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DESIGN REVIEW ANALYSIS OF THE USE OF STONE HEAPS FROM STONE EXCAVATIONS IN THE PROBOLINGGO – BANYUWANGI TOLL ROAD CONSTRUCTION PROJECT SECTION 3

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Abstract

In constructing a toll road, the road structure will be carried out by constructing embankments on the road. However, in practice it often causes elevation differences between the two land surfaces, thereby increasing the risk of landslides. The objectives of the research are 1) Identifying the impact if Common Borrow Material (CBM) embankment work is replaced by rock embankment from excavation results, 2) Determine the value engineering process steps related to completing alternative design selection if there are differences between the actual Detailed Engineering Design in the field and 3) Determine the strategy and design optimization for volume differences which have implications for additional costs and project implementation time. The research uses a combination of quantitative and qualitative research methods. The data analysis technique is carried out using the Zero-one and Cost Analysis methods. The research results prove that 1) Implementation of the design review method for changes in common borrow material dumping work requires innovation to reduce cost elements and match performance and quality. 2) Solving problems using the design review method in the civil works construction phase where the Detail Engineering Design and actual field conditions have different stages of value engineering analysis. 3) Based on function analysis to optimize cost savings for work items using design review, a Preliminary Design according to DED Rp. 4,068,258,782,670 and Design after RE Rp. IDR 3,987,286,153,268 so the cost reduction after implementing the design review for the work of piling stones from stone excavation results is IDR 80,972,629,402.

Keywords: *Cost Saving, Common Borrow Materi, Stone Excavation*

1. INTRODUCTION

A project is a temporary effort that has specific targets with limited scope, costs and implementation time. In construction projects, controlling project costs is an important process in managing the costs incurred for the project. Before the project owner decides to continue the project to the design and construction stage, the project owner needs to prepare a cost budget first. The cost budget that has been prepared by the project owner sometimes exceeds the initial planning. Inaccurate preparation of the planned cost budget at the start was due to inefficient use of materials, unskilled labor and delays in project completion time (Rompas, 2013).

Project complexity refers to the level of difficulty, complexity, or level of complexity of a project. It is important for project managers and teams to understand the level of complexity of the project because this will affect the strategy, planning, risk management, and resources required to complete the project successfully. Identifying and managing factors that cause complexity will help minimize risks and increase project success, one of which is toll road construction projects.

The construction of this toll road requires very large costs, this construction requires assistance from various parties to finance the construction of this toll road, other parties involved besides the government are banking institutions, this institution is an institution that has a big role in the construction of this toll road because it provides loan funds up to trillions of rupiah. The construction of this toll road requires good quality, in terms of comfort and safety for users it must also be taken into account, road route planning must be made effective and efficient so as to obtain a safe and comfortable route, apart from that the construction of toll roads must take into account local regional factors such as the economy, social, and cultural. Toll road construction is mostly carried out in areas with diverse contours such as hills, mountains, rice fields, etc. (Hidayat & Ardianto, 2011). The various contours cause construction to be difficult and the road to be built will be less comfortable and safe, so it is necessary to have several aspects that must be considered carefully to ensure the success of the project.

The construction of road structures certainly cannot be separated from the construction of embankments on the road. The construction of road embankments causes elevation differences between the two ground surfaces, so that a pressing force can occur which causes the high ground elevation to move downwards due to gravitational force which results in the ground being unstable and prone to landslides. Generally, highland or mountainous areas are very threatened by landslides. The landslide was caused by soil erosion, excessive load on the landslide area, strong vibrations, and high rainfall. The higher the embankment work, the greater the force that occurs and the higher the risk of landslides. Therefore, it is necessary to strengthen the embankment slopes so that the embankment work is safe and strong.

Each project has unique challenges depending on local geographic and environmental conditions (Witjaksana, n.d.). Therefore, solutions to overcome elevation differences will depend on careful planning and careful analysis according to the specific characteristics of the project. Differences in elevation on the ground surface are often an obstacle to carrying out infrastructure development in Indonesia, so one solution that can be implemented as mentioned in point 4 above is to carry out cut and fill work. However, this solution will create a slope. Slopes having a horizontal slope angle cause the stability of the slope to become unstable and can become a problem, unstable slopes are the cause of landslides and endanger those around them (Send Pristianti Day., 2012).

