Construction Value Engineering Construction of Serang - Panimbang Toll Road Section 3, Cileles - Panimbang Sta.50+677 - Sta.83+677 Banten Province

Okto Ferry Silitonga[1], Dr. Ir. Dwi Dina Riana, MT[2], Dr. Ir. Hari Nugraha Nurjaman, MT[3]

[1] Master Student of Civil Engineering Management and Construction Engineering, Faculty of Civil Engineering, Universitas Persada Indonesia - YAI
Email: *oktoferry.silt1971[at]gmail.com*

[2] Lecturer of Master of Civil Engineering, Faculty of Civil Engineering, University of Persada Indonesia - YAI
E - mail: *dwidinariana[at]yahoo.com*
E - mail: *tgdd_yai2017[at]yahoo.com*

[3]Lecturer of Master of Civil Engineering, Faculty of Civil Engineering, University of Persada Indonesia - YAI
Email: *hari. nugraha1969[at]icloud.com*

Abstract: ***The cost for the construction of a project is very important but if there is no control in its use, the project owner's finances will lose. OnSerang – Panimbang Toll Road Construction Project, Section 3 (Cileles – Panimbang), Sta.50+667 – Sta.83+677 Work Section 10 (Concrete Structure), Work Section 4 (Road Earthwork), Work Section 9 (Pavement) and Work Section 12 (Miscellanoues) cost more than other works. Value engineering is one way to reduce the cost factor because it will identify what work items may cost a lot by going through the information stage, creative stage, analysis stage, and recommendation stage and using the Paired Comparison method in determining the factors that will be used as design. his replacement.***

Keywords: Cost Model – Cost Breakdown – Functional Analysis –Creative and Innovation – LCC – IRR

1. Preliminary

The Serang Panimbang Toll Road is one of the four toll road sections of government - to - business cooperation (PPP), which receive government support in the form of joint guarantees from the Ministry of Finance and PT. Indonesia Infrastructure Guarantee (PII). The Serang Panimbang Toll Road is 83.6 km long, divided into 3 (three) sections, namely Section I: Serang – Rangkasbitung, Section II: Rangkasbitung – Bojong, and Section III: Bojong – Panimbang. The Serang Panimbang Toll Road is one of the National Strategic Projects (PSN) established by the Government. This toll road was built to support the development of the Tanjung Lesung Special Economic Zone (SEZ).

Therefore, in order to obtain quality work results at a more efficient cost, it is necessary to apply Value Engineering at the planning stage and at the project work implementation stage. This will have the effect of increasing value and saving costs because alternative materials can be obtained and used which are considered better by taking into account the proper design criteria.

Problem Description

The construction of the Serang – Panimbang, Cileles – Panimbang Toll Road is a national strategic project. Every development has a very large negative impact on the environment such as ozone depletion, global warming, water depletion, energy consumption and others. Therefore, a VE study will be conducted to find out what cost components can be optimized from the toll road construction cost components in order to obtain a better and more efficient development.

Formulation of the Problem

So the formulation of the problem that must be answered in this study is:

1) What are the cost savings resulting from these alternatives in the Serang – Panimbang, Cileles – Panimbang Toll Road project.
2) What alternative designs are considered the best in terms of cost efficiency for the Toll Road Construction work.

1.1 Research Purposes

1) To get the results of cost savings from the selected alternative in the Toll Construction project.
2) Determine the best alternative material that can reduce construction costs by taking into account various design criteria, in the construction of toll roads.

1.2 Scope and Object of Research

The research was conducted on the Serang – Panimbang, Cileles – Panimbang Toll Road project

1) Theoretical Basis

Engineering Value

Value Engineering is a systematic and structured multidisciplinary - based decision - making process.

Performing a function analysis to achieve the best value (best value) of a project by defining the functions needed to achieve the desired value target and providing these functions at an optimum cost, consistent with the required quality and performance (Berawi, 2003).2013).

Value Engineering Concept

The concept of Value Engineering is to reduce the cost of a product or service by involving the principles of Engineering. This technique seeks to achieve the same minimum quality as planned with the minimum possible cost. The planning process carried out in the implementation of Value Engineering is always based on the required functions and the value obtained. Therefore, Value Engineering is not:

1) *Cost cutting process*, lowering project costs by reducing unit prices, or sacrificing quality and appearance.
2) *Design Review*, correcting the existing design results.
3) *Requirements done on all designs*, is not a requirement for every designer to implement value engineering programs. (Chandra, 2014).
4) Correcting errors made by the planner, or recalculating the existing RAB.
5) Reduce costs by lowering appearance and quality.
6) Quality control. Value engineering strives to achieve the same minimum quality as planned at the lowest possible cost. So Value Engineering is more than quality control but rather an effort to improve quality. (Berawi, 2013).

Value (Value)

Value is defined as a relationship between cost, time and quality where quality consists of a number of variables determined from the knowledge and experience of an individual or several individuals in a group, which is made explicit with the intention of making a choice among various functionally suitable options. Therefore, the value system that is made explicit is a description at a certain time of various variables on all decisions that affect the core business or a project, so that it can be audited (Berawi, 2013).

Function

Function is defined as the main element in Value Engineering because the purpose of Value Engineering is to obtain the required functions of an item with an efficient total cost. Understanding the meaning of function is very important because function will be the main object in relation to cost. Functions can be divided into 2 categories:

1) The basic function is the main reason the system is realized, a basis or reason for the existence of a product and has a usability value.
2) Secondary function is a function that is not directly used to fulfill basic functions, but is needed to support it. By combining the principles of the concept of cost efficiency, value engineering can optimize project costs by analyzing the function of an activity item to simplify or modify planning or implementation while maintaining / improving the desired quality and considering operations and maintenance.

