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Application of Value Engineering in Lecture Buildings (Case Study Joint Lecture Building, Campus C, Airlangga University, Surabaya)

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Abstract. *Over time, construction projects in Indonesia as a developing country have become increasingly complex and require large costs and require more attention to proper time and resource management. The Joint Lecture Building, Campus C, Airlangga University, Surabaya, with a project cost of IDR 8,300,000.00/m2 is considered to exceed the standard cost of similar buildings in Surabaya, which is IDR 6,250,000.00/m², so it requires a cost efficiency evaluation. This study uses a value engineering method by analyzing work items to find alternative materials that are more cost-effective without reducing function and quality. This study was conducted with five stages of value engineering: information, creativity, analysis, development, and recommendations. The results show significant cost savings on several work items such as beam work, floor slabs and columns, achieving a potential reduction of up to 71% of the total existing budget.*

Keywords: Construction Cost, Cost Efficiency, Value Engineering

1. Instroduction

Infrastructure in a country is a very important sector, especially Indonesia as a developing country that also needs to follow the rapid development of technology and digitalization in this era. Despite the rapid development of technology and digitalization in this era, construction projects still face many fundamental problems such as project delays, cost overruns, and low efficiency and performance (Zhiliang et al., 2004). According to (Siswanto & Lestari, 2018) construction projects are becoming increasingly complex and require large costs so that they require more attention to the proper management of time and resources. The use of less efficient costs such as inappropriate work methods, making too many design changes, low human resources, and taking a long time to make decisions due to lack of coordination between parties involved are the main causes that often occur in the construction of a public facility construction project (Alwi et al., 2002). Therefore, a method is needed that can produce innovation in the form of alternatives to produce cost efficiency in a project. Cost efficiency is important to do by choosing a method that has a fairly large potential for success in the use of less than optimal costs without reducing the quality and function of the project construction, namely by using the value engineering method. This method is a creative approach to identify and optimize unnecessary costs by looking for alternatives or ideas that have lower costs than previously planned prices (Hidayat, 2011). The application of the Value Engineering (VE) method is believed to be beneficial for project owners, consultants, and contractors who aim to optimize the function and cost of a project because cost savings with the application of VE range from 2.5% - 41% of the total budget depending on the type and condition of the project (Untoro, 2009). So the value engineering method is suitable for use in problems of implementing large-scale building construction such as the Joint Lecture Building project at Airlangga University. In a study conducted by (Rabiatul & Halik, 2018) at the Modisland Manado Store, it succeeded in achieving cost efficiency of IDR 159,651,236.39 or 3.86% of the total project cost. In addition, (Mufti Rachmawan & HS, 2021) conducted research using the value engineering method and succeeded in optimizing costs in their research on the Airlangga Dormitory Development Project in Surabaya by IDR 2,269,297,758.04, which is 10.19% of the total cost of architectural work. Another study by (Lestari & HS, 2021) succeeded in optimizing costs by IDR 14,514,456,000 or 18.24% of the existing planning for all structural work items in the Unair Campus B Surabaya Multi-Level Parking Development Project. According to (Pratiwi, 2014), value engineering has advantages such as being systematic, structured, and organized in analyzing the value of a problem based on its function or use. This method maintains consistency with the need for aesthetics, quality, and project maintenance. However, value engineering is not easy to implement, because it is difficult to reduce project costs without sacrificing project integrity. As a result, value engineering has its own risks where a recent survey by (CM, 2021) of more than 10,000 professionals in the construction industry revealed that one of the biggest risks to construction projects is uncontrolled value engineering such as the presence of cheaper materials can pose a risk to the integrity of the project. If not controlled properly, these changes can reduce quality.

The Joint Lecture Building Project of Airlangga University Surabaya consists of 10 floors with an area of 21,116 m2 located in Mulyorejo which is Campus C of Airlangga University Surabaya. This building functions

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as a shared classroom with a theater format (20 rooms), transit room, meeting room, visiting lecturer room, Doctor by Research room, Joint Computer Laboratory, Auditorium, Rooftop Garden, Lobby, place of worship, etc. (Putri, 2022). In addition, the Joint Lecture Building of Campus C of Airlangga University Surabaya can accommodate up to approximately 7,238 students with a construction process lasting 435 days (Hermawan. Nuri, 2019). Therefore, this is a consideration for carrying out value engineering considering that the Joint Lecture Building meets the applicable provisions.

According to the Regulation of the Minister of Public Works and Public Housing Number 22/PRT/M/2018 concerning the Construction of State Buildings, there are provisions governing the value engineering method, namely for the construction of construction projects with a height of eight floors or more than 12,000 m2. Therefore, the Joint Lecture Building project of Airlangga University meets the requirements for this value engineering method because the building project has 10 floors. This is recommended to the project owner in accordance with the Regulation of the Minister of Public Works Number: 06/PRT/M/2008 Attachment II where the use of the value engineering method is due to waste (inefficiency) in terms of the fairness of construction prices, analysis of the selection of types or types of construction, and design calculations. Thus, as a form of making construction costs efficient in order to reduce waste without reducing the planned function and value. In the RAB (Cost Budget Plan) for the construction of the Joint Lecture Building of Airlangga University, a considerable cost is required, namely IDR 175,262,387,000.00 with IDR 8,300,000.00 per m2. Meanwhile, the decision of the Surabaya Mayor's Regional Regulation No. 7 of 2023 concerning the standard unit price for the construction of state buildings is IDR 6,250,000.00 per m2. Therefore, the Budget Plan is considered too large for an equivalent type of building.

