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Construction Analysis for Flowing Babon River Water During Construction of Semarang – Demak 1C Toll Road Development Project

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ABSTRACT
Frequent flooding caused by the Babon River overflow during the rainy season presents a significant challenge for the construction of the Semarang–Demak Toll Road Section 1C. High tidal water and unstable subgrade conditions threaten project timelines and worker safety. This study aims to determine the most efficient temporary water flow management structure at the Babon River estuary during construction. A scientific approach was adopted through field observation, hydraulic and geotechnical data collection, and hydrological-hydraulic modeling using Q2 and Q5 flood scenarios. Four culvert alternatives were analyzed in terms of hydraulic performance and cost efficiency. Among them, the Armco Type Multi Plate Pipe (MPP) Arch culvert—with a 4,580 mm span, 3,050 mm rise, and 7 mm thickness—was found to be the most optimal due to its low cost, ease of installation, and rapid construction timeline. The implementation of this system is projected to minimize flood risks, ensure safer construction conditions, and reduce operational delays. The findings contribute valuable insights into temporary drainage solutions for flood-prone construction zones and can be adapted for similar infrastructure projects in urban lowland areas.

Keywords: Babon River Estuary, Semarang – Demak Toll Road, Hydraulics, Construction Stability, Armco Culvert.

INTRODUCTION

The government supports infrastructure development through programs that support growth in all fields. The Department of Public Works and Public Housing is the center of infrastructure development. One of the fields includes water resources (SDA). The duties of SDA according to the law include controlling the destructive power of water due to river normalization, utilization of SDA in irrigation and watering, raw water and groundwater, and conservation of SDA (Amanatillah & Anggraini, 2020; Latif, Irwan, et al., 2019; Latif, Rusdi, et al., 2019; Posumah, 2015; Riskayanti, 2022).

Controlling the destructive power of water in the Watershed System and Urban Drainage System is part of Water Resources (SDA). Water flows through tertiary channels to accommodate rainwater flowing over the land surface, which is channeled to a larger system (secondary and primary), which then flows into rivers. It is also called a water building system (Alfarobi & Tujni, 2023; Deng et al., 2022; Masthura et al., 2023; Xie et al., 2017). The goal is to reduce the amount of excess water in the soil so that the land can be fully used after drying. Sanitation can also be an additional goal to control soil quality. During the rainy season, the area where the Semarang-Demak Toll Road Package 1C is located in Trimulyo Village, Genuk

District, Semarang City, experiences a rise in river water levels. This causes flooding, especially overflowing water from the Babon River, which passes through and empties into the Semarang-Demak Toll Road Package 1C work location. This can impact several things, such as flood-prone locations that make workers unsafe and pump houses that are worried about being flooded by the overflowing Babon River. Therefore, it is necessary to conduct research on overflowing water from the Babon River, especially during the upcoming rainy season. About the construction project of retention ponds integrated with sea walls on the Semarang Demak Toll Road, river integration activities, especially on the Babon River in Semarang, as the outlet channel for the Terboyo retention pond.

Culverts support the construction of temporary connecting bridges, which are used as temporary access roads to facilitate traffic, and permanent buildings related to handling the flow at the Babon River estuary. Planning and implementation of activities at the river estuary are followed by construction implementation technology that focuses on hydrological, hydraulic, and geotechnical development engineering. The development of this technology usually occurs in river channel areas where relevance is required between the maximum discharge during the calculated Q2 and Q5 work implementation periods.

Calculate the highest elevation that will be recorded in the water reservoir on the river morphology, which will affect the initial structure to be built. The retention pond is one of the urban drainage systems that can be specialized again. The retention pond is a substitute for infiltration land changed for housing purposes. Office and industrial areas that do not have much infiltration. The retention pond also functions as water distribution, flood control, and waste management, based on the volume of water collected (Wahyudi & Adi, 2016). In this case, the polder drainage system is a collection of lowlands that form an artificial hydrological unit surrounded by embankments (Alam et al., 2017; Cahyono et al., 2022; Santos et al., 2023).

Drainage can be a curved water channel on the surface or underground, made by humans or naturally, and designed as a system to meet needs. In field situations, ditches above the surface or culverts below the surface can prevent flooding and maintain water supply and irrigation. A channel is needed in certain systems to drain rainwater that falls on the land. Those above the ground surface are channeled into larger channels, while smaller channels, such as household channels, are integrated with other infrastructure systems. and are made for use in liquid waste treatment systems.

