Implementation of value engineering in design building for the construction of general hospitals in Jembrana Regency

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Abstract. The choice of construction design is very important to do because it can show the quality of the building, and produce development at an efficient and optimal cost. One of them can be done by value engineering. According to Zimmerman and Hart in Hutabarat (1995) value engineering is a systematic approach to achieving the best functional balance between costs, reliability and appearance of a system or project. In this study, we tried to analyse the Construction of Negara General Hospitals in Jembrana Regency especially in structural work because it had a high probability of VE. This project consists of 3 floors which require a total cost of IDR 31,965,702,000. In the creative stage this research uses alternative - the best alternative by changing the quality of existing concrete (K300) to concrete quality (K350) and Composite. From these stages, the best alternative is used in column, plate and beam reinforced concrete, namely alternative II composite or using WF Steel Column, floor deck plus Wire mesh can be chosen because it has the largest total value compared to other alternatives. While the cost savings is IDR 636,761,310.87 or 14.19 percent of existing.

1. Introduction

Material limitations, technological developments, implementation times and implementation methods are one of the problems in a financing aspect. The choice of construction design is very important to do because it can show the quality of the building, and produce development at an efficient and optimal cost. There are many ways to make the cost efficiency of the project, one of which is value engineering [1]. Value engineering studies are conducted to examine cost saving opportunities without reducing overall construction performance, which will certainly benefit all parties involved. The best value of a project is achieved by defining the functions needed to achieve the target value desired. VE also provides those function with the optimum cost, quality consistency and the required performance [2].

The Construction Project for the Construction of the State General Hospital in Jembrana Regency is a 3-storey building construction project with a cost of IDR 31,965,702,000, - with the percentage of K300 concrete structure work at 22.45%. This percentage looks very large and is likely to have the potential to be saved from unnecessary costs. This research is expected to be a very meaningful input for policy holders and project organizers on the application of value engineering to obtain material alternatives that are possible, as well as a correction of the actual conditions that are underway to improve the efficiency of development funds.

Based on that background, the problem of this research is to find out the best alternative of using material and structural design in order to use budget efficiently in the construction of General State Hospital in Jembrana Regency and the amount of cost saving in planning project cost after the implementation of Value Engineering Analysis.

Based on the problem above, the purpose of this research is to know the best alternative from the use of materials and structural design in budget efficiency in the work of the Construction of the State General Hospital in Jembrana Regency and determine the amount of cost saving that occurs in planning the total project cost after Value Engineering analysis.

2. Methodology

2.1. Research design
In this study the object to be examined is the Design Project for the Construction of the State General Hospital in Jembrana District, the IRD Building. The research conducted is descriptive research with research methods using Value Engineering analysis on components of sloofs columns, slabs and beams concrete structures.

2.2. Determination of data sources
In this study, the types of data used are as follows: Primary data to be used are unit price of materials (survey to building shops), price of worker wages (survey to foreman), worker productivity data (observations on the project), and data alternative function criteria (questionnaire to academics and construction service companies). Secondary data can be in the form of technical data from the project, including: plan drawings, cost budget plans (RAB), work plans and terms (RKS), time schedules, and building regulations.

2.3. Data collection
The data collection is done by following the philosophies of information phase which is the first phase of VE job plan. Aim of the data collection is to know the problem well. Data gathered from interviewing and collecting project related materials from owner, contractor and designer concerned with the project undertaken. The collected data will be the base for the further progress of the study.

2.4. Research variables
The variables used in this study are independent variables and dependent variables. The independent variables in this study are alternatives that have the potential to save costs, namely by replacing the existing concrete quality from K300 with K350 and Composite using SAP 2000 version 15. The dependent variable in this study is the criteria for alternative functions used namely costs, quality, implementation time, methods of implementation, and availability of materials.

2.5. Stages of research
The value methodology is a systematic process that follows the Job Plan Job Plan is an organized and logical approach of the Value Engineering. It helps to identify the key areas of unnecessary cost and seeks new and creative ways of performing the same function as the original part, process or material [3]. The recommended VE methodology (Job Plan) used has four distinct phases.