Based on the description of the problems above that underlie the Joint Lecture Building Construction Project at Campus C, Airlangga University, Surabaya, the application of value engineering is carried out because it meets the requirements according to existing regulations and to reduce wasteful costs that can be avoided. The application of this value engineering method can optimize costs and identify work items that can be used to save significant costs in the Joint Lecture Building and the amount of savings obtained after the application of the value engineering method. Thus, unnecessary and supporting costs and efforts can be eliminated, then the quality and value of the project costs can be reduced and also provide benefits in the form of cost optimization.

Based on the background that has been explained, the formulation of the problem that will arise is: what are the work items that are worthy of cost efficiency using the value engineering method in the Joint Lecture Room Building, Campus C, Airlangga University, Surabaya? What is the percentage of cost efficiency results using the value engineering method on the Joint Lecture Room Building, Campus C, Airlangga University, Surabaya?

The objectives of this study are: to determine the work items that are feasible to be cost efficient using the value engineering method on the Joint Lecture Room Building, Campus C, Airlangga University, Surabaya and to understand the percentage of cost efficiency results using the value engineering method on the Joint Lecture Room Building, Campus C, Airlangga University, Surabaya.

2. Method

This study uses quantitative descriptive analysis techniques at the Joint Lecture Building, Campus C, Airlangga University, Surabaya, located on Jl. Dr. Ir. H. Soekarno, Mulyorejo, Mulyorejo District, Surabaya with the owner of the Airlangga University activity, Construction Management Consultant PT. Bina Karya, and the Implementing Contractor PT. PP.

The data used in this study came from relevant previous research journals, brochures of alternative materials to be used, the 2019 Activity Unit Price (HSPK), and project documents such as the Cost Budget Plan (RAB), Work Plan and Requirements (RKS), and Unit Price and Labor Analysis (AHSP). The case study analysis in this study uses the following stages:

1. The value engineering stage is a series of analyzes carried out such as:

a. Information stage to identify work items with a Pareto diagram and analyze their functions.

b. Creativity stage to find alternatives to existing materials by brainstorming.

c. Profit and loss analysis stage to find the advantages and disadvantages of each alternative and existing

d. The development stage consists of life cycle cost analysis, zero one matrix, and scoring matrix.

e. The recommendation stage is the stage of recommending selected alternatives based on the analyses that have been carried out.

2. Conclusions and suggestions as the final stage in compiling research.

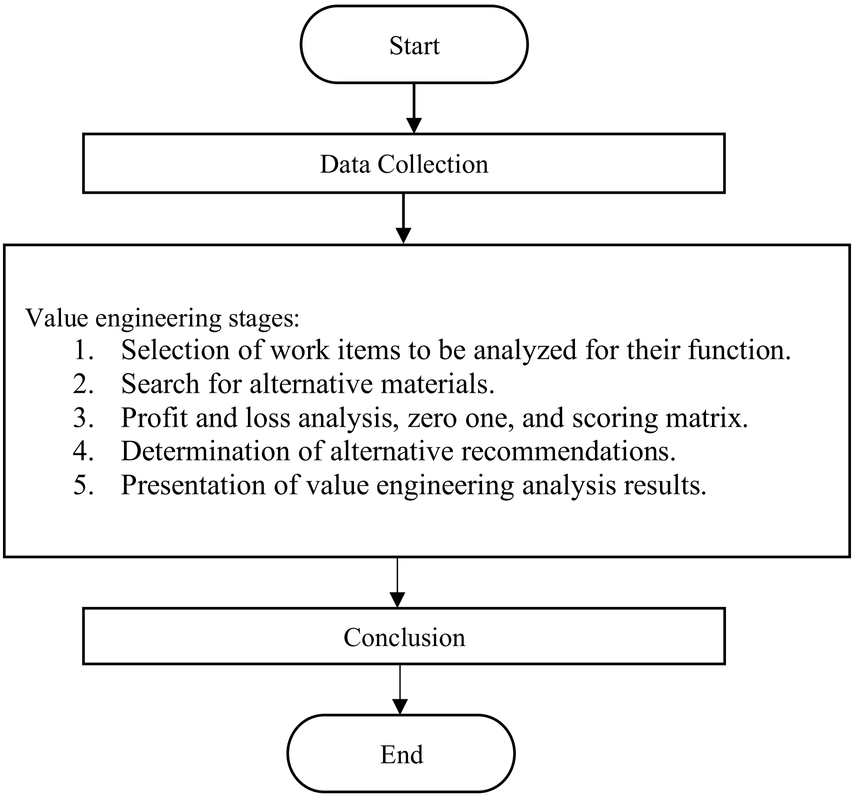

Fig. 1. Data Analysis Technique Flowchart

3. Result

The following is the project data for the Joint Lecture Building, Campus C, Airlangga University, Surabaya:

Project Name : Joint Lecture Building Construction Project, Campus C, Airlangga University.
Project Location : Jl. Dr. Ir. H. Seokarno, Mulyorejo, Mulyorejo District, Surabaya, East Java 60115.
Owner Name : Airlangga University
Planning Consultant : PT. Pandu Persada
Implementing Contractor : PT. Sasmito
Planning Consultant : PT. Bina Karya Persero
Project Value Rp 175,262,387,000.00
Main Structure : Reinforced Concrete
Foundation : Pile Foundation
Number of Floors : 10 Floors

3.1 Work items selection

According to (Nasrul & Oscar, 2017), the basis for selecting work items uses the breakdown of the Cost Budget Plan (RAB). From table 4.1 it can be seen that structural work has the highest price than other work. In order to find out the potential of work items to be analyzed further, the costs of the structural work items are compared with the total cost of the entire project.