The subgrade and geological classification behavior are important for building structures, including river reinforcement structures. Especially in the estuary area, clay (silt) is mixed with sand and shell fragments at a depth of up to 12 meters. Hard soil can be found at a depth of 100 meters. After conducting excavations at the temporary building placement location, structural analysis with previous geotechnical conditions was completed. Geographical Position Semarang City consists of Upper City (above) and Lower City (below). The lower city often experiences flood disasters according to the natural law of water flow. This condition worsens when the lower city's land surface drops, making Rob fly towards the sea. Normalization of the Babon River, located east of Semarang City, is one of the activity steps in the lower area. The subject of this study is one of the objects of the Semarang-Demak toll road construction project, integrated with the sea wall and toll road, with a retention pond structure, and related to simulation and evaluation to assess temporary building structures to support work influenced by underlying soil and hydrology behavior. Construction evaluation in its function is the core of this study. This research can provide

recommendations for typical implementation in other places that are better and more efficient than the one in Kali Babon Semarang.

During the Semarang–Demak 1C Toll Road construction, particularly in the Trimulyo area near the Babon River estuary, high rainfall and river overflow frequently cause flooding. This threatens construction infrastructure and project continuity, compromises worker safety, and delays progress. A critical issue arises in managing the Babon River's flow effectively during construction, requiring technical solutions that balance cost efficiency, flood mitigation, and hydraulic performance under temporary conditions.

Infrastructure projects, especially toll roads integrated with sea walls and retention ponds, play a vital role in urban flood control and transportation development. The Babon River is a key drainage route in Semarang's lowland area, prone to tidal flooding and heavy runoff during the rainy season. Without an effective interim drainage structure during construction, there is a heightened risk of flooding that may damage temporary facilities, delay the project, and endanger personnel.

Furthermore, improper handling of river flow during the construction phase can result in long-term hydrological imbalances and additional post-construction repair costs. Therefore, it is urgent to ensure effective flood discharge management through accurate hydrologic-hydraulic analysis and construction design. Evaluating cost-efficient, technically feasible alternatives makes this study essential for informing better practices in similar large-scale infrastructure developments in flood-prone zones.

Wahyudi & Adi (2016) emphasized the importance of retention ponds and polder systems in managing urban drainage, particularly in flood-prone zones like Semarang. Their work outlined how these systems substitute for lost infiltration zones and help regulate stormwater discharge. Similarly, Kodoatie (2003) defined integrated water management structures, such as culverts and drainage channels, as critical for flood prevention during urban development projects.

Zakaria (2009) and Terzaghi & Peck (1948) Investigating soil stability and foundation behavior in saturated zones underscores the significance of understanding subgrade characteristics when implementing temporary water diversion systems. These studies emphasize the necessity of geotechnical considerations in construction near estuarine areas like the Babon River. Meanwhile, Hubert Chanson (1998) discussed simplified hydraulic modeling methods for overflow control, highlighting the application of cost-effective culvert designs in temporary projects.

However, most prior studies have focused on long-term infrastructure or permanent drainage solutions. They seldom explore temporary hydraulic structures applied under dynamic construction conditions or compare different culvert design alternatives based on technical and economic feasibility. This creates a gap in guidance for temporary river diversion strategies in active toll road projects.

Although previous research has addressed flood control, urban drainage, and soil stability, few studies have investigated temporary water diversion structures during infrastructure construction, particularly those comparing hydraulic efficiency with construction costs. There is also limited research on the use of Armco Multi Plate Pipe (MPP) Arch culverts in temporary flood discharge settings during toll road development in Indonesia. This study addresses that gap by analyzing hydraulic modeling and cost evaluations of multiple alternatives for managing Babon River flow during construction.

The novelty of this research lies in its comparative evaluation of multiple culvert alternatives using hydrologic-hydraulic modeling combined with cost analysis for temporary

flood control. By incorporating both geotechnical and tidal data in the design of temporary drainage structures, the study proposes a cost-efficient, rapid-deployment solution—specifically the Armco MPP Arch culvert—for managing river discharge in a construction setting, which has not been widely applied in similar contexts in Indonesia.

The objective of this study is to identify and recommend the most efficient and cost-effective water drainage structure to control the flow of the Babon River during the construction of the Semarang–Demak 1C Toll Road, using hydraulic modeling, geotechnical assessment, and cost analysis of culvert alternatives.