Cost (Cost)

Cost is the sum of all the effort and expenditure that is made in developing, producing and applying the product/project or in other words is a life cycle cost (LCC). LCC is the total cost starting from the initial planning stage until the end of the utilization of a facility (Dell'Isola, 1997 in Berawi, 2013).

Benefits of Value Engineering

The application of VE in a construction project assures the parties to the project that investment in construction produces a valuable asset where the value is effective to build, use, and maintain. Certainty of producing more valuable products or achieving value for money from these products, based on Connaughton and Green (1996) in Berawi (2013) because basically the application of Value Engineering will ensure the need for projects that will always be verified and supported by data, objectives of the project that are discussed openly and clearly, important decisions in the value engineering process that are rational, firm, and reliable, designs developed within the framework of agreed project objectives, various alternative options are always taken into account.

Value Engineering Application

In Buildings, Value Engineering studies can be carried out at each stage of project development in accordance with the expected results and benefits of the Value Engineering study. Of course, if implemented at the beginning of the project, the benefits will be greater in terms of cost and time.

Data Analysis with Value Engineering

Data analysis is a systematic process that follows a job plan. Data analysis using the Value Engineering method consists of six stages, namely the information stage, the function analysis stage, the creativity stage, the evaluation stage, the development stage and the presentation stage.

- Information Stage.
- Function Analysis Stage.
- Creative Stage.
- Evaluation Stage.
- Development Stage.
- Presentation/Recommendation Stage.

2. Research Methodology

2.1 Discussion

This chapter discusses the research methodology that will be used as the research design. The research method aims to determine and explain the right method to answer the problems in this research, namely the development of value engineering guidelines to improve the function of buildings so that research objectives can be achieved. The research method determines how a research process is carried out starting from data collection, processing data into information for analysis and finally producing findings that can be concluded.

2.2 Method of Collecting Data

1) Primary data collection method

The primary data collection method is by conducting direct observations or direct surveys to the field, both to implementers and consultants who handle projects the.

2) Secondary data collection method

Secondary data collection method by visiting agencies and companies that are considered interested. The companies include building materials / materials companies, heavy equipment rentals, consultants, contractors, labor contractors, agencies dealing with service and building construction issues. While the data collection methods used in this study are as follows:

3) Documentation

Documentation is shown to obtain data directly from the research site, including working drawings, Budget Plan (RAB), Work Plan and Conditions (RKS), relevant books, regulations, activity reports, photographs, documentary films, and data relevant to research.

4) Interview

Interview is a way of collecting data used to obtain information directly from the source. This interview is conducted if the researcher wants to know directly in depth about the research subject. In this study, guided free interviews were used, namely a combination of free interviews and guided interviews. In practice, the interviewer brings a guide which is only an outline of the things to be asked. In this study, interviews with value engineering (VE) experts will be conducted.

5) Observation (Observation) / Survey

Observation is to make observations directly to the object of research to see closely the activities carried out. Observations were made at the information gathering stage. The primary data collection method was carried out by means of direct surveys to consultants and implementers who handled the project and made direct observations in the field. As for the secondary data collection method, it is carried out by direct surveys to agencies or companies that are considered interested. The company can include building materials/material companies, contractors, and other companies that can be used as reference materials.

2.3 Data Analysis

The analysis used to answer the two problem formulations in this study is value engineering (VE) analysis. The steps for the value engineering (VE) work plan according to the USA's DOD (Department Of Defense) include five stages, namely:

1) Information Stage.
2) Function Analysis Phase.
3) Creative Stage.
4) Evaluation Stage.
5) Development Stage.
6) Presentation Stage.

3. Implementation and Discussion of Research Results

3.1 Information Stage

At this stage the VE estimators must collect data, both primary data in the form of direct interviews with related parties such as contractors, owners, consultants, and secondary data in the form of RAB, BOQ, Master Schedule and other references. Data collection in this case is needed to find out the opinions and inputs of interested parties in the project and can find out the characteristics of a project ranging from work items, unit prices, work volumes, work methods, types of equipment and materials to be used and the duration of the project. .

3.2 Project Data

Package name	Serang – Panimbang Toll Road Construction Section 3, Chile - Consider
Contract number	HK.0201/Bb.27/SATKER. TSP/PPK/JBHSP - 1/23
Contract Date	November 24, 2020
Contract Value (VAT 10%)	Rp 4, 585, 032, 615, 891.12
Provider	SRBGC - WIKA - ADHI (JO)
Implementation time	730 Calendar Days
Maintenance period	730 Calendar Days
Supervision Consultant	Contract Target 30 July 2021

Project Location

Analysis and Stages of Value Engineering Construction (Value Engineering)

Cost Model

The cost model is carried out on the Budget and Cost Plan (RAB) by making a work table grouped according to the elements of each work. The table also includes the budget plan for each work item. This cost model is made to choose which section of work will be carried out by Value Engineering.