Table 1. Budget Plan Recapitulation

Work Items		Total Price
Structural Work		Rp 56.045.373.000,00
Mechanical Electrical Work		Rp 51.932.092.743,17
Architectural Work		Rp 51.085.229.378,43
HSE Work		Rp 266.748.000,00
	Total	Rp 159.329.443.121,59

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Work Items	Total Price
Tax 10%	Rp 15.932.944.312,16
Total= (Total+Tax 10%)	Rp 175.262.387.433,75
Rounded	Rp 175.262.387.000,00

From the data, it can be seen that structural work is the largest contributor of funds among other works as a whole with a fairly large difference of Rp 56,045,373,000.00. From this fact, an analysis of structural work can be carried out to find large costs in the case study of the Joint Lecture Building, Campus C, Airlangga University, Surabaya.

3.2 Determining the work items to be analyzed

The initial stage in the application of value engineering is the information stage, where at this stage the highest to lowest costs of structural work are sorted in the form of a table below by sorting the data using the Pareto method, namely the weight approaching 80% has the potential for value engineering.

Table 2. Pareto Analysis of Structural Work

Work Item	Cost	Cumulative	Percentage (%)
Beam Work	Rp17.533.573.802,65	Rp17.533.573.802,65	31%
Floor Slab Work	Rp15.423.238.098,02	Rp32.956.811.900,67	59%
Column Work	Rp7.742.721.610,39	Rp40.699.533.511,06	73%
Pile Work	Rp6.123.506.633,58	Rp46.823.040.144,63	84%
Pilecap Work	Rp1.861.690.023,22	Rp48.684.730.167,85	87%
Small Theater Stage Work	Rp1.334.982.160,43	Rp50.019.712.328,28	89%
Staircase Work	Rp1.130.383.634,11	Rp51.150.095.962,40	91%
Ground Work	Rp1.028.104.793,10	Rp52.178.200.755,50	93%
Large Theater Stage Work	Rp754.044.109,90	Rp52.932.244.865,40	94%
Cladding Work	Rp672.437.986,73	Rp53.604.682.852,13	96%
Wall Concrete Work	Rp589.272.140,93	Rp54.193.954.993,06	97%
Building Roof Work	Rp551.165.416,44	Rp54.745.120.409,50	98%
Wall Slab Work	Rp544.880.011,47	Rp55.290.000.420,97	99%
Rock Foundation Work	Rp265.622.417,85	Rp55.555.622.838,82	99%
Shear Wall Work	Rp246.028.530,36	Rp55.801.651.369,18	100%
Canopy Roof Work	Rp109.878.066,38	Rp55.911.529.435,56	100%
Roof Slab Work	Rp48.907.562,22	Rp55.960.436.997,77	100%
Waterproofing Work	Rp43.852.037,85	Rp56.004.289.035,62	100%
Waterstop Work	Rp20.905.000,00	Rp56.025.194.035,62	100%
Preparation Work	Rp15.108.074,68	Rp56.040.302.110,30	100%
Short Wall Concrete Work	Rp5.071.452,60	Rp56.045.373.562,90	100%
Total	Rp56.045.373.562,90		

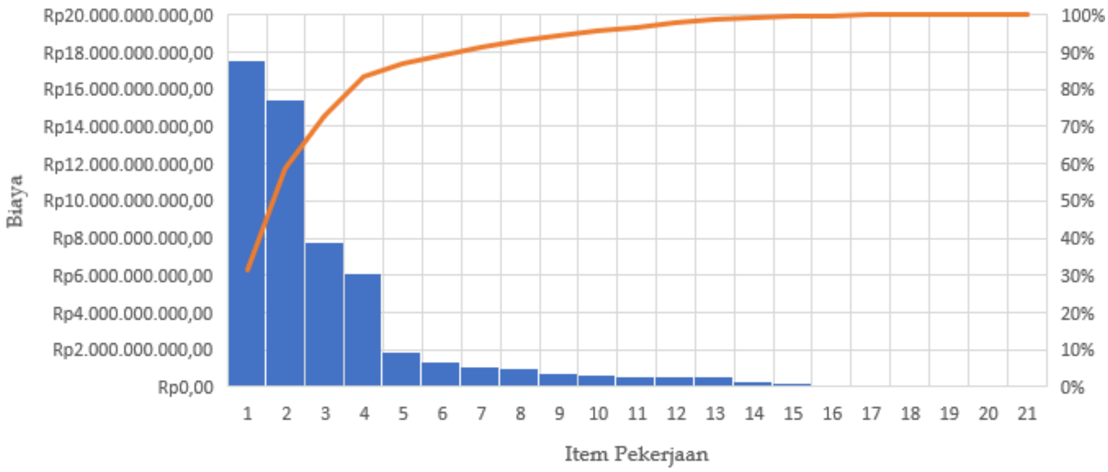

Fig. 1 Pareto Diagram Chart

Based on the Pareto results, items that have the potential to be value engineered are beams, floor slabs, columns, and piles. These work items are analyzed for their functions to identify primary (basic) and secondary (supporting) functions and to obtain a comparison of worth/cost. The cost value comes from the Budget Plan (RAB) project data. Meanwhile, worth is obtained if the work description has a function as a primary function (B).