This study provides practical guidelines for contractors, engineers, and policymakers involved in flood-prone infrastructure projects. It delivers data-driven recommendations for temporary water flow management using efficient and implementable culvert systems. The findings serve as a reference for planning similar flood mitigation strategies during toll road construction and contribute to more resilient and economically feasible construction practices in vulnerable urban areas.

METHOD

The study begins with a descriptive approach, collecting data through documentation, field observations, and geospatial surveys. These methods are essential to capture the physical characteristics of the Babon River, including river morphology, water levels, sedimentation, and surrounding infrastructure conditions. Primary data, such as flood elevations and structural measurements, were gathered directly from the field, while secondary data were sourced from authoritative bodies like the River Basin Center. These data include topography, rainfall records, flood discharge estimations, geological profiles, and prior technical reports related to soil stability and hydrology.

To support analysis, the study applies a hydrological and hydraulic modeling framework, using quantitative methods to simulate flood discharge scenarios (Q2 and Q5 return periods) and evaluate alternative drainage solutions. This includes analyzing riverbed elevations, tidal interactions, and flow velocities to determine the most suitable culvert design. Both permanent and temporary water flow management strategies were compared using modeled output to assess their hydraulic efficiency, construction feasibility, and cost implications. Data were processed through multiple stages: editing, coding, and tabulation, ensuring consistency and alignment with engineering standards.

The analytical method used combines engineering design principles with economic feasibility analysis. A comparative cost analysis was performed on each culvert alternative, using standard unit prices, labor coefficients, and regulatory benchmarks, such as the Minister of PUPR Regulation No. 1 of 2022. Through this integrated methodology, the study identifies the optimal construction solution (Armco MPP Arch culvert) based on hydraulic performance and cost efficiency. This comprehensive approach enables evidence-based recommendations for similar flood-prone infrastructure projects, especially during temporary construction.

RESULTS AND DISCUSSION

Figure 1. Research Location

Hydraulic Modeling Results

A. Ebb and Flow of Water Elevation

The tidal design water level is the water level that will be used for planning. In short, input is required to model the Babon River as a planned flood discharge in the form of a time step and tidal data that occurs downstream of the Babon River. To determine the planned flood discharge data that will be used:

Table 1. Peak Discharge of Babon River

Repeat Period	Peak Discharge m3/sec
Q2	262,75
Q5	314,38
Q10	320,00
Q25	368,33
Q50	409,02
Q100	453,94
Q1000	640,11

(Source: Researcher Processing, 2024)

It can be seen that in the Babon River, the peak flood discharge plan in various return periods of the analysis results has a higher value up to Q50; several factors are the analysis of the differences, namely unrefreshed rainfall data, differences in watershed delineation, differences in distribution methods, and others. The flood discharge analysis used for the model is a return period of 2 years (Q2) and 5 years (Q5). The planned flood discharge used in the Babon River flood modeling uses the results of the consultant's analysis as follows.

Table 2. Peak Discharge Return Period of Babon River

DEBIT BABON TOTAL KONDISI EKTREAM (M3/s)						
Q2	Q5	Q10	Q25	Q50	Q100	Q1000
-	-	-	-	-	-	-
6.24	7.21	8.14	9.65	11.05	12.70	22.55
29.31	34.23	38.44	44.84	50.50	57.00	89.74
123.07	143.55	161.32	188.42	212.54	240.32	387.34
260.62	307.36	343.53	395.00	438.10	485.52	680.79
262.75	314.38	348.94	393.05	426.00	458.78	550.65
210.95	253.70	281.00	314.40	338.15	360.66	417.01
177.55	214.12	236.98	264.39	283.44	301.34	347.34
156.04	188.19	208.39	232.77	250.28	267.30	316.89
144.99	174.44	193.48	217.08	234.28	251.11	306.30
136.63	164.03	182.17	205.15	222.26	239.35	298.10
128.62	154.26	171.38	193.47	210.17	227.06	286.37
117.15	140.47	156.04	176.39	191.90	207.69	263.18
102.06	123.10	135.88	153.85	167.66	181.86	233.01
87.04	104.37	115.87	131.25	143.11	155.33	199.67
71.95	86.16	95.78	108.52	118.35	128.49	165.37
59.47	71.17	79.16	89.69	97.83	106.23	136.83
49.27	58.92	65.58	74.31	81.05	88.01	113.36
40.71	48.68	54.19	61.40	66.97	72.72	93.67
33.60	40.18	44.72	50.67	55.27	60.02	77.30
27.70	33.13	36.88	41.79	45.58	49.49	63.75
22.66	27.10	30.16	34.17	37.28	40.48	52.14
18.36	21.96	24.44	27.69	30.20	32.80	42.24
15.04	17.99	20.02	22.68	24.74	26.87	34.60
12.39	14.82	16.49	18.68	20.38	22.13	28.50
10.30	12.31	13.70	15.53	16.94	18.39	23.69
8.68	10.38	11.55	13.09	14.28	15.50	19.97