The Probolinggo Banyuwangi Section 3 toll road construction project is part of the Trans Java Toll road program with an estimated 175.40km long road crossing 3 districts, namely Probolinggo, Situbondo and Banyuwangi which is divided into 5 sections. Currently the Trans Java Toll Road has entered the construction stage of section 3. Section 1 starts from Probolinggo (Gending) – Kraksaan with a length of 12.88 km. Section 2 starts from Kraksaan – Paiton for 11.2 km. And section 3 starts from Paiton – Besuki for 25 km. Currently the Probolinggo Banyuwangi Toll Road has three Interchanges (SS), namely SS Kraksaan, SS Paiton, and SS Besuki. Apart from that, there are two rest areas, namely at STA 33+500 in both Probolinggo and Besuki directions.

Creating a new network (toll roads) is indeed one way to overcome congestion, but this cannot necessarily overcome the problem as a whole, including geographical, demographic, political, ecological and social aspects of the communities whose areas are affected by this project (Cesaria, 2013). The objectives of this research are 1) Identifying the impacts that would arise if common borrow material (CBM) stockpiles were replaced with rock piles from excavation results. 2) Determine the steps and stages in the value engineering process related to completing the selection of alternative designs if there are differences between the Detail Engineering Design (DED) and the actual in the field at the construction work implementation stage (civil work). 3) Determine the strategy by analyzing and optimizing the design for volume differences which have implications for increasing costs and project implementation time.

2. LITERATURE REVIEW

2.1. Toll Road

Toll roads are public roads that are part of the road network system and also as national roads that pass through are required to pay. Procurement of toll roads is intended to increase the efficiency and effectiveness of goods and services distribution services to support increased economic growth, increase development results and facilitate traffic (Asiyanto, 2002).

2.2. Slopes

Slopes are the uneven surface of the earth and have an angle of inclination to the horizontal plane, the formation of slopes occurs due to natural processes such as hills, mountains, river banks or due to artificial (man-made) processes such as embankments and excavations due to the construction of embankments, roads (Sekarti, 2018).

2.3. Soil

Soil is mineral grains and solid particles in aggregates that contain liquid and gas in their empty spaces. Minerals in soil come from physical and chemical weathering of rocks which are the parent material of soil. The process of soil formation affects soil stability, especially in sloping areas which are currently closely related to landslides. Landslides are ranked second as the most frequent disaster in Indonesia (BAPPENAS-BAKORNAS, n.d.).

2.4. Soil Classification

The general properties of soils, which vary greatly, are briefly explained in this classification. Soil classifiers are used to obtain results on whether a soil can be used and to obtain basic data about soil conditions in various areas such as soil density, soil strength, compaction characteristics, and so on. There are 2 land classification systems that are often used in Indonesia, namely the AASHTO and USCS classification systems (Ahmed & Pandey, 2016).

2.5. Landfill Subsidence

Direct settlement refers to the elastic properties of the soil without changing its water content (the water is not drained). The initial stage usually takes between 0 and 7 days, and can be found in sand, silt, and clay with saturation less than 90% (Berawi et al., 2011).

2.6. Landfill / Slope

A slope is a land surface that has no protection on an inclined gradient and forms a certain angle with the horizontal plane. Slopes are separated into two categories: man-made slopes and natural slopes (Chandra, 1987). Artificial slopes are made by people and are usually used for construction purposes, such as river embankments, railway embankments, earth dams and so on. Natural slopes are usually found in highlands such as mountains and hills (Mitchell & Chandra, 1987).

2.7. Factors That Influence Slope Stability

Collapse of natural slopes or artificial slopes is caused by several factors, namely changes in topography, seismicity, loss of strength, groundwater flow, and season/weather, due to external forces, the slope-forming material has a tendency to slide, the shear strength of the material itself resists this sliding tendency (Atabay & Galipogullari, 2013). Shear stress can be generated throughout the soil mass by factors that influence slope stability, except that the shear stress acts greater than the shear resistance on each failure surface (Bowles, 1991).