No.	No. Section	Uraian Pekerjaan Konstruksi	Total (Rp.)	Persentase (%)	Rank
1.	SECTION 1	GENERAL	69,557,159,203	1.66	8
2.	SECTION 2	SITE CLEARING	12,492,768,275	0.30	11
3.	SECTION 3	DEMOLITION	5,889,025,080	0.14	14
4.	**SECTION 4**	**ROAD EARTHWORK**	**1,059,191,047,653**	**25.35**	**2**
5.	SECTION 5	STRUCTURE EXCAVATION	227,722,030,592	5.45	5
6.	SECTION 6	DRAINAGE	97,993,222,881	2.35	6
7.	SECTION 7	SUB GRADE	4,653,262,929	0.11	15
8.	SECTION 8	AGGREGATE BASE	70,145,144,060	1.68	7
9.	**SECTION 9**	**PAVEMENTS**	**388,050,079,367**	**9.29**	**3**
10.	**SECTION 10**	**CONCRETE STRUCTURES**	**1,869,552,952,237**	**44.75**	**1**
11.	SECTION 11	STRUCTURAL STEEL WORK	-	-	
12.	**SECTION 12**	**MISCELLANEOUS**	**307,923,972,401**	**7.37**	**4**
13.	SECTION 13	LIGHTING, TRAFFIC SIGNALS AND ELECTRICAL WORKS	10,833,149,818	0.26	13
14.	SECTION 14	TOLL PLAZAS	11,228,755,704	0.27	12
15.	SECTION 15	DIVERSION AND PROTECTION OF EXISTING UTILITIES	3,000,000,000	0.07	16
16.	SECTION 16	TOLL OFFICE AND FACILITIES	19,124,046,429	0.46	10
17.	SECTION 17	DAY WORK	20,790,306,686	0.50	9
	(A)	**Jumlah Harga Pekerjaan (termasuk Keuntungan)**	**4,178,146,923,315**	**100.00**	
	(B)	**Pajak Pertambahan Nilai (PPN) = 10% x (A)**	**417,814,692,332**		
	(C)	**JUMLAH TOTAL HARGA PEKERJAAN = (A) + (B)**	**4,595,961,615,647**		
	(D)	**Dibulatkan**	**4,595,961,615,000**		

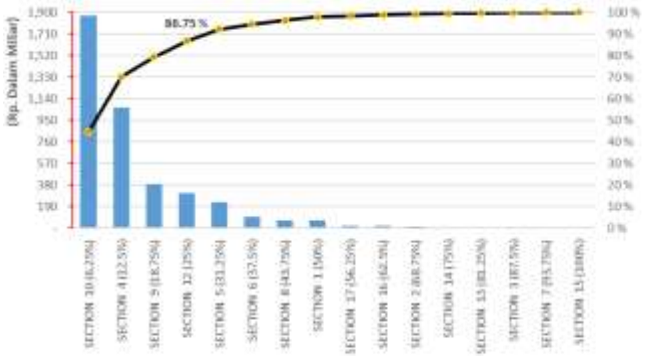
Cost Model Analysis

From Table 9 – the Cost Model of Construction Work, a Ranking of Work Cost Weights (Section) is arranged from the lowest to the highest ranking for each Job (Section) by eliminating Section 11 – Structural Steel Work that does not have a Work Cost (Zero Weight), and can seen in Table 11 – Cost Model Analysis of Construction Work Costs.

No.	No. SEction	Uraian Pekerjaan Konstruksi	Persentase Biaya (%)	Komulatif Biaya (%)	Persentase Pekerjaan (%)	Komulatif Pekerjaan (%)
1.	**SECTION 10**	**CONCRETE STRUCTURES**	**44.75**	**44.75**	**6.25**	**6.25**
2.	**SECTION 4**	**ROAD EARTHWORK**	**25.35**	**70.10**	**6.25**	**12.50**
3.	**SECTION 9**	**PAVEMENTS**	**9.29**	**79.38**	**6.25**	**18.75**
4.	**SECTION 12**	**MISCELLANEOUS**	**7.37**	**86.75**	**6.25**	**25.00**
5.	SECTION 5	STRUCTURE EXCAVATION	5.45	92.20	6.25	31.25
6.	SECTION 6	DRAINAGE	2.35	94.55	6.25	37.50
7.	SECTION 8	AGGREGATE BASE	1.68	96.23	6.25	43.75
8.	SECTION 1	GENERAL	1.66	97.89	6.25	50.00
9.	SECTION 17	DAY WORK	0.50	98.39	6.25	56.25
10.	SECTION 16	TOLL OFFICE AND FACILITIES	0.46	98.85	6.25	62.50
11.	SECTION 2	SITE CLEARING	0.30	99.15	6.25	68.75
12.	SECTION 14	TOLL PLAZAS	0.27	99.42	6.25	75.00
13.	SECTION 13	LIGHTING, TRAFFIC SIGNALS AND ELECTRICAL WORKS	0.26	99.68	6.25	81.25
14.	SECTION 3	DEMOLITION	0.14	99.82	6.25	87.50
15.	SECTION 7	SUB GRADE	0.11	99.93	6.25	93.75
16.	SECTION 15	DIVERSION AND PROTECTION OF EXISTING UTILITIES	0.07	100.00	6.25	100.00

Pareto Cost Model Diagrams

The Pareto diagram helps to define which work, if changed, will have the greatest impact, so in Table 10 – Cost Analysis of the Construction Work Cost Model is a comparison of the Cumulative Percentage (Weight) of each job with the Cumulative Percentage (Weight) of the Total Cost sequentially from the highest weight ranking to the lowest weight ranking which is then formed using a Pareto Diagram.



Cost Details (Cost Breakdown)

Further analysis is carried out on Cost Breakdown on Table 10 - Cost Analysis of the Construction Work Cost Model above, on Section 10 (Concrete Structure), Section 4 (Road Earthwork), Section 9 (Pavement) and Section 12 (Miscellaneous) works. which has the largest Budget Plan compared to other work and is carried out by Value Engineering

Function Analysis Stage

Work Function Analysis Section 10 (Concrete Structure)

The results of the Functional Analysis carried out on the Work Section 10 (Concrete Structure) resulted in an Index Function Analysis with a Cost/Worth (C/W) ratio equation of 1.08 > 1, so in general, from several reference items, the work has the potential to be used for Value Engineering.) and then analyzed using the Function Analysis System Technique (FAST) method.