Table 3. Analysis of Beam Work Function

Work Item	Function			Cost (Rp)	Worth (Rp)
	Verb	Noun	Kind		
			Beam Work		
Ready Mix K-350 Concrete	Withstand	Compressive Loads	B	Rp3.596.272.191,42	Rp3.596.272.191,42
Steel Bar	Withstand	Tensile Load	B	Rp8.342.298.866,36	Rp8.342.298.866,36
Formwork	Supporting	Concrete	S	Rp5.520.167.979,59	-
			Total:	Rp17.458.739.037,37	Rp11.938.571.057,78
			cost/worth ratio:	1,462	

Table 4. Analysis of Floor Slab Work Function

Work Item	Function			Cost (Rp)	Worth (Rp)
	Verb	Noun	Kind		
			Floor Slab Work		
Ready Mix K-350 Concrete	Withstand	Compressive Loads	B	Rp3.145.909.122,28	Rp3.145.909.122,28
Steel Bar	Withstand	Tensile Load	B	Rp3.967.078.638,90	Rp3.967.078.638,90
Formwork	Supporting	Concrete	S	Rp8.257.651.969,02	-
			Total:	Rp15.370.639.730,20	Rp7.112.987.761,18
			cost/worth ratio:	2,161	

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Table 5. Analysis of Column Work Function

Work Item	Function			Cost (Rp)	Worth (Rp)
	Verb	Noun	Kind		
Column Work					
Ready Mix K-350 Concrete	Withstand	Compressive Loads	B	Rp1.878.787.081,08	Rp1.878.787.081,08
Steel Bar	Withstand	Tensile Load	B	Rp3.815.793.734,09	Rp3.815.793.734,09
Formwork	Supporting	Concrete	S	Rp2.048.067.444,56	-
			Total:	Rp7.742.648.259,73	Rp5.694.580.815,17
			cost/worth ratio:	1,360	

Table 6 Analysis of Pile Work Function

Work Item	Function			Cost (Rp)	Worth (Rp)
	Verb	Noun	Kind		
Pile Work					
Pile Foundation	Supporting	Building Loads	B	Rp5.112.879.200,00	Rp5.112.879.200,00
			Total:	Rp5.112.879.200,00	Rp5.112.879.200,00
			cost/worth ratio:	1	

Based on the functional analysis table above, the cost/worth ratio results for the beam work are 1,462, the floor slab is 2,161, the column is 1,360, and the pile is 1,000. Where the ratio results are more than or equal to 1, there is potential or value engineering can be done.

3.2 Alternative Material Search

In the Work Plan and Requirements (RKS) of the Joint Lecture Building, Campus C, Airlangga University, Surabaya, general requirements for formwork are found and there are three alternative materials that are considered to meet the general requirements for formwork in the Work Plan and Requirements such as:
1. Does not experience deformation, the formwork must be thick enough and firmly bound.
2. Waterproof by closing all gaps with tape.
3. Resistant to vibrator vibrations from outside and from inside the formwork.
So these requirements are used as a reference for brainstorming. The results of this stage can be seen in the table

Table 7. Creativity Stage

No.	Work Item	Existing	Alternative
1	**BEAM WORK**		
		Conventional Formwork	Fiberglass Formwork Board
			Plastic Formwork Board
2	**FLOOR SLAB WORK**		
		Conventional Formwork	Fiberglass Formwork Board
			Plastic Formwork Board
3	**COLUMN WORK**		
		Conventional Formwork	Fiberglass Formwork Board
			Plastic Formwork Board

4	**PILE WORK**		
		Pile Foundation	Well Foundation
			Franki Pile Foundation

Based on the table above, it is obtained:

1. Beam Work:
   a. Existing or formwork materials currently used are conventional formwork where the formwork boards or formwork panels use plywood.
   b. The first alternative chosen is fiberglass formwork boards as alternative 1. This alternative material is strong enough and meets the general requirements for formwork in replacing the role of plywood as existing.
   c. The second alternative is a formwork board using high-quality plastic material which in addition to meeting the general requirements for formwork in the project RKS, this material can be used more than 100 times with good maintenance. So plastic formwork was chosen as alternative 2 with the hope of making construction costs more efficient.
   d. The results of this study also apply to floor slab and column work because they have the same substitute materials.
2. Pile Work:
   a. Existing currently used is a pile foundation measuring 50x50 cm.
   b. The first alternative chosen is a well foundation that has a deep foundation system so that it can be used as an alternative to replace the pile foundation. In addition, this foundation has a greater bearing capacity.
   c. The second alternative is the franki pile foundation which also has a deep foundation system so it is suitable as alternative 2 for pile foundations. In addition, this foundation is suitable for hard soil types..