2.5.1. Information phase. This phase maximum information regarding problem is collected from various aspects of the project to clearly identify the problem to be solved and gather information on the background, function and requirements of the project [4]. The importance of this phase lies in collection of as much possible information collection for understanding and assisting the problem

2.5.2. Creative phase. The creativity phase aims to generate ideas of how other alternatives run the functions of the building/system or functions that have been identified as having high potential to be able to do improvements. In this phase, the author utilizes of creativity techniques to develop ideas in carrying out the functions of the building/system [5].

2.5.3. Evaluation/analytical phase. The ideas generated during the Speculative/Creative Phase are screened and evaluated. The ideas showing the greatest potential for cost savings and project improvement are selected for further study. The authors would evaluate the ideas developed during the

creative phase and ranks the ideas. Ideas found to be irrelevant or not worthy of additional study are disregarded; those ideas that represent the greatest potential for cost savings and improvements are selected for development [5].

2.5.4. Recommendation phase. The recommendation phase is important, as the selected alternatives are presented to top management with the full comparative position of costs as well as technical ranking. The major changes in design are also described briefly with sketches, drawings or models as appropriate.[6].

3. Results and discussion

3.1. Information phase
All necessary and possible information regarding the project collected by visiting the site office and company directly. The information includes financial and technical aspects of the projects. The data were collected though meetings, interviews and questionnaires with the owner, consultant and contractor.

3.1.1. Building Data Project
- Project name   : Design Building for The Construction of General Hospitals in Jembrana Regency
- Project location : Negara City
- Owner   : Office of Public Works and Spatial Planning of Jembrana Regency
- Project Type   : Hospital
- Scope of work   : Structural Work, Works Architecture, Mechanical Electrical and Plumbing Works
- Cost   : IDR 31,965,702,000.00

The summary of project costs is shown in Table 1.

Table 1. Summary of project costs.

	Work item	Cost
1	Preparatory Work	13,471,200.00
2	Architectural and Structure Work	16,460,948,874.71
3	Electrical Mechanical and Plumbing Work	12,585,309,110.90
	Real Cost	29,059,729,185.61
	VAT 10%	2,905,972,918.56
	Total	31,965,702,000.00

3.1.2. Pareto analysis. Law of Pareto of the 80/20 law is found by an Italian economist, Vilfredo Pareto. Pareto stated that 80% outcome is the result from 20% income. 80% reaction is caused from 20% action, or 80% result comes from 20% effort. Pareto analysis is the method used to analyze the highest cost of the item of work which has the potential to be analyzed in value engineering. Only the cumulative cost of 80% will be further analyzed through value engineering [7].
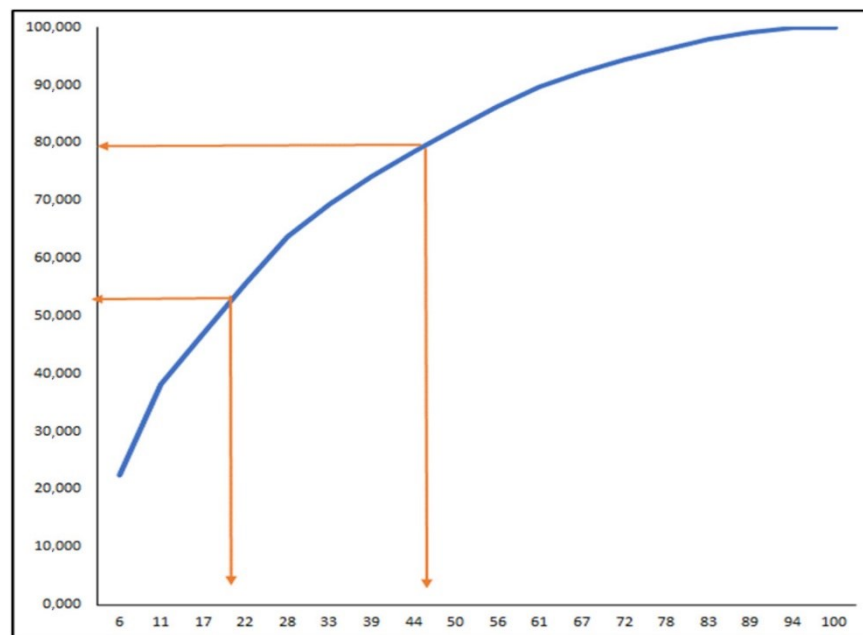
Figure 1. Graph of Pareto total project.