Function Phase Study : Section 10 (Concrete Structure) Rekayasa Nilai Konstruksi Pembangunan Jalan Tol Serang – Panimbang Seksi 3, Cileles – Panimbang, Sta. 50+677 – 83+677 Propinsi Banten		Function Worksheet
Why ?	Function	How ?
Mengoptimalkan Pembiayaan Proyek.	1. Melaksanakan Pekerjaan Struktur.	Pembangunan Jalan Tol Serang - Panimbang.
	2. Memancang Tiang Pondasi. 3. Menyangga Beban.	
	4. Memikul Balok.	
	5. Memasang Balok *(Girder)*. 6. Menyalurkan Beban ke Kolom. 7. Meneruskan Beban ke Pondasi. 8. Menyalurkan Reaksi Balok dan Deformasi. 9. Memberikan Ikatan antara Balok 10. Mengakomodasi Gerakan Jembatan. 11. Menambah Kuat Tarik Beton.	
	12. Melindungi Tulangan. 13. Memperkuat Struktur. 14. Menahan Beban Beton selama dicor. 15. Melakukan Pengujian.	
	16. Mengalirkan Air	

Section 4 Work Function Analysis (Road Earthwork)

From Table 18 - Work Function Analysis Section 4 (Road Earthwork) it is found that Cost/Worth < 1, which can be analyzed that Section 4 (Road Earthwork) work does not require Value Engineering due to the Cost of the Work Plan being the same as the Cost of Implementation Results Definite work can not be done Cost Efficiency or cost savings.

Section 9 Work Function Analysis (Pavement)

From Table 20 - Section 9 (Pavement) Work Function Analysis, it is found that Cost/Worth < 1, which can be analyzed that Section 9 (Pavement) work does not require Value Engineering due to the Cost of the Work Plan is the same as the Cost of Execution of the Work which definitely cannot be done Cost Efficiency or cost savings.

Section 12 Job Function Analysis (Miscellaneous)

From Table 21 - Analysis of the Work Function Section 12 (Miscellaneous) it is found that Cost/Worth < 1, which can be analyzed that Section 12 (Miscellaneous) work does not require Value Engineering due to the Cost of the Work Plan which is the same as the Cost of the Results of the Work carried out definitely can not be done Cost Efficiency or cost savings.

Creativity and Innovation Stage

Creativity and Work Innovation Section 10 (Concrete Structure)

At this stage, an alternative design will be presented as a comparison to the existing designs that have been made previously. With the emergence of this alternative design, it is hoped that it will create new design opportunities that can minimize project costs and the alternatives taken in carrying out the creation and innovation stage are:

1) Alternative 0 (Initial/Existing Design).

Pile Slab span length 5 m with data:

a) Structure Type: Deck Slab on Piles
b) Concrete quality: Fc' = 35 MPa.
c) Structure Length: 7, 130 m
d) Expansion Joint: Per 7 spans
   With a typical group structure is 7 x 5 m = 35 m between spans using a monolith connection.
e) Deck Width: 25.2 m
f) Thickness of Deck: 35 Cm (Slab Cast in Situ)
g) Pole Type: Prestressed Concrete Spun Pile
h) Reinforcement steel quality: for reinforcement with ∅> 12 mm (fy = 3, 900 MPa) and for reinforcement with ∅< 12 mm (fy = 2, 400 MPa)
i) Calculation of concrete is guided by:
   - SNI 1725: 2016 concerning Loading for Bridges.
   - SNI 2833: 2016 concerning Bridge Planning for Earthquake Loads.
   - SNI 8460 - 2017 Geotechnical Planning Requirements
   - RSNI T - 12 - 2004 concerning Regulation of Concrete Structures for Bridges.
   - Earthquake Map 2017.
   - AASTHO Bridge Design Specification 2012
   - AASTHO Bridge Seismic Design 2011.

2) Alternative 1.

Changes in the span of the Pile Slab Structure from 5 m to 7.5 m and at the same time changing the Column (Piles) from ∅ 80 Cm to ∅ 60 cm with data:

a) Structure Type: Deck Slab on Piles
b) Concrete quality: Fc' = 35 MPa.
c) Structure Length: 7, 130 m
d) Expansion Joint: Per 7 spans
   With a typical structure group is 7 x 7.5 m = 52.5 m between spans using a monolith connection.
e) Deck Width: 25.2 m
f) Thickness of Deck: 35 Cm (Slab Cast in Situ)
g) Pile Type: Pre-stressed Concrete Spun Pile
h) Existing Pile: ∅ 80 cm.
i) Reinforcement steel quality: for reinforcement with ∅> 12 mm (fy = 3, 900 MPa) and for reinforcement with ∅< 12 mm (fy = 2, 400 MPa)
j) Calculation of concrete is guided by:
   - SNI 1725: 2016 concerning Loading for Bridges.
   - SNI 2833: 2016 concerning Bridge Planning for Earthquake Loads.
   - SNI 8460 - 2017 Geotechnical Planning Requirements
   - RSNI T - 12 - 2004 concerning Regulation of Concrete Structures for Bridges.
   - Earthquake Map 2017.
   - AASTHO Bridge Design Specification 2012
   - AASTHO Bridge Seismic Design 2011.

3) Alternative 2.

Changes in the span of the Pile Slab Structure from a span length of 5 m to 10 m, with the following data:

a) Structure Type: Deck Slab on Piles
b) Concrete quality: Fc' = 35 MPa.
c) Structure Length: 7, 130 mm
d) Expansion Joint: Per 6 spans
   With a typical group structure is 6 x 10 m = 60 m between spans using a monolith connection.
e) Deck Width: 25.2 m
f) Thickness of Deck: 36 Cm (Slab Cast in Situ)
g) Pole Type: Prestressed Concrete Spun Pile
h) Reinforcement steel quality: for reinforcement with ∅> 12 mm (fy = 3, 900 MPa) and for reinforcement with ∅< 12 mm (fy = 2, 400 MPa)
i) Calculation of concrete is guided by:
   - SNI 1725: 2016 concerning Loading for Bridges.
   - SNI 2833: 2016 concerning Bridge Planning for Earthquake Loads.
   - SNI 8460 - 2017 Geotechnical Planning Requirements
   - RSNI T - 12 - 2004 concerning Regulation of Concrete Structures for Bridges.
   - Earthquake Map 2017.
   - AASTHO Bridge Design Specification 2012
   - AASTHO Bridge Seismic Design 2011.