2.8. Zero-One Method

According to (Asiyanto & IPM, 2005) and (Listiono, 2011), the zero-one method is a method of decision making which aims to determine the priority order of functions. The principle of this method is to determine the relativity of a function being "more important" or "less important" relative to other functions. According to (Ustoyo, 2007) and Listiono (2011), the zero one method is a method of decision making which aims to determine the priority order of functions (criteria).

2.9. Final Assessment of Alternatives and Existing (Weighting)

According to (Thoengsal, 2014) and Listiono (2011), after obtaining the index values and temporary weights of all the criteria for the alternatives used, the final weighting is carried out using an evaluation matrix. Part of this method is to determine the priority value of an item presented using existing and alternative assessment methods.

3. RESEARCH METHODS

3.1. Place and Research Object

This case study and research was carried out on the Probolinggo Banyuwangi Section 3 toll road construction project, which is located in Besuki sub-district, Situbondo district, East Java.

3.2. Types of Research

This research uses a combination of quantitative and qualitative research methods, taking into account the philosophy of postpositivism. Used to research natural object conditions (versus experiments), where the researcher is the key instrument. The data collection technique was carried out using triangulation (combination). Data analysis is inductive/qualitative. Qualitative research results emphasize meaning rather than generalizations.

3.3. Types of Research Data

This research uses the following types of data collection:

a) Primary Data

Primary data is a data source obtained directly from the original source (from the work location) or basic data used in carrying out Value Engineering analysis. In this research, direct measurements were carried out in the field, taking visual photos, direct interviews and coordination with field supervisors and work implementers to obtain detailed information and shop drawings as well as technical data from the field.

b) Secondary Data

Secondary Data is supporting data that can be used as input and reference in carrying out Value Engineering analysis. In this research, a list of Work Unit Price Analysis (AHSP) was obtained, a list of materials or building materials used, DED drawings, a list of daily labor data (daywork), RAB data, and other data that can be used as a reference in analyzing Value Engineering.

3.4. Data Collection

Data collection can be done by:

a) The primary data collection method is by conducting a direct survey of the supervisory consultant (supervision consultant) and service provider (contractor) carrying out work on the project, as well as making direct observations at the work location.
b) The secondary data collection method is by carrying out direct surveys on service users (owners) and related agencies as well as companies directly involved in the development project.

3.5. Daya Analysis Method

The research method used in value engineering is carried out in several stages, namely: (a). Information stage, (b). Function analysis stage, (c). Creativity stage, (d). Evaluation Stage, (e). Development Stage, (f). Presentation Stage.

4. RESULTS AND DISCUSSION

4.1. Information Stage

Probolinggo – Banyuwangi toll road construction project package 3b which is located in the north coast of Java Island in the package: Probolinggi – Banyuwangi toll road construction project STA 29+600 – 45+800, via Jasamarga Probolinggo Banyuwangi (JPB) which is one of the toll road construction work packages in When construction work (civil work) started, there were obstacles caused by differences in soil investigation results in the initial documents (detailed engineering design / DED). The impact due to differences in land data which results in not matching the volume of work and has implications for the cost of the contract value.

4.2. Design Criteria

Table 1. Design Criteria

Technical specifications	Design Criteria	Unit
Length of Main Street	16,2	Km/hour
Planned Road Speed	80	Km/hour
Number and Width of Traffic Lanes	3,6	m
Outer Shoulder	3	m
Deep Shoulders	1,5	m
Media Width (includes inner shoulder)	4	m
Pavement Type	Rigid Pavement	

Source: Probowangi Toll Road Project Secondary Data (2023)

In accordance with the plan drawing in the Detail Engineering Design (DED) document, you can see the cross section of the road in a typical shape. Other primary data obtained from supervision consultants and work owners is the Budget and Cost Plan document (bill of quantity) in which the physical work of building roads and bridges uses the 2010 General Specifications revision-3 with a Unit Price Contract).