The results of the Pareto analysis show that a decent work item for value engineering is a structural work item. While the structural components are sloofs, beams, columns and slabs.

Table 2. Structure work breakdown.

No	Work item	Cost	% cost
1	Foundation	1,107,353,701.00	16.97
2	Sloofs	309,367,405.00	4.65
3	Columns	976,461,826.00	14.97
4	Beams	1,831,589,353.00	28.07
5	Slabs	2,305,107,950.00	35.33
	Total	6,523,880,235.00	100.00

3.2. Creative phase

This analysis is to analyse each stage of an alternative obtained from the phase of creativity. This stage is to reduce the quantity of ideas that should be identified are common to a short list of ideas with great potential to increase the value of buildings. At this stage of the evaluation will be conducted analysis of the advantages and disadvantages in order to get the most appropriate alternative. Here are the results of VE some work items, which are as follows:

Table 3. Creative phase.

No	Creative ideas
1	Sloof, beams, columns and slabs, using the existing reinforced concrete with K300
2	Sloof, beams, columns and slabs, using the reinforced concrete with K350
3	Sloof, beams, using the reinforced concrete with K350 columns, using the reinforced concrete with K350 and steel slabs, using the reinforced concrete with K250 and wire mesh floor deck

Each alternative has advantages and disadvantages that will be chosen best based on value engineering analysis. The advantages and disadvantages of each alternative are:

- Conventional Concrete (Existing), the advantages are relatively high compressive strength, fire resistance and water, the structure is very sturdy, maintenance costs are almost very low, high durability, easily available materials while the disadvantages of the price of concrete and formwork are relatively expensive, takes longer, requires scaffolding more, Requires longer formwork to withstand the weight when casting.
- Concrete K-350 with downsizing dimensions, the advantages can save concrete volume, steel and formwork so the duration of work is faster, while the disadvantages are high quality concrete prices are more expensive.
- Alternative Floor Decks and reinforcement wire mesh, drawbacks are young experience buckling, greater vibration, steel plate can expand due to changes in temperature, reduce aesthetics while the excess accelerates production, minimizes formwork waste material and scaffolding, minimizes cracks, rust and lighter.
- Alternative Steel WF has high tensile strength and compressive strength, saves labour, can be recycled, can be connected during installation More resistant to receiving earthquake loads, while the disadvantages Can be rusty not flexible, not resistant to fire.

3.3. Analysis phase

At this stage, an alternative for concrete work on sloof, beam, column and slab are extracted which will be analysed further. Calculation of loading with new dimensioning and SAP 2000 results v.15. followed by the calculation of the alternative costs of each.

In this stage an analysis of ideas or alternatives is provided. Bad ideas are eliminated. Alternatives or ideas that arise formulated and considered the advantages and disadvantages are viewed from various angles, then made a ranking of the assessment results. In evaluating it can use techniques such as, zero one method and evaluation matrix

3.3.1. Unit price analysis.

Analysis of unit price is a way of calculating unit prices of construction work outlined in the multiplication needs building materials, wages, and equipment with the price of building materials, labour wage standards and prices lease / purchase of equipment to complete per unit of construction work. At this stage it is a phase in which alternative given on the value engineering affect the cost of the overall project value. The cost efficiency can be seen from the following table:

Table 4. Comparison of costs between existing and alternative I.