4) Alternative 3.

Changes in the span of the Pile Slab Structure from a span of 5 m to 14 m, with the following data:

a) Structure Type: Deck Slab on Piles
b) Concrete quality: Fc' = 35 MPa.
c) Structure Length: 7, 130 m
d) Expansion Joint: Per 4 spans
e) With a typical structure group is 4 x 15 m = 60 m between spans using a monolith connection.
f) Deck Width: 25.2 m
g) Thickness of Deck: 52 Cm (Slab Cast in Situ)
h) Pole Type: Prestressed Concrete Spun Pile
i) Reinforcement steel quality: for reinforcement with ∅> 12 mm (fy = 3, 900 MPa) and for reinforcement with ∅< 12 mm (fy = 2, 400 MPa)
j) Calculation of concrete is guided by:
   - SNI 1725: 2016 concerning Loading for Bridges.
   - SNI 2833: 2016 concerning Bridge Planning for Earthquake Loads.
   - SNI 8460 - 2017 Geotechnical Planning Requirements
   - RSNI T - 12 - 2004 concerning Regulation of Concrete Structures for Bridges.
   - Earthquake Map 2017.
   - AASTHO Bridge Design Specification 2012
   - AASTHO Bridge Seismic Design 2011.

5) Alternative 4.

Comparing the alternative design changes from Pile Slab with alternative replacements into Girder Beams, the data obtained are:

a) Girder Beams: PC - I Girder Nominal Span of 39.00 m to 41.00 m, H=2.10 m
b) Structure Length: 7, 130 m
c) Deck Width: 25.2 m
d) Deck Plate Thickness: 25 cm
e) Pile: ∅ 80 cm and ∅ 60 cm.
f) Pile Depth: Average 22 to 37 m

g) Reinforcement steel quality: for reinforcement with ∅> 12 mm (fy = 3, 900 MPa) and for reinforcement with ∅< 12 mm (fy = 2, 400 MPa)
h) Calculation of concrete is guided by:
- SNI 1725: 2016 concerning Loading for Bridges.
- SNI 2833: 2016 concerning Bridge Planning for Earthquake Loads.
- SNI 8460 - 2017 Geotechnical Planning Requirements
- RSNI T - 12 - 2004 concerning Regulation of Concrete Structures for Bridges.
- Earthquake Map 2017.
- AASTHO Bridge Design Specification 2012
- AASTHO Bridge Seismic Design 2011.

Advantages and Disadvantages

To facilitate the calculation and analysis of Value Engineering will be presented in the table Advantages and Disadvantages of each Alternative design and will also appear comparison of alternative design criteria

No.	Alternatif Desain	Keuntungan	Kerugian
1.	Alternatif 0 (Eksisting). Bentang Struktur Pile Slab 5 m.	1. Mengurangi Jumlah Kolom Tiang Pancang. 2. Menghemat Waktu Pelaksanaan. 3. Dapat menghemat Biaya dengan adanya pengurangan Tiang Pancang.	1. Menambah Dimensi Pile Slab. 2. Menambah alternatif perhitungan dan tehnologi struktur Pile Slab. 3. Rentan terhadap keruntuhan bangunan.
2.	Alternatif 1. Perubahan bentang Struktur Pile Slab dari 5 m menjadi 7,5 m.	1. Waktu Pelaksanaan Cepat. 2. Metode Pelaksanaan Lebih Gampang dan cepat. 3. Material Mudah didapat. 4. Pekerjaan tidak terpengaruh kondisi Cuaca (Good). 5. Penggunaan SDM lebih sedikit. 6. Tidak memerlukan Teknologi khusus.	1. Biaya Lebih Mahal.
3.	Alternatif 2. Perubahan bentang Struktur Pile Slab dari panjang bentang 5 m menjadi 10 m.	1. Waktu Pelaksanaan Cepat. 2. Metode Pelaksanaan Lebih Gampang dan cepat. 3. Material Mudah didapat. 4. Pekerjaan tidak terpengaruh kondisi Cuaca (Good). 5. Penggunaan SDM lebih sedikit. Tidak memerlukan Teknologi khusus.	1. Harus memperhitungkan kembali kondisi Tanah. 2. Memerlukan peralatan tambahan.
4.	Alternatif 3. Perubahan bentang Struktur Pile Slab dari panjang bentang 5 m menjadi 14 m.	1. Waktu Pelaksanaan Cepat. 2. Metode Pelaksanaan Lebih Gampang dan cepat. 3. Material Mudah didapat. 4. Pekerjaan tidak terpengaruh kondisi Cuaca (Good). 5. Penggunaan SDM lebih sedikit. 6. Tidak memerlukan Teknologi khusus.	1. Harus memperhitungkan kembali kondisi Tanah. 2. Memerlukan peralatan tambahan.
5.	Alternatif 4. Perubahan desain dari Pile Slab dengan menjadi Balok Girder.	1. Waktu Pelaksanaan Cepat. 2. Metode Pelaksanaan Lebih Gampang dan cepat. 3. Material Mudah didapat. 4. Pekerjaan tidak terpengaruh kondisi Cuaca (Good). 5. Penggunaan SDM lebih sedikit. Tidak memerlukan Teknologi khusus.	1. Biaya sangat mahal. 2. Harus memperhitungkan kembali kondisi Tanah 3. Memerlukan peralatan tambahan.

ANALYSIS STAGE

At this stage, further analysis is carried out after selecting an alternative in the value engineering process on the cost element to be reduced. This stage is carried out with Life Cicle Cost (LCC) analysis which is based on the analysis of the prediction of the value of money against time (Value Time of Money) which is based on the estimated rate of interest (Rate of Interest) and the duration of the plan life, with the aim of knowing the long - term benefits of several alternative innovations that have been determined both from the aspects of initial cost prediction (Initial Cost), repair costs (Replacement/Repair Cost), maintenance and operational costs (Maintanance and Operational) and prediction of residual costs (Salvage Cost), then performed a cumulative analysis of costs - costs and benefits that may be obtained over the life of the alternative to be selected.