3.3 Profit and Loss Analysis of Each Alternative and Existing

The following are the results of the analysis of the advantages and disadvantages of the existing and each alternative.

Table 8. Profit and Loss Analysis of Beam Work

No.	Work Item	Alternative	Advantages	Disadvantages
I.	**BEAM WORK**			
1		(E1)	Easily adaptable to various shapes	Can only be used a few times
			More affordable	The resulting concrete surface is rougher
2		(A1)	Fiberglass formwork boards can be used up to 40-70 times	The procurement of fiberglass formwork is quite high compared to conventional formwork.
			Resistant to moisture, not easy to rust, does not deform, and is resistant to heat and ultraviolet light.	The use of fiberglass formwork is still minimal in Indonesia
			The concrete results with a smooth and precise surface due to its rigid structure and resistance to vibration.	Requires attention in storage and maintenance so as not to be damaged, especially during rough transportation and installation.

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No.	Work Item	Alternative	Advantages	Disadvantages
I.	**BEAM WORK**			
3		(A2)	Easy disassembly and quick cleaning with just water	Plastic formwork panel material fabrication does not yet exist in Indonesia
			Durable and reusable	Less flexible for complex or special formwork shapes
			Quick assembly, reducing labor costs and project schedules.	

Table 9. Profit and Loss Analysis of Floor Slab Work

No.	Work Item	Alternative	Advantages	Disadvantages
II.	**FLOOR SLAB WORK**			
1		(E1)	Easily adaptable to various shapes	Can only be used a few times
			More affordable	The resulting concrete surface is rougher
2		(A1)	Fiberglass formwork boards can be used up to 40-70 times	The procurement of fiberglass formwork is quite high compared to conventional formwork.
			Resistant to moisture, not easy to rust, does not deform, and is resistant to heat and ultraviolet light.	The use of fiberglass formwork is still minimal in Indonesia
			The concrete results with a smooth and precise surface due to its rigid structure and resistance to vibration.	Requires attention in storage and maintenance so as not to be damaged, especially during rough transportation and installation.
3		(A2)	Easy disassembly and quick cleaning with just water	Plastic formwork panel material fabrication does not yet exist in Indonesia
			Durable and reusable	Less flexible for complex or special formwork shapes
			Quick assembly, reducing labor costs and project schedules.	

Table 10. Profit and Loss Analysis of Column Work

No.	Work Item	Alternative	Advantages	Disadvantages
III.	**COLUMN WORK**			
1		(E1)	Easily adaptable to various shapes	Can only be used a few times
			More affordable	The resulting concrete surface is rougher

2		(A1)	Fiberglass formwork boards can be used up to 40-70 times	The procurement of fiberglass formwork is quite high compared to conventional formwork.
			Resistant to moisture, not easy to rust, does not deform, and is resistant to heat and ultraviolet light.	The use of fiberglass formwork is still minimal in Indonesia
			The concrete results with a smooth and precise surface due to its rigid structure and resistance to vibration.	Requires attention in storage and maintenance so as not to be damaged, especially during rough transportation and installation.
3		(A2)	Easy disassembly and quick cleaning with just water	Plastic formwork panel material fabrication does not yet exist in Indonesia
			Durable and reusable	Less flexible for complex or special formwork shapes
			Quick assembly, reducing labor costs and project schedules.	

Table 11. Profit and Loss Analysis of Pile Work

No.	Work Item	Alternative	Advantages	Disadvantages
IV.	**PILE WORK**			
1		(E1)	Capable of withstanding large loads, both vertical and lateral.	Its long size requires special equipment for transportation and storage.
			Precast concrete piles allow for consistent quality and faster installation times.	The piling process often produces high noise, which can disturb the surrounding area.
2		(A1)	No heavy equipment required, suitable for narrow locations or limited access.	Because it is done manually, the processing time is longer than other methods.
			Can use local building materials such as river stones and cast-in-place concrete.	Effectiveness decreases in soft soils or areas with high water tables.
3		(A2)	The installation process is quieter than concrete piles.	Compared with concrete or steel piles, Franki pile installation takes more time.
			Capable of withstanding large loads with minimal deformation.	Special equipment and processing methods result in higher costs.
			Suitable for soil conditions with low bearing capacity.	

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According to table, the profit and loss analysis of pile work is a description of the comparison between the existing pile foundation (E1) with two alternatives, namely the well foundation (A1) and the franki pile foundation (A2). Each alternative and existing are sought for their advantages and disadvantages as one of the considerations for finding the best alternative.

3.4 Life Cycle Cost Analysis Calculation

The calculation of Life Cycle Cost (LCC) on each work item focuses on determining the alternative that has the lowest cost and savings obtained. It should be noted that there are basic provisions used in this case study which include:

1. The economic value of the building is 25 years.
2. The assumption of deposit interest of 5 major banks in Indonesia in 2024 is 12%.