No	Work Item	Existing	Alternative I	Cost efficiency	%
1	Sloofs	309,367,405.00	271,428,238,42	31,939,166.08	10.528
2	Columns	966,439,844.94	718,375,201.69	248,064,643.25	25.668
3	Beams	1,799.335295,19	1,652,847,428.38	126,487,866.81	7.109
4	Slabs	1,439,815,810.50	1,334,729,551.84	105,086,258.65	7.299
	Total	4.488.958.355,13	3,977,380,420.33	511,577,934.80	11.40

Table 5. Comparison of costs between existing and alternative II.

No	Work Item	Existing	Alternative II	Cost efficiency	%
1	Sloofs	309,367,405.00	271,428,238.42	31,939,166.08	10.528
2	Columns	966,439,844.94	736.547,579.05	229,892,265.89	23.788
3	Beams	1,799.335295.19	1,652,565,743.47	126,769,551.72	7.125
4	Slabs	1,439,815,810.50	1,191,655,483.31	248,160,327.19	17.236
	Total	4,488,958,355.13	3,852,197,044.25	636,761,310.87	14.190

From Tables 4 and 5 the price of structural work for alternative I is by using concrete quality K 350 when compared to the existing has a cost savings of IDR 511,577,934.79 or equal to 11.40% and the

price of structural work for alternative II is by using a composite when compared to the existing has a cost savings of IDR 636,761,310.87 or 14.19%. Comparison of each for structural work as shown in Figure 2.
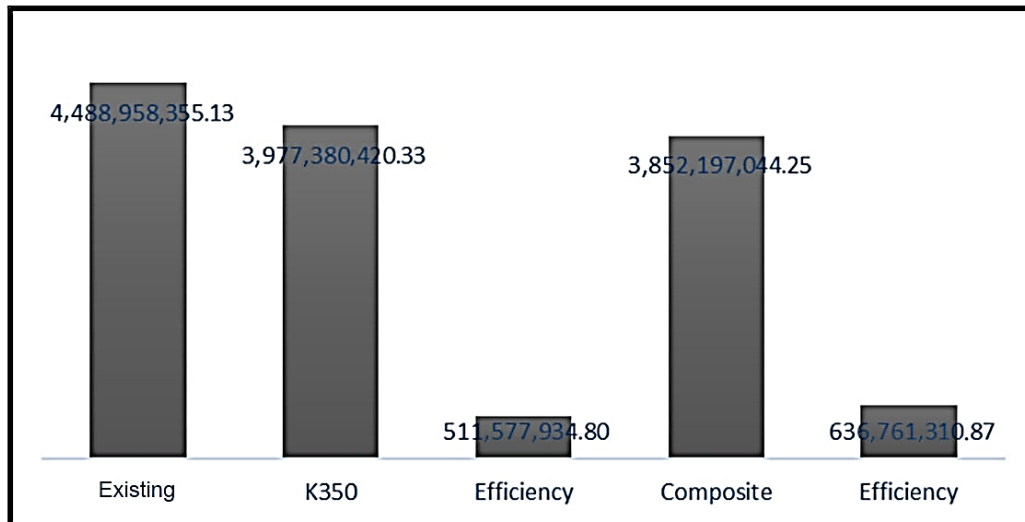

Figure 2. Comparison of structural work costs.

3.3.2. Selection of alternatives for structural work. To determine the best alternative on column, plate and beam work with value engineering analysis is not only seen in terms of cost, but there are several criteria in determining the best alternative that has been mentioned in the creative stage. In calculating the Value Engineering analysis using the function analysis method, the Zero-One Method to search for weights, and the evaluation matrix.

3.3.3. Ranking analysis. The criteria for evaluation which have been selected in evaluation phase as well as weighting is given for each criterion. The matrix shown below (Table 6) in the evaluation phase fixes the scores/weightage.

Table 6. Identifying criteria for selection with rank and score.