The alternatives are then aggregated as a whole and then considered if they have the lowest potential cost. However, this is not only seen from the cost aspect, but must be studied comprehensively from several other important aspects.

Life Cycle Cost Analysis (LCCA)

Based on the analysis that has been carried out, the determination of the strategy for changing the length of the Pile Slab span from 5 m to 7.5 m greatly affects the Life Cycle Cost (LCC) in the construction of the Serang – Panimbang Toll Road, Section 3 (Cileles – Panimbang) Sta.50+677 – Sta.83+677 and in this study, the more economical Life Cycle Cost (LCC) is in Alternative 1 (First) for the following reasons:

1) Alternative 1 LCC is more economical than Alternative 0 (Existing) LCC, with:
   Changed the length of the Pile Slab span from 5 m to 7.5 m at the same location from Sta.69+625 – Sta.83+695 or 6, 878.60 m long.
   a) Changing the pile diameter from∅80 Cm to∅60 cm without reducing the quality of work.
   b) Changes also occur in the thickness of the floor slab from 35 cm (slab span 5 m) to 36 cm (slab span 7.5 m).
   c) Operational and Maintenance Costs on the two alternatives (alternative 0 and alternative 1) have no effect, because the type of construction is the same (Pile Slab) so that the management pattern and annual financing scheme for Operational and Maintenance costs are the same.
   d) Cost savings between LCC Alternative 1 and Alternative 0, have a difference of Rp.175, 090, 815, 421, - or 1.43%.

2) Alternative 1 LCC is more economical than Alternative 2 LCC, with:
   a) Changed the length of the Pile Slab span from 7.5 m to 10 m at the same location (Station) from Sta.69+625 – Sta.83+695 or 6, 878.60 m long.
   b) Changes occur in the thickness of the Pile Slab deck dimension from 35 Cm to 36 Cm so that it makes a big difference in Concrete Volume.
   c) Operational and Maintenance Costs on the two alternatives (alternative 0 and alternative 1) have no effect, because the type of construction is the same (Pile Slab) so that the management pattern and annual financing scheme for Operational and Maintenance costs are the same.
   d) There is an increase in LCC costs between Alternative 1 and Alternative 2, having a difference of Rp.281, 495, 309, 095, - or 2, 33% of alternative 1.

3) Alternative 1 LCC is more economical than Alternative 3 LCC, with:
   a) Changed the length of the Pile Slab span from 7.5 m to 15 m at the same location (Station) from Sta.69+625 – Sta.83+695 or 6, 878.60 m long.
   b) Changes occur in the thickness of the pile dimensions of the pile slab from 36 cm to 52 cm so that it makes a big difference in concrete volume.
   c) Operational and Maintenance Costs on the two alternatives (alternative 0 and alternative 1) have no effect, because the type of construction is the same (Pile Slab) so that the management pattern and annual financing scheme for Operational and Maintenance costs are the same.
   d) There is an increase in LCC costs between Alternative 1 and Alternative 3, having a difference of Rp.272, 154, 358, 065, - or 2.26% of alternative 1.

4) Alternative 1 LCC is more economical than Alternative 4 LCC, with:
   a) Changed the Pile Slab span to Beam Girder along the Pile Slab plan (at the same location), Sta.69+625 – Sta.83+695 or 6, 878.60 m long.
   b) Changes in the Pile Slab structure to a Girder Structure (continuous bridge) results in differences in work items and work volumes.
   c) Operational and maintenance costs for the two alternatives (alternative 0 and alternative 4) are different, because in routine and periodic maintenance of the bridge the length of the bridge will increase by 6, 878.60 m.
   d) The addition of the length of the bridge was due to a change in the Pile Slab length of 6, 878.60 m, bringing the total length of the Serang - Panimbang Toll Bridge to 8, 293.20 m.
   e) There is an increase in LCC costs between Alternative 1 and Alternative 4, having a difference of Rp.13, 532, 732, 411, 814, - or 112, 19% from alternative 1.

Function Analysis Matrix

There are 8 Design Criteria, each of which has a working weight, namely Project Cost (LCC) (27.42 %), Project Cost (LCC) per – m2 (00.00 %), Work Accident Risk Level (8.06 %), Implementation Method (24.19 %), Material Ease (11.29 %), Labor Use (4.84 %), Implementation Time (17.74 %) and Weather Conditions (6.45%).

a) Giving value to the weights based on the importance of the criteria through analysis using the Paired Comparison method.
b) From each of the Design Criteria, the Design Criteria Index is multiplied by the weight of the Work Alternatives.
c) The total result is the sum of (Index x Weight), and with the largest result, which is 37.12% who are in alternative work 2, so this result will be used as a substitute for the existing design by considering the Project Cost (LCC), Project Cost (LCC) per – m2, Work Accident Risk Level, Implementation Method, Material Ease, Labor Use, Implementation Time and Weather Conditions.

Development Stage

This phase is an advanced analysis phase and develops this short list of ideas and developments by considering value alternatives. General activities for this phase are as follows:

1) Calculating the planned acceptance fee for the planned toll tariff per km for the concession period of 40 years since 2016.
2) The operational plan of the Serang – Panimbang Toll Road after the completion of construction which is predicted to be at the end of 2023 and operational implementation at the beginning of 2024.
3) Conducting a cost - benefit analysis again for the delay in the operational plan which was originally planned to be opened (operational) in 2019.
4) Ending the development of the initial Alternative with Recommendations, Conclusions and Suggestions.