Table 12 Life Cycle Cost of Beam Work

No	Alternative	Initial Cost	Maintenance Cost	Total Cost/Worth	Saving	Saving (%)
1	Existing	Rp5.520.167.979,59	Rp662.420.157,55			
	PW	Rp5.520.167.979,59	Rp2.387.876.419,89	Rp7.908.044.399,48	-	-
2	Alt 1	Rp2.204.341.767,06	Rp264.521.012,05			
	PW	Rp2.204.341.767,06	Rp953.539.049,25	Rp3.157.880.816,30	Rp4.750.163.583,17	60%
3	Alt 2	Rp4.200.812.757,99	Rp504.097.530,96			
	PW	Rp4.200.812.757,99	Rp1.817.158.783,26	Rp6.017.971.541,25	Rp1.890.072.858,23	24%

The largest cost savings in formwork for beam work is in alternative 1, which is 60%, namely fiberglass formwork boards.

Table 13 Life Cycle Cost of Floor Slab Work

No	Alternative	Initial Cost	Maintenance Cost	Total Cost/Worth	Saving	Saving (%)
1	Existing	Rp8.257.651.969,02	Rp990.918.236,28			
	PW	Rp8.257.651.969,02	Rp3.572.038.476,62	Rp11.829.690.445,64	-	-
2	Alt 1	Rp10.624.385.245,92	Rp1.274.926.229,51			
	PW	Rp10.624.385.245,92	Rp4.595.823.731,89	Rp15.220.208.977,81	-Rp3.390.518.532,17	-43%
3	Alt 2	Rp5.945.406.786,01	Rp713.448.814,32			
	PW	Rp5.945.406.786,01	Rp2.571.823.307,46	Rp8.517.230.093,47	Rp3.312.460.352,17	42%

The largest cost savings in formwork for floor slab work is in alternative 2, which is 42%, namely plastic formwork boards.

Table 14 Life Cycle Cost of Column Work

No	Alternative	Initial Cost	Maintenance Cost	Total Cost/Worth	Saving	Saving (%)
1	Existing	Rp2.048.067.444,56	Rp245.768.093,35			
	PW	Rp2.048.067.444,56	Rp885.938.974,19	Rp2.934.006.418,75	-	-
2	Alt 1	Rp2.328.097.436,70	Rp279.371.692,40			
	PW	Rp2.328.097.436,70	Rp1.007.072.428,39	Rp3.335.169.865,09	-Rp401.163.446,34	-5%
3	Alt 2	Rp1.867.760.789,92	Rp224.131.294,79			
	PW	Rp1.867.760.789,92	Rp807.943.157,66	Rp2.675.703.947,58	Rp258.302.471,17	3%

The largest cost savings in formwork for column work is in alternative 2, which is 3%, namely plastic formwork boards.

Table 15 Life Cycle Cost of Pile Work

No	Alternative	Initial Cost	Maintenance Cost	Total Cost/Worth	Saving	Saving (%)

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1	Existing	Rp5.112.879.200,00	Rp613.545.504,00			
	PW	Rp5.112.879.200,00	Rp2.211.694.231,87	Rp7.324.573.431,87	-	-
2	Alt 1	Rp4.231.000.800,00	Rp507.720.096,00			
	PW	Rp4.231.000.800,00	Rp1.830.217.319,51	Rp6.061.218.119,51	Rp1.263.355.312,36	16%
3	Alt 2	Rp34.199.585.487,60	Rp4.103.950.258,51			
	PW	Rp34.199.585.487,60	Rp14.793.822.227,49	Rp48.993.407.715,09	-Rp41.668.834.283,22	-527%

The largest cost savings in pile driving work is in alternative 2, which is 16%, namely the well foundation.

3.5 Determining Priority Criteria with Zero One

The following are the results of the zero one matrix analysis research for beam, floor slab, column and pile work.

Table 16. Zero One Analysis of Beam Work

Criteria	**Strength**	**Functional**	**Cost**	**Implementation**	**Schedule**	**Aesthetics**	**Total**	**Ranking**
Strength	X	1	1	1	1	1	5	1
Functional	0	X	1	1	1	1	4	2
Cost	1	1	X	1	1	1	3	3
Implementation	0	0	0	X	1	1	2	4
Schedule	0	0	0	0	X	1	1	5
Aesthetics	0	0	0	0	0	X	0	6

Table 17. Zero One Analysis of Floor Slab Work

Criteria	**Strength**	**Functional**	**Cost**	**Implementation**	**Schedule**	**Aesthetics**	**Total**	**Ranking**
Strength	X	1	1	1	1	1	5	1
Functional	0	X	1	1	1	1	4	2
Cost	0	0	X	1	1	1	3	3
Implementation	0	0	0	X	1	1	2	4
Schedule	0	0	0	0	X	1	1	5
Aesthetics	0	0	0	0	0	X	0	6

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Table 18. Zero One Analysis of Column Work

Criteria	Strength	Functional	Cost	Implementation	Schedule	Aesthetics	Total	Ranking
Strength	X	1	1	1	1	1	5	1
Functional	0	X	1	1	1	1	4	2
Cost	0	0	X	1	1	1	3	3
Implementation	0	0	0	X	1	1	2	4
Schedule	0	0	0	0	X	1	1	5
Aesthetics	0	0	0	0	0	X	0	6

Table 19 Zero One Analysis of Pile Work

Criteria	Strength	Functional	Cost	Implementation	Schedule	Aesthetics	Total	Ranking
Strength	X	1	1	1	1	1	5	1
Functional	0	X	1	1	1	1	4	2
Cost	0	0	X	1	1	1	3	3
Implementation	0	0	0	X	1	1	2	4
Schedule	0	0	0	0	X	1	1	5
Aesthetics	0	0	0	0	0	X	0	6

In table zero one analysis of beam work shows that the number 1 is given to criteria that are more priority than the comparison criteria, the number 0 is given to criteria that are not more priority than the comparison criteria, while (X) is the same criterion so that it cannot be compared. These numbers will be totaled which results in the strength criterion being the most priority criterion because this criterion has the highest total, making this criterion rank 1 compared to other criteria. This applies to the zero one analysis of floor slab, column, and pile work.