No	Work Item	Score	Rank	%
1	Time to Implementation	9	10	11.15
2	Initial Cost	10	11	16.67
3	Quality Assurance	8	9	13.64
4	Easy to Implementation	7	8	12.12
5	Supervision and Condition	5	6	9.09
6	Field Condition	2	3	4.55
7	Total Manpower	3	4	6.06
8	Final Condition/expose	0	1	1.52
9	Weather Dependence	1	2	3.03
10	Availability of Material	6	7	10.61
11	Weight Structure	4	5	7.58
Total			66	100.00

3.3.4. Decision matrix. Giving values on weights based on criteria on structural work items or get Table 6, while indexes obtained from scores on a scale of 1-5. In lines 1, 2, 3 are divided into 2 (two) parts, namely the top is filled in the index and the bottom is filled with the weight multiplied by the index. For the selection of alternative jobs of the largest total value. The decision matrix in Table 7 is the last step for choosing the best alternative. The total score can be seen in the last column in the right side in which proposed idea alternative II with the highest score of 377.27 was selected.

Table 7. Decision matrix.

	Function		Criteria											Total Score
			A	B	C	D	E	F	G	H	I	J	K	
	%		16.67	15.15	13.64	12.12	10.61	9.09	7.58	6.06	4.55	3.03	1.52	
1	Existing (K300)	I =	2	2	2	4	5	5	2	2	2	2	2	283.33
		B x I	33.33	30.3	27.27	48.48	53.03	45.45	15.15	12.12	9.09	6.06	3.03	
2	Alternative I (K350)	I =	3	3	5	4	3	3	3	3	3	3	3	339.90
		B x I	50	45.45	68.18	48.48	31.82	27.27	22.73	18.18	13.64	9.09	4.55	
3	Alternative II (Composite)	I =	5	5	3	2	2	2	5	5	5	5	5	377.27
		B x I	83.33	75.76	40.91	24.24	21.21	18.18	37.88	30.3	22.73	15.15	7.58	

3.4. Analysis phase

The final stage in value engineering analysis is to provide recommendations on the results that have been done.

3.4.1. Initial Design. Reinforced concrete structures use the quality of K300 concrete and the quality of basic reinforcing steel fy = 400 Mpa and the quality of reinforcing steel fangs = 240 Mpa. With the cost of implementing the structure of sloof, column, beam and K300 reinforced concrete in the amount of IDR 4,488,958,355.13

3.4.2. Proposal. Using K350 concrete quality, quality of threaded steel = 400 Mpa and steel with high quality = 240 Mpa. The benefits are: less concrete and reinforcing steel needs. The cost of a reinforced concrete structure is IDR 3,977,380,420.33 and cost savings in this alternative is IDR 511,577,934.80 (11.40%). Using K350 quality concrete blend, WF steel column and Floor deck + wire mesh floor plate. The benefits are: less concrete and reinforcing steel needs. The cost of reinforced concrete structures is IDR 3,852,197,044.25 and cost savings in this alternative is IDR 636,761,310.87 (14.19%).

3.4.3. Selection of used alternatives. From the value engineering analysis carried out, it can be taken that the alternative choice used is Alternative II (Composite), namely K350 quality concrete mix, WF steel column and Floor deck + Wire mesh floor plate as the best alternative with the following considerations: Cost savings due to changes in concrete quality that affect the dimensions of columns, plates and beams; Better concrete quality; Implementation time is faster due to changes in volume. The overall structure of columns, plates and beams is lighter because the dimensions of concrete are smaller.

4. Conclusions

From the value engineering analysis conducted at the State General Hospital in Jembrana Regency, namely the Construction of an Emergency Installation Building (IRD). Alternative II (Composite) namely K350 quality concrete mix, WF steel column and floor deck + wire mesh floor plate are the best alternatives of concrete structures which have the highest weight of 40.91%. With a total cost efficiency of the initial project value is IDR 636,761,310.87 or 14.19% of the initial value of the project.

5. References

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