4.3. Speculation Stage (Creativity)

The speculation stage in value engineering consists of generating a number of alternative ideas from segments that are viewed with various advantages so that it is hoped that optimal results will be obtained. The costs and percentage weights for each type of work are as follows:

Table 2. Percentage of Employment

DIVISI 4	PEKERJAAN TANAH		
4.03 (1)	Galian Biasa untuk Timbunan	119.247.795.517,46	2,931%
4.03 (3)	Galian Biasa untuk Dibuang *(Waste)*	52.242.267.405,63	1,284%
4.03 (4)	Galian Batu Lunak untuk Timbunan	231.678.159.596,44	5,695%
4.04a	Galian Batu *(Rock Blasting Excavation) untuk Timbunan*	7.907.450.878,18	0,194%
4.04c	Galian Batu Mekanik *(Mechanic Rock Excavation)* untuk Timbunan	64.806.194.449,80	1,593%
4.05 (1)	Common Borrow Material	473.213.154.271,03	11,632%
4.09	Urugan Material Berbutir (Granular Backfill)	41.609.811.330,28	1,023%
4.11 (2)	Drainase Pasir Horisontal	148.087.951.288,03	3,640%
4.12 (1)	Geotekstile Filter Untuk Drainase Bawah Permukaan (Kelas 2)	739.067.751,26	0,018%
4.12 (2)	Geotekstile Separator (Kelas 1)	32.089.491.865,60	0,789%
4.12 (5)	Geotekstile Stabilisator (Kelas 1)	12.859.722.641,49	0,316%
4.14 (1)	Pemantauan Tekanan Air Pori	2.770.059.600,00	0,068%
4.14 (2)	Pemantauan Penurunan Vertikal	969.375.550,00	0,024%
4.14 (3)	Pemantauan Pergerakan Horizontal	481.819.800,00	0,012%
		1.188.702.321.945,19	

Source: Probowangi Toll Road Project Secondary Data (2023)

The consideration for choosing work items as an alternative design review is to prioritize quality and at a more economical price. The order of high-cost types of work is as follows:

Table 3. High cost job sequences

NO. MATA PEMBAYARAN	URAIAN	HARGA SATUAN	VOLUME	JUMLAH HARGA (Rp)	PERSENTASE
a	b	d	e		
4.05 (1)	Common Borrow Material	171.737,00	2.755.452,55	473.213.154.271,03	23,160%
4.04c	Galian Batu Mekanik (*Mechanic Rock Excavation*) untuk Timbunan	136.218,00	475.753,53	64.806.194.449,80	3,172%
4.04a	Galian Batu (*Rock Blasting Excavation) untuk Timbunan*	152.420,00	51.879,35	7.907.450.878,18	0,387%

Source: Author's analysis results (2023)

From the table above, it is known that the common borrow material work in the Probolinggo - Banyuwangi toll road construction package is the work with the highest price weight, while the handling length or effective length of embankment must be fulfilled in accordance with the Contract Documents.

Embankment work that uses common borrow material in contracts has very high volumes and relatively expensive prices, so the types of work that will be subject to design review are: Planning to change the use of materials from common borrow materials to piles of rock from excavations at the project location, from the results of soil tests which resulted in very abundant rock content. The benefits gained by changing the embankment design are:

a) Relatively cheap price of stockpiles from outside the project
b) Relatively faster work time because there is no need to source from outside the project
c) Abundant availability of material requirements
d) Does not cause dust in areas outside the project produced by CBM trucks
e) The potential for land subsidence is very small

4.4. Analysis Stage

This stage aims to find out whether the selection of alternative ideas to replace the work construction has potential advantages and disadvantages, so a design review is carried out.