3.6 Determining Alternative Recommendations with Scoring Matrix

Each criterion and weight used can be different for each case, it depends on the perspective and preferences of each. The existing criteria need to be further analyzed based on project needs by giving a range of 1-10 based on the ranking from the previous zero one analysis. If the criteria are considered a priority, the weight will be closer to 10 and if less important it will be closer to the value of 1. The weights listed in the following table are obtained according to the ranking of the criteria from the zero one analysis where the strength criteria are ranked 1 while the functional is ranked 2 so that the weight of the strength criteria is higher, namely 10 than the functional criteria which are ranked 2 with a weight of 9 as well as other criteria and the weight of other work criteria. Then it can be continued to the scoring matrix analysis process using the previously determined weights.

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Table 20. Beam Work Criteria Weight

Criteria	Weight
Strength	10
Functional	9
Cost	8
Implementation	7
Schedule	6
Aesthetics	5

Table 21. Floor Slab Work Criteria Weight

Criteria	Weight
Strength	10
Functional	9
Cost	8
Implementation	7
Schedule	6
Aesthetics	5

Table 22. Column Work Criteria Weight

Criteria	Weight
Strength	10
Functional	9
Cost	8
Implementation	7
Schedule	6
Aesthetics	5

Table 23. Pile Work Criteria Weight

Criteria	Weight
Strength	10
Functional	9
Cost	8
Implementation	7
Schedule	6
Aesthetics	5

Table 24. Beam Work Scoring Matrix Analysis

Criteria	Strength	Functional	Cost	Implementation	Schedule	Aesthetics	Total	Ranking
Weight	10	9	8	7	6	5		
Existing	4	4	2	4	4	2	154	2
	40	36	16	28	24	10		
Alternative 1	4	4	4	4	4	3	175	1
	40	36	32	28	24	15		
Alternative 2	3	3	3	3	2	2	124	3
	30	27	24	21	12	10		

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According to table scoring matrix analysis of beam work, the weight is multiplied by the assessment of the criteria for existing and existing alternatives so that the existing and alternative rankings are obtained from the highest total value. Thus, alternative 1 is the recommended material.

Table 25. Floor Slab Work Scoring Matrix Analysis

Criteria	Strength	Functional	Cost	Implementation	Schedule	Aesthetics	Total	Ranking
Weight	10	9	8	7	6	5		
Existing	4	4	2	4	4	2	154	2
	40	36	16	28	24	10		
Alternative 1	4	4	4	4	4	3	175	1
	40	36	32	28	24	15		
Alternative 2	3	3	4	3	2	2	132	3
	30	27	32	21	12	10		

Based on table, the results of the scoring matrix for the selected alternative floor slab work are alternative 1, namely fiberglass formwork boards based on its ranking.

Table 26. Column Work Scoring Matrix Analysis

Criteria	Strength	Functional	Cost	Implementation	Schedule	Aesthetics	Total	Ranking
Weight	10	9	8	7	6	5		
Existing	4	4	2	4	4	4	164	2
	40	36	16	28	24	20		
Alternative 1	4	4	3	4	4	3	175	1
	40	36	24	28	24	15		
Alternative 2	3	3	4	3	2	2	132	3
	30	27	32	21	12	10		

Based on table, the results of the scoring matrix for the selected alternative column work are alternative 1, namely fiberglass formwork boards according to their ranking.

Table 27 Pile Work Scoring Matrix Analysis

Criteria	Strength	Functional	Cost	Implementation	Schedule	Aesthetics	Total	Ranking
Weight	10	9	8	7	6	5		
Existing	4	4	2	4	4	4	164	2
	40	36	16	28	24	20		
Alternative 1	4	4	3	4	4	3	175	1
	40	36	24	28	24	15		
Alternative 2	3	3	4	3	2	2	132	3
	30	27	32	21	12	10		

Based on table, the results of the scoring matrix for the selected alternative pile work are alternative 1, namely well foundations, according to their ranking.

3.7 Presentation of Value Engineering Analysis Results

After the analyses were carried out, the results of the analysis were presented in accordance with the priority criteria and general requirements in the Work Plan and Requirements for the Joint Lecture Building Project at Campus C, Airlangga University and the reasons for recommending the selected alternative in table.

