,50
Sanitation Works	Rp. 58.993.022,00
Electrical Works	Rp. 11.356.400,00
<b>Total</b>	Rp. 541.711.259,17
<b>Rounded</b>	Rp. 541.700.000,00

**Table 5.** Cost Calculation Based on regulation 2016 for Two Story House Project

<b>Work Description</b>	<b>Cost</b>
Preparation Works	Rp. 6.505.945,60
Soil Works	Rp. 4.456.758,90
Foundation Works	Rp. 197.704,11
Concrete Works	Rp. 205.518.371,31
Steel and Aluminium Works	Rp. 11.575.429,48
Wall Works	Rp. 72.574.941,81
Plaster Works	Rp. 79.797.133,57
Floor and Wall Covering Works	Rp. 71.249.459,83
Ceiling Works	Rp. 50.160.956,65
Roof Works	Rp. 6.783.720,46
Wood Works	Rp. 1.940.879,60
Door and Window Works	Rp. 76.734.418,20
Paint Works	Rp. 26.673.087,53
Sanitation Works	Rp. 84.445.184,21
Electrical Works	Rp. 24.189.440,00
<b>Total</b>	Rp. 722.803.431,27
<b>Rounded</b>	Rp. 722.800.000,00

**Table 6.** Cost Calculation Based on regulation 2022 for Two Story House Project

<b>Work Description</b>	<b>Cost</b>
Preparation Works	Rp. 6.505.945,60
Soil Works	Rp. 4.456.758,90
Foundation Works	Rp. 197.704,11
Concrete Works	Rp. 201.190.421,58
Steel and Aluminium Works	Rp. 11.575.429,48
Wall Works	Rp. 56.368.344,12
Plaster Works	Rp. 79.797.133,57
Floor and Wall Covering Works	Rp. 71.249.459,83
Ceiling Works	Rp. 50.160.956,65
Roof Works	Rp. 6.783.720,46
Wood Works	Rp. 1.940.879,60
Door and Window Works	Rp. 76.734.418,20
Paint Works	Rp. 26.673.087,53
Sanitation Works	Rp. 82.124.049,07
Electrical Works	Rp. 24.189.440,00
<b>Total</b>	Rp. 699.947.748,70
<b>Rounded</b>	Rp. 699.900.000,00

From the tables above, between regulation 2016 and regulation 2022 there are three different calculation results: concrete works, wall works, and sanitation pieces, as seen in Figure 4 below.

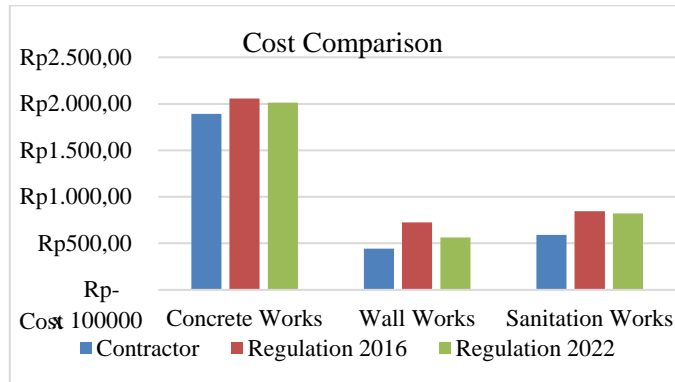


Figure 5. Cost Calculation Comparison for Two-Story Housing Project

When compared, regulation 2022 has a closer value to contractor calculation/actual cost than regulation 2016, meaning that the changes in regulation 2022, at least in the works analyzed in this research, can give a more accurate calculation than its predecessor. Below is also a comparison of the two-story house cost.

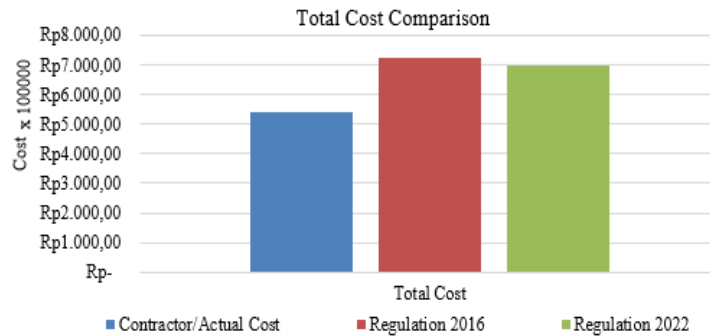


Figure 6. Total Cost Comparison for Two-Story Housing Project

Compared to the total, regulation 2022 still has a closer figure to the contractor/actual cost than Regulation 2016. For the rest of the price, the comparison can be seen in Figure 7.