NPV = PV Benefit – PV Cost
NPV = Rp.10, 071, 912, 7283 - Rp.10, 070, 346.0657
NPV = Rp.1, 566.6627 Million
NPV = Rp.1, 566, 662, 658.62, NVP>0, then Eligible

4. Recommendation Stage

Based on the results of research in conducting Value Engineering on the Serang – Panimbang Toll Road Development Project, Section 3 (Cileles – Panimbang) Sta.50+677 – Sta.83+677, then we can recommend the following:

1) The determination of the strategy for changing the length of the Pile Slab span from 5 m to 7.5 m greatly affects the Life Cycle Cost (LCC) in the construction of the Serang – Panimbang Toll Road, Section 3 (Cileles – Panimbang) Sta.50+677 – Sta.83+677 and in this study, the more economical Life Cycle Cost (LCC) is in Alternative 1 (First) for the following reasons:

a) Alternative 1 LCC is more economical than Alternative 0 (Existing) LCC, with:

- Changed the length of the Pile Slab span from 5 m to 7.5 m at the same location from Sta.69+625 – Sta.83+695 or 6, 878.60 m long.
- Changing the pile diameter from 80 Cm to 60 cm without reducing the quality of work.
- Changes also occur in the thickness of the floor slab from 35 cm (slab span 5 m) to 36 cm (slab span 7.5 m).
- Operational and Maintenance Costs on the two alternatives (alternative 0 and alternative 1) have no effect, because the type of construction is the same (Pile Slab) so that the management pattern and annual financing scheme for Operational and Maintenance costs are the same.
- The cost of saving LCC from alternative 0 and alternative 1 has a difference of Rp.175, 090, 815, 421, - or 1.43%.

b) Alternative 1 LCC is more economical than Alternative 2 LCC, with:

- Changed the length of the Pile Slab span from 7.5 m to 10 m at the same location (Station) from Sta.69+625 – Sta.83+695 or 6, 878.60 m long.
- Changes occur in the thickness of the Pile Slab deck dimension from 35 Cm to 36 Cm so that it makes a big difference in Concrete Volume.
- Operational and Maintenance Costs on the two alternatives (alternative 0 and alternative 1) have no effect, because the type of construction is the same (Pile Slab) so that the management pattern and annual financing scheme for Operational and Maintenance costs are the same.
- There is an increase in LCC costs from alternative 1 and alternative 2 which has a higher difference of Rp.281, 495, 309, 095, - or 2, 33% of alternative 1.

c) Alternative 1 LCC is more economical than Alternative 3 LCC, with:

- Changed the length of the Pile Slab span from 7.5 m to 15 m at the same location (Station) from Sta.69+625 – Sta.83+695 or 6, 878.60 m long.
- Changes occur in the thickness of the pile dimensions of the pile slab from 36 cm to 52 cm so that it makes a big difference in concrete volume.
- Operational and Maintenance Costs on the two alternatives (alternative 0 and alternative 1) have no effect, because the type of construction is the same (Pile Slab) so that the management pattern and annual financing scheme for Operational and Maintenance costs are the same.
- There is an increase in LCC costs from alternative 1 and alternative 3 which has a higher difference of Rp.272, 154, 358, 065, - or 2.26% of alternative 1.

d) Alternative 1 LCC is more economical than Alternative 4 LCC, with:

- Changed the Pile Slab span to Beam Girder along the Pile Slab plan (at the same location), Sta.69+625 – Sta.83+695 or 6, 878.60 m long.
- Changes in the Pile Slab structure to a Girder Structure (continuous bridge) results in differences in work items and work volumes.
- Operational and maintenance costs for the two alternatives (alternative 0 and alternative 4) are different, because in routine and periodic maintenance of the bridge the length of the bridge will increase by 6, 878.60 m.
- The addition of the length of the bridge was due to a change in the Pile Slab length of 6, 878.60 m, bringing the total length of the Serang - Panimbang Toll Bridge to 8, 293.20 m.
- There is an increase in LCC costs between alternative 1 and alternative 4 which has a higher difference of Rp.13, 532, 732, 411, 814, - or 112, 19% from alternative 1.

2) Recalculated the financing for the Serang – Panimbang Toll Road Development Project due to a change in the final implementation plan from the original expected to be operational in 2019, but due to the condition of the contract implementation process and the loan agreement from the Export Import of China Bank which was delayed, so it is predicted that the operation of the Serang – Panimbang Toll Road in 2024.

5. Results and Discussion

5.1 Conclusion

The conclusions obtained are based on the results of the analysis that has been carried out on the Value Engineering Construction of the Serang – Panimbang Toll Road, Section 3 (Cileles – Panimbang), Sta.50+667 – Sta.83+677 is as follows:

1) The determination of the strategy for changing the length of the Pile Slab span from 5 m to 7.5 m (Alternative 1) greatly affects the Life Cycle Cost (LCC) in the construction of the Serang – Panimbang Toll Road, Section 3 (Cileles – Panimbang) Sta.50+677 – Sta.83+677.
2) Construction costs or Initial Cost (Present Value) that must be incurred based on Alternative 1 is Rp.6, 309, 586, 773, 000, - (Six Trillion Three Hundred Nine Billion Five Hundred Eighty Six Million Seven Hundred Seventy Three Thousand Rupiah, -).
3) Life Cycle Cost (LCC) Alternative 1 (Change in the length of the Pile Slab span from 5 m to 7.5 m) has a value of Rp.12, 061, 857, 725, 754 (Twelve Trillion Sixty One Billion Eight Hundred Fifty Seven Million Seven Hundred Twenty Five Thousand Seven Hundred

Fifty Four Rupiah, -) in 2023 (end of Construction) and is more economical than other Alternatives, so Alternative 1 is recommended to proposed design changes.