No	Work Item	Existing	Recommendation	Potensial Saving	Reasons
I	Beam Work				
		Conventional Formwork	Fiberglass Board Formwork	2,71%	Has the highest score in the scoring matrix analysis and the largest savings in life cycle costs
II	Floor Slab Work				
		Conventional Formwork	Fiberglass Board Formwork	1,89%	The biggest savings on life cycle costs and has the highest value compared to other materials
III	Column Work				
		Conventional Formwork	Fiberglass Board Formwork	0,15%	The biggest savings on life cycle costs and has the highest value compared to other materials
IV	Pile Work				
		Pile Foundation	Well Foundation	0,72%	The biggest savings on life cycle costs and has the highest value compared to other materials
			Total	5,47%	

Based on the table above, it is recommended that alternative 1, namely using fiberglass formwork boards as the best alternative for beam work compared to other options and has a potential saving of 2.71% obtained from the alternative saving cost that has the largest saving divided by the total project cost. for floor slab and column work using plastic formwork because it can save up to 1.89% and pile work using alternative 1, namely well foundation of 0.72%. So when compared to all the work that has been analyzed by value engineering, the formwork savings in this case study are 5.47%.

4. Conclusion

Based on the formulation of the problem and the results of the analysis that have been obtained, it can be concluded that the work items that are feasible to carry out cost efficiency using the value engineering

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method at the Joint Lecture Building Campus C, Airlangga University, Surabaya are structural work that has the highest price with the largest contributor work items, namely beam work, floor slabs, columns, and piles. The results of cost efficiency using the value engineering method at the Joint Lecture Building Campus C, Airlangga University, Surabaya are 5.47% of the total costs incurred.

References

Alwi, S., Hampson, K., & Mohamed, S. (2002). *Factor Influencing Contractors' Performance in Indonesia: A Study of Non Value-Adding Activities*. http://eprints.qut.edu.au/archive/00004494

Berawi, M. (2014). Aplikasi Value Engineering pada Industri Konstruksi Bangunan Gedung. In *Universitas Dharma Andalas* (Issue 1).

CM, S. (2021, July 13). *Uncontrolled Value Engineering 'One of Biggest Risks' to Built Environment*. Https://Constructionmanagement.Co.Uk/.

Departemen Pekerjaan Umum. (2008). *Peraturan Menteri PU Nomor : 06/PRT/M/2008 Lampiran II*.

Halawa, A. M., & Putu, I. (2016). *Analisis Perbandingan Bekisting Fiberglass dengan Bekisting Semi Konvensional Pada Proyek Apartemen Grand Taman Melati Margonda Depok*.

Hermawan. Nuri. (2019). *Rektor UNAIR Resmikan Pembangunan Gedung Kuliah Bersama*. 2019.

Hidayat, A. (2011). *Rekayasa Nilai Pembangunan Gedung Rusunawa Ambarawa*.

Kementrian Pekerjaan Umum dan Perumahan Rakyat Direktorat Jenderal Bina Marga. (2022). *04/P/BM/2022 Pedoman Pelaksanaan Teknis Rekayasa Nilai (Statement of Work Value Engineering)*.

Lestari, I. A., & HS, M. S. (2021). Penerapan Rekayasa Nilai (Value Engineering) Untuk Efisiensi Biaya Pada Proyek Konstruksi Studi Kasus: Pembangunan Parkir Bertingkat Unair Kampus B Surabaya. *Jurnal Teknik Sipil*.

Menteri Pekerjaan Umum dan Perumahan Rakyat. (2018). *Peraturan Menteri Pekerjaan Umum dan Perumahan Rakyat Republik Indonesia Nomor 22/PRT/M/2018*.

Miles, L. D. (1976). *Principles Of Value Analysis: Basics Of Function Analysis*.

Mufti Rachmawan, A., & HS, M. S. (2021). Analisa Penerapan Rekayasa Nilai (Value Engineering) Pada Proyek Pembangunan Dormitory Airlangga Surabaya. *Jurnal Teknik Sipil*, *00*.

Nugraha, D., & Adi, T. (2015). *Rekayasa Struktur dengan Modifikasi Pelat Lantai dan Dinding pada Proyek Apartemen Marvell City Surabaya*.

Pratiwi, N. (2014). Analisa Value Engineering Pada Proyek Gedung Riset Dan Museum Energi Dan Mineral Institut Teknologi Bandung. *Jurnal Teknik Sipil Dan Lingkungan*, *2*(1).

Putri. (2022). *Gedung Kuliah Bersama Kampus C (GKB C)*. 2022.

Rabiatul, S., & Halik, M. (2018). *Analisis Value Engineering Pada Plat Atap Dan Pasangan Dinding (Studi Kasus: Toko Modisland Manado)*.

Siswanto, A. B., & Lestari, D. (2018). *Pelaksanaan Rekayasa Nilai (Value Engineering) Pada Proyek Gedung Perkuliahan Fakultas Teknik UNDIP*. https://www.researchgate.net/publication/323756649

Untoro, V. (2009). *Penerapan Value Engineering Dalam Penyelenggaraan Infrastruktur Bidang Ke-PU-an Di Lingkungan Departemen Pekerjaan Umum Dalam Usaha Meningkatkan Efektivitas Penggunaan Anggaran*.

Walikota Surabaya. (2023). *Peraturan Daerah Kota Surabaya No. 7*.

Zhiliang, M., Heng, L., Shen, Q. P., & Jun, Y. (2004). Using XML to support information exchange in construction projects. *Automation in Construction*, *13*(5 SPEC. ISS.), 629–637. https://doi.org/10.1016/j.autcon.2004.04.010

Zimmerman, L., & Hart, G. (1988). *Value Engineering: A Practical Approach For Owners, Designers And Contractors*.