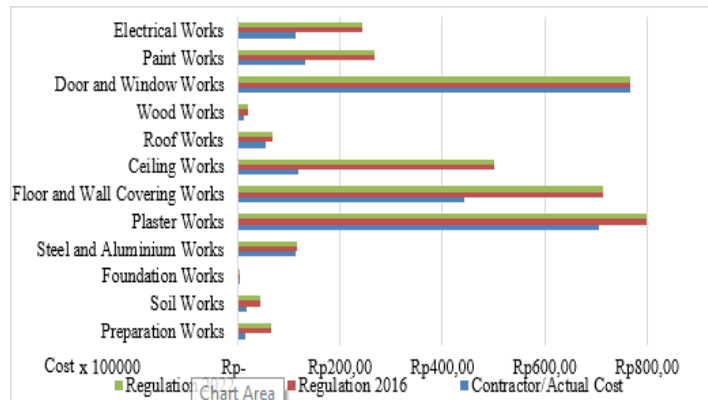


Figure 7. Cost Comparison for Two-Story Housing Project in Cikupa for Its Works

As seen in Figure 7 and the previous figures and tables, there are several differences in the calculation for regulation 2016 and regulation 2022 against the actual cost. This difference can become advice on what to improve for the following (or revised) Regulation.

**Cost Calculation Comparison for Apartment Project**

After analyzing the cost estimation for the two-story housing project, the following analysis is for the apartment project in Tangerang. Below in table 7, table 8, and table 9 is the comparison.

Table 7. Cost Calculation Based on the Contractor/Actual Cost Calculation for the Apartment Project

NO	Work Description	Cost
1	Floor Plate Formwork	Rp7.632.931.522,38
2	Column Formwork	Rp1.961.457.804,08
3	Beam Formwork	Rp2.779.981.496,45
4	Shear Wall Formwork	Rp1.002.086.006,33
5	Ladder Formwork	Rp230.428.017,33
6	Pouring of Floor Plate Concrete	Rp9.655.105.047,68
7	Pouring of Column Concrete	Rp4.745.371.461,32
8	Pouring of Concrete Blocks	Rp4.999.676.785,46
9	Shear Wall Concrete Pouring	Rp2.534.100.700,39
10	Ladder Concrete Pouring	Rp343.219.837,81
11	Floor Plate Concrete Repair	Rp11.299.174.278,87
12	Column Concrete Gap	Rp24.024.707.427,62
13	Bending Concrete Beams	Rp21.303.271.887,14
14	Shear Wall Concrete Reinforcement	Rp7.925.910.066,60
15	Ladder Concrete Reinforcement	Rp1.097.900.610,36
<b>Total</b>		Rp101.535.322.949,81
<b>Rounded</b>		Rp101.540.000.000,00

Table 8. Cost Calculation Based on regulation 2016 for the Apartment Project

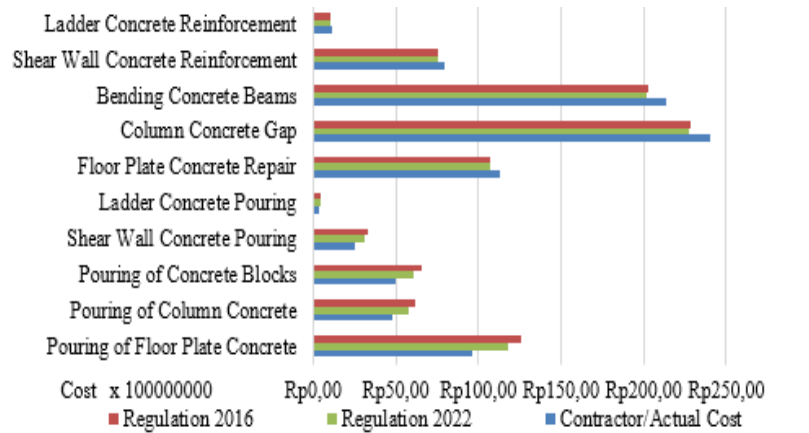
NO	Work Description	Cost
1	Floor Plate Formwork	Rp6.139.284.823,81
2	Column Formwork	Rp1.420.010.802,66
3	Beam Formwork	Rp2.012.798.045,28
4	Shear Wall Formwork	Rp792.287.748,07
5	Ladder Formwork	Rp166.614.937,26
6	Pouring of Floor Plate Concrete	Rp11.759.738.871,44
7	Pouring of Column Concrete	Rp5.779.774.425,83
8	Pouring of Concrete Blocks	Rp6.089.513.593,87
9	Shear Wall Concrete Pouring	Rp3.086.487.652,24
10	Ladder Concrete Pouring	Rp418.035.396,72
11	Floor Plate Concrete Repair	Rp10.703.534.539,33
12	Column Concrete Gap	Rp22.758.236.965,12
13	Bending Concrete Beams	Rp20.180.262.806,55
14	Shear Wall Concrete Reinforcement	Rp7.508.093.074,74
15	Ladder Concrete Reinforcement	Rp1.040.024.413,62
<b>Total</b>		Rp99.854.698.096,54
<b>Rounded</b>		Rp99.900.000.000,00