4.4.1. Structur Analysis

Table 4. Structural analysis of rock pile work

Alternative Selected	Potential Profits	Potential Losses
Piles of stones from stone excavations	a. The cost/price per cubic meter is relatively cheaper than common borrow material b. Materials are easily obtained from excavations	a. Quality control of material gradation b. It is necessary to re-evaluate the box culvert which will be filled with stone material

Alternative Selected	Potential Profits	Potential Losses
	within the scope of the project c. Does not create dust in areas outside the project d. The potential for land subsidence is very small e. The work time is relatively faster because there is no need to take materials from outside f. There is no need to use geotextile spars on existing land	c. There are no specific specifications for this pile of stones yet

Source: Author's analysis results (2023)

4.4.2. Feasibility Analysis

Feasibility analysis of rock pile work from stone excavation results:

Table 5. Results of weighting calculations for rock embankment work items

Sequence of Criteria	Notation	Ranking	Weight
Price	A	1	100
Implementation in the field	B	2	83.333
Technology	C	3	66.667
Quality control	D	4	50
Strength	E	5	33.333
Aesthetics	F	6	16.667

Source: Author's analysis results (2023)

4.4.3.Function Analysis

At the stage of analyzing the function of the stone pile work, the results of the comparison ratio between Cost / Worth > 1 can be seen as follows:

Table 6. Results of functional analysis of rock pile work

No	Job Description	Cost (Rp)	Worth (Rp)
1	Rock Blasting Excavation for Embankment	7.907.450.817,18	7.907.450.817,18
2	Mechanical Rock Excavation for Embankments	6.806.194.449,80	375.342.235.211,34
3	Common Borrow Material	473.213.154.271,03	81.704.484.108,01

No	Job Description	Cost (Rp)	Worth (Rp)
Amount		545.926.799.599,00	464.954.170.197,53
Rasio=Cost / Worth		**1,174**	

Source: results of the author's analysis (2023)

$Rasio = \frac{cost}{worth} = \frac{545.926.799.599,00}{464.954.170.197,53} = 1{,}174 > 1 \rightarrow$ costs do not need to be high

Next, a cost benefit analysis will be carried out. At this stage, the most important thing is the cost and benefit analysis (cost benefit analysis) where ideas need to be refined so that they can meet operational conditions and lifetime cost analysis (life cycle costing).

Table 7. Results of volume calculations and DED design costs

No. Payment Points	Description	Unit	Unit price	Volume	Total Price (Rp)
4.03 (1)	Ordinary Excavation for Embankments	m^3	62.678,00	1.902.546,28	119.247.795.517,46
4.03 (3)	Ordinary Excavations for Disposal (Waste)	m^3	53.162,00	982.699,44	52.242.267.405,63
4.03 (4)	Excavation of Soft Rock for Embankment	m^3	103.275,00	2.243.313,09	231.678.159.596,44
4.04a	Rock Blasting Excavation for Embankment	m^3	152.420,00	51.879,35	7.907.450.878,18
4.04c	Mechanical Rock Excavation for Embankments	m^3	136.218,00	475.753,53	64.806.194.449,80
4.05 (1)	Common Borrow Material	m^3	171.737,00	2.755.452,55	473.213.154.271,03
4.09	Granular Backfill Material	m^3	277.197,00	150.109,17	41.609.811.330,28
4.11 (2)	Horizontal Sand Drainage	m^3	193.376,00	765.803,16	148.087.951.288,03
4.12 (1)	Geotextile Filter For Subsurface Drainage (Class 2)	m^2	17.079,00	43.273,48	739.067.751,26
4.12 (2)	Geotextile Separator (Class 1)	m^2	17.404,00	1.843.799,81	32.089.491.865,60
4.12 (5)	Geotextile Stabilizer (Class 1)	m^2	16.295,00	789.182,12	12.859.722.641,49
4.14 (1)	Pore Water Pressure Monitoring	Point	32.976.900,00	84,00	2.770.059.600,00
4.14 (2)	Vertical Drop Monitoring	Point	5.735.950,00	169,00	969.375.550,00
4.14 (3)	Horizontal Movement Monitoring	Point	5.735.950,00	84,00	481.819.800,00
Total					**1.188.702.321.945,19**