4) The best decision - making in the Value Engineering Construction of the Serang – Panimbang Toll Road, Section 3 (Cileles – Panimbang) Sta.50+677 – Sta.83+677 also compares several Design Criteria by assigning a value (weight) based on the importance of the criteria through the Analysis of the Paired Comparison Method.
5) There are 8 Design Criteria, each of which has a Working Weight, namely Project Cost (LCC) (27.42 %), Project Cost (LCC) per – m2 (00.00 %), Work Accident Risk Level (8.06 %), Implementation Method (24.19 %), Material Ease (11.29 %), Labor Use (4.84% %), Implementation Time (17.74 %) and Weather Conditions (6.45%).
6) From the results of the Function Analysis Matrix (Table 60) that Alternative 1 (Change in the length of the Pile Slab span from 5 m to 7.5 m) has the largest weight compared to other alternatives with a total weight of 37.12% with each working weight:
   a) Project Cost (LCC) with Weight x Work Index of 11.75 %;
   b) Project Cost (LCC) per – m2 with Weight x Work Index of 0.00 %;
   c) Work Accident Risk Level with Weight x Work Index is 2.55%;
   d) Implementation Method with Weight x Work Index of 8.47 %;
   e) Material Ease with Weight x Work Index of 2.66%;
   f) Employment of Labor with Weight x Work Index of 2.80%;
   g) Implementation Time with Weight x Work Index of 7.60 %; and
   h) Weather Conditions with Weight x Work Index of 1.29%.
7) That there is a change in the investment return plan as a result of the change in the final construction implementation from 2019 to 2023, so that it has an impact on the operational plan (time) of the Serang – Panimbang Toll Road from 2020 to 2024, while the concession period remains for 40 years (2016). – 2056).
8) Return on Investment starts in 2024 with the calculation of the initial (basic) vehicle fare still referring to the original calculation in accordance with Table 61 - Growth of LHR and Increase in Tariffs per Vehicle Class by taking into account the increase in the growth rate of Daily Traffic (LHR) Vehicles of (8% - 9 %) per year and an increase in rates for the Serang – Panimbang toll road by 6.3% per year.
9) The recalculation of the financing of the Serang – Panimbang Toll Road Development Project due to delays in contract execution and delays in the loan agreement between the Ministry of Finance of the Republic of Indonesia and the Export Import of China Bank can still be said to be eligible with the following data:

6. Suggestion

Based on the results of the study and conclusions, several suggestions can be made, including the following:

1) Advise the Owner to be able to perform Value Engineering on the Serang – Panimbang Toll Road Development Project, Section 3 (Cileles – Panimbang), Sta.53+677 – Sta.83+677 by changing the design of the Pile Slab span length from 5 m to 7.5 m and changing the Pile Spun diameter from 80 Cm in diameter to 60 Cm in diameter.
2) Making changes to the budget structure due to delays in the implementation of work which originally started in 2019, but in fact that construction work has not started until 2021 (November 2020 Contract Sign) so that it can change the funding scheme.
3) Re - calculation of NPV, Cost/Benefit Ratio, IRR and Pay Back Period and Break Event Point (BEP) due to changes in design and budgeting schemes.

References

[1] Minister of Public Works and Public Housing, 2016, Regulation of the Minister of Public Works and Public Housing Number: 28/PRT/M/2016 concerning Analysis of Unit Prices for Public Works;

[2] Minister of Public Works and Public Housing, 2020, Regulation of the Minister of Public Works and Public Housing Number: 16 of 2020 concerning Organization and Work Procedures of Technical Implementing Units at the Ministry of Public Works and Public Housing;

[3] Planning Consultant, Review of Preliminary Design Feasibility Studies and Land Planning Documents for Serang – Panimbang Toll Road, Ministry of Public Works and Public Housing, Directorate General of Highways, Work Unit of Directorate of Road Network Development, Integrated Planning and Network System Activities.

[4] Consultant Engineering, 2020, Detail Engineering Design Serang – Panimbang Tollroad Project (Sta.50+677 – Sta.83+677), Ministry of Public Work and Housing, Directorate General of Highways, Directorate Freeway and Urban Roads.

[5] PT. Wijaya Karya Serang – Panimbang, December 2016, Business Plan for Concession of Serang – Panimbang Toll Road, Ministry of Public Works and Public Housing, Directorate General of Highways.

[6] Director General of Highways, 2017, Road Pavement Manual (Revised June 2017) Number: 04/SE/Db/2017, Directorate General of Highways, Ministry of Public Works and Public Housing;

[7] Federal Highway Administration, 1998, Life Cycle Cost Analysis in Pavement Design (In Search of Better Investment Decisions), Federal Highway Administration: Pavement Division Interim Technical Bulletin, Publication No. FHWA - SA - 98 - 079;

[8] Rayendra, May 2019, Alternative Analysis of Life Cycle Cost Selection during the Maintenance Period of the Janti – Prambanan Km.7+759 – 8+750, Lecturer of Civil Engineering Study Program, Faculty of Civil Engineering and Planning, Islamic University of Indonesia, Email: rayendra[at]uii. ac. id;

[9] Agung Yana, AA Gde, Marthajaya, Nyoman Erick Triswandana and I Wayan Gede, September 2018, Application of Functional Analysis using the Function Analysis System Technique (FAST) Diagram (Case Study of Sanur Independent School), Civil Engineering Study Program, Udayana University, Bukit Jimbaran Campus Bali;
[10] 23 April 2016, Pareto Chart; Definition, Principles, Implementation, Preparation Steps, Source: ihquality. com;
[11] Shahin, M, 1994, Pavement Management for Airport, Roads, and Parking Lots, New York: Springer Science and Business Media, LLC;
[12] Sukirman, S, 1999, Highway Flexible Pavement, Nova, Bandung;
[13] Giyatno.2016. Analysis of Road Damage Using the PCI Method Economic Study and Management Strategy (Case Study of the Ponorogo – Pacitan Road Section KM.231+000 to Km.246+000, KM 0+000 in Surabaya), Thesis, (Unpublished), University Muhammadiyah Surakarta;