Table 9. Cost Calculation Based on regulation 2022 for the Apartment Project

NO	Work Description	Cost
1	Floor Plate Formwork	Rp6.139.284.823,81
2	Column Formwork	Rp1.420.010.802,66
3	Beam Formwork	Rp2.012.798.045,28
4	Shear Wall Formwork	Rp792.287.748,07
5	Ladder Formwork	Rp166.614.937,26
6	Pouring of Floor Plate Concrete	Rp12.624.832.536,63
7	Pouring of Column Concrete	Rp6.204.957.867,10
8	Pouring of Concrete Blocks	Rp6.537.482.693,52
9	Shear Wall Concrete Pouring	Rp3.313.542.091,52
10	Ladder Concrete Pouring	Rp448.787.760,95
11	Floor Plate Concrete Repair	Rp10.746.176.687,49
12	Column Concrete Gap	Rp22.848.904.221,72
13	Bending Concrete Beams	Rp20.260.659.590,75
14	Shear Wall Concrete Reinforcement	Rp7.538.004.803,06
15	Ladder Concrete Reinforcement	Rp1.044.167.799,62
<b>Total</b>		Rp102.098.512.409,42
<b>Rounded</b>		Rp102.100.000.000,00

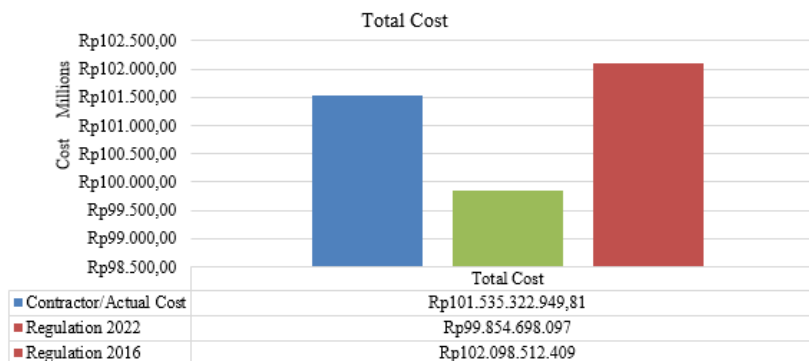


For the apartment project in Tangerang, the cost difference between regulation 2022 and regulation 2016 happens in: the pouring of concrete blocks, shear wall concrete pouring, ladder, concrete pouring, floor plate concrete repair, column concrete gap, bending concrete beams, shear wall concrete reinforcement, ladder concrete reinforcement. The comparison can be seen in figure 8.