Table 8. Results of design review design volume and cost calculations

No. Payment Points	Description	Unit	Unit price	Volume	Total Price (Rp)
Division 4	**Earth Works**				
4.03 (1)	Ordinary Excavation for Embankments	m3	62.678,00	1.902.546,28	119.247.795.517,46
4.03 (3)	Ordinary Excavations for Disposal (Waste)	m3	53.162,00	982.699,44	52.242.267.405,63
4.03 (4)	Excavation of Soft Rock for Embankment	m3	103.275,00	2.243.313,09	231.678.159.596,44
4.04a	Rock Blasting Excavation for Embankment	m3	152.420,00	51.879,35	7.907.450.878,18
4.04c	Mechanical Rock Excavation for Embankments	m3	136.218,00	2.755.452,55	375.342.235.211,34
4.05 (1)	Common Borrow Material	m3	171.737,00	475.753,53	81.704.484.108,01
4.09	Granular Backfill Material	m3	277.197,00	150.109,17	41.609.811.330,28
4.11 (2)	Horizontal Sand Drainage	m3	193.376,00	765.803,16	148.087.951.288,03
4.12 (1)	Geotextile Filter For Subsurface Drainage (Class 2)	m2	17.079,00	43.273,48	739.067.751,26
4.12 (2)	Geotextile Separator (Class 1)	m2	17.404,00	1.843.799,81	32.089.491.865,60
4.12 (5)	Geotextile Stabilizer (Class 1)	m2	16.295,00	789.182,12	12.859.722.641,49
4.14 (1)	Pore Water Pressure Monitoring	titik	32.976.900,00	84,00	2.770.059.600,00
4.14 (2)	Vertical Drop Monitoring	titk	5.735.950,00	169,00	969.375.550,00
4.14 (3)	Horizontal Movement Monitoring	titik	5.735.950,00	84,00	481.819.800,00
Total					**1.107.729.692.543,72**

Source: Author's analysis results (2023)

4.5. Presentation Stage and Follow-up Program

At this stage, a comparison is carried out between the work items in the initial DED design (detail engineering design) and the design review design with the results of cost optimization that can be saved.

Initial design according to DED = Rp. 1.188.702.321.945,19
Design after design review = Rp. 1.107.729.692.543,72

The amount of cost savings after implementing the design review for the rock pile work was IDR. 80,972,629,402

5. CONCLUSION

Implementation of construction work for the Trans Java toll road infrastructure project, one of which is on the Probolinggo – Banyuwangi section in one of the 3 paiton district packages. Probolinggo – Besuki district. Situbondo with an effective length of 25.06 Km with a total value of Rp. 4,068,258,782,670. There are problems that arise during the construction phase which can be summarized as follows: 1) Implementation of the design review method for changes in common borrow material (CBM) embankment work which is replaced by excavation of rock embankments is to carry out design reviews which require innovation and creativity in the process of reducing cost elements which have the potential for additions while remaining on the principle of not eliminating performance (performance), durability, reliability, quality, function, benefits, aesthetics and other aspects so that conditions of right quality, right time and right cost are met. 2) Solving problems using the design review method that occurs in the civil works construction phase where there are differences between the Detail Engineering Design (DED) and actual field work. The stages generally used in a value engineering analysis include; information gathering stage, analysis stage, creativity and innovation stage, implementation presentation and follow-up stage. 3) To determine the selection of design and material alternatives, function analysis is carried out using the Cost / Worth (C/W) ratio equation and if the index value is > (1~1.5) then the work item being analyzed has the potential to have high unnecessary costs. To optimize cost savings for work items analyzed using a design review, a Preliminary Design according to DED Rp. 4,068,258,782,670 and Design after RE Rp. IDR 3,987,286,153,268 so that the cost reduction (cost saving) after implementing the design review for rock pile work from stone excavation results is IDR 80,972,629,402.

It is necessary to provide special specifications for the stone filling work on the Probolinggo – Banyuwangi toll road, one of which explains the density and gradation of the stone to be filled. Supervisory consultants and related parties in carrying out design review analysis are advised to follow existing stages based on previous research. Further researchers are advised to analyze aspects of ease of implementation, social and economic aspects, occupational safety and health (K3) and the environment in detail, in order to obtain more accurate analysis results.

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