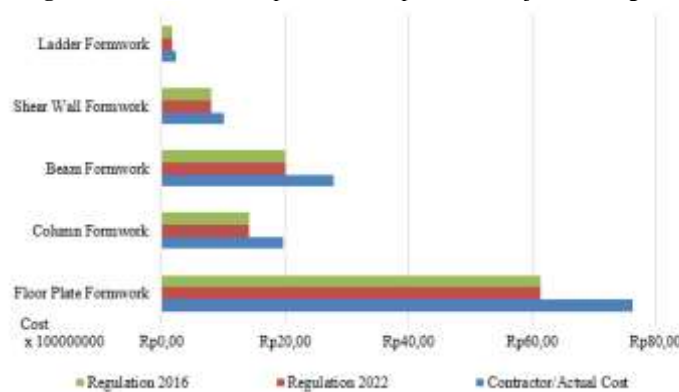


**Figure 8.** Cost Comparison for Apartment Project in Tangerang for Its Structural Works

As seen in Figure 8, most of the regulation 2022 has a closer value to contractor/actual cost when compared to cost calculation with different Results between regulation 2022 and regulation 2016. Still, when compared as a whole, Regulation 2022 cost is below the contractor/actual price, and regulation 2016 is closest to the contractor/actual cost, as seen in figure 9. The reason is that the cost for the item in (Figure 10) contractor/actual cost has a higher price than regulation 2022 and regulation 2016. With regulation 2016 showing higher costs than regulation 2022 (as seen in Figure 8), the total cost for regulation 2016 is closest to the contractor/actual price.



**Figure 9.** Total Cost Comparison for Apartment Project in Tangerang



**Figure 10.** Additional Cost Comparison for Apartment Project in Tangerang Showing Higher Cost for the Contractor/Actual Cost than Either Regulations

### ***Result in Recapitulation and Analysis***

After the cost calculation and comparison in the previous section, we can recap all the preliminary analysis results. Based on the analysis of the works coefficient:

1. From the observed work coefficient, regulation 2022 has a closer value to contractor calculation cost and observed work analysis cost calculation.
2. For the two-story housing project in Cikupa, there are three different calculation results between regulation 2022 and regulation 2016, and they are: concrete works, wall works, and sanitation works. Of these three, regulation 2022 has the closest value to contractor/actual cost. When compared for the total cost, it still shows that regulation 2022 is most comparable to contractor/actual price. When compared as a whole (two-story house project), it shows that the most significant disparity between regulation calculation and contractor/ actual cost are: floor and wall covering works, ceiling works, paint works, and. electrical works.
3. For the apartment project in Tangerang, there ten different calculation results between regulation 2022 and regulation 2016, they are: pouring of floor plate concrete, pouring of column concrete, pouring of concrete blocks, shear wall concrete pouring, ladder concrete pouring, floor plate concrete repair, column concrete gap, bending concrete beams, shear wall concrete reinforcement, and ladder concrete reinforcement. When compared between the ten works, regulation 2022 has a closer value than regulation 2016 to the contractor/actual cost. But when compared in total, the value most immediate to contractor/actual cost is regulation 2022. The cause of this can be seen when we reach the work cost as a whole (Figures 8 and 10). When compared, several contractor/actual costs are higher than regulation 2022, with Regulation 2016 costs mostly more elevated than the two others. This makes Regulation 2016 closer to contractor/actual cost as a total cost, but regulation 2022 is more comparable to contractor/actual price when observed as a comparison between regulations.

### **Conclusions**

It can be concluded that: regulation 2022 produces a lower cost than regulation 2016, which is one of the reasons why the total cost for the apartment project in Cikupa regulation 2016 is closer in price to the contractor/actual cost than regulation 2022. Rule 2022, which calculates work cost calculation using a different value and equation than regulation 2016, gives a more accurate estimate (when compared against the contractor/actual cost). Overall, it can be concluded that regulation 2022 can produce more accurate results, at least in areas that are calculated in this research, which are a two-story house and structural works of an apartment project.

Some of the work costs suggested to be improved/revised/reconsidered: are for structural works: floor plate formwork, column formwork, beam formwork, shear wall formwork, and ladder formwork. For housing works: preparation works, soil works, foundation works, steel and aluminum works, plaster works, floor and wall covering works, ceiling works, roof works, wood works, door and window works, paint works, and electrical works. As these work calculations in regulation 2022 and regulation 2016 can be used for another type of house or work, it is essential to reconsider the formula for cost calculation for the following Regulation or future revision.

### **Advice**

This research shows some improvements that could be taken in the Recapitulation sub-chapter. Regulation 2022 can give more modest cost calculation/estimation and more accurate results, although several improvements should still be considered.

For future research, we should expand the number of projects analyzed by regulation 2016 and regulation 2022. The projects should be varied from housing to apartments to other projects to ensure that regulation 2022 has improved from regulation 2016 and to make sure what kind of improvements the following Regulation (or revision) can implement.

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