Source: Researcher Processing, 2024

In addition to the flood discharge from the river, ebb and flow occur downstream of the Babon River, affecting the water level in the channel cross-section, especially in the downstream area of the river. The following is the tidal data that will be used in the model.

Table 3. Tidal Data

Pengamatan (m)

REKAP PENGAMATAN PASANG SURUT

LOKASI : TANJUNG MAS

T/J	00:00	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
30/07/2023	2.35	2.31	2.25	2.19	2.14	2.13	2.10	2.12	2.16	2.16	2.13	2.12	2.03	1.92	1.84	1.75	1.68	1.68	1.80	1.89	2.02	2.17	2.28	2.37
31/07/2023	2.41	2.37	2.30	2.25	2.18	2.14	2.11	2.09	2.10	2.11	2.08	2.03	1.98	1.93	1.86	1.75	1.67	1.67	1.81	1.90	2.03	2.19	2.32	2.44
01/08/2023	1.59	1.57	1.54	1.52	1.50	1.49	1.49	1.50	1.53	1.55	1.54	1.54	1.51	1.46	1.43	1.38	1.34	1.35	1.45	1.53	1.63	1.75	1.84	1.92
02/08/2023	2.51	2.57	2.57	2.51	2.42	2.37	2.27	2.22	2.13	2.11	2.06	2.01	1.91	1.86	1.83	1.80	1.76	1.67	1.69	1.72	1.84	2.00	2.13	2.24
03/08/2023	2.33	2.46	2.53	2.51	2.46	2.42	2.34	2.24	2.17	2.07	1.99	1.98	1.97	1.94	1.88	1.87	1.86	1.84	1.80	1.82	1.93	2.05	2.18	2.23
04/08/2023	2.32	2.47	2.55	2.55	2.49	2.40	2.35	2.28	2.16	2.05	1.96	1.89	1.85	1.85	1.77	1.73	1.72	1.78	1.75	1.76	1.79	1.92	2.09	2.21
05/08/2023	2.33	2.40	2.48	2.55	2.56	2.53	2.44	2.39	2.28	2.14	2.02	1.92	1.86	1.83	1.81	1.76	1.73	1.78	1.84	1.86	1.87	1.94	2.04	2.21
06/08/2023	2.32	2.36	2.43	2.49	2.55	2.53	2.47	2.42	2.35	2.26	2.12	1.98	1.85	1.82	1.81	1.77	1.78	1.75	1.85	1.89	1.94	2.02	2.08	2.18
07/08/2023	2.30	2.31	2.40	2.39	2.42	2.43	2.43	2.42	2.37	2.27	2.17	2.01	1.93	1.83	1.75	1.78	1.80	1.86	1.91	1.95	2.05	2.09	2.10	2.21
08/08/2023	2.27	2.29	2.30	2.31	2.38	2.36	2.34	2.36	2.33	2.27	2.19	2.06	1.97	1.85	1.80	1.75	1.76	1.81	1.89	1.98	2.10	2.19	2.20	2.26
09/08/2023	2.30	2.31	2.27	2.19	2.24	2.24	2.24	2.22	2.25	2.23	2.18	2.09	2.00	1.90	1.81	1.75	1.76	1.80	1.86	1.97	2.10	2.20	2.24	2.26
10/08/2023	2.29	2.24	2.19	2.13	2.08	2.07	2.12	2.11	2.17	2.13	2.10	2.03	1.95	1.89	1.80	1.78	1.80	1.83	1.91	2.03	2.17	2.28	2.31	2.32
11/08/2023	2.31	2.30	2.17	2.12	2.01	1.96	1.97	1.99	2.01	2.01	2.00	1.96	1.88	1.83	1.71	1.73	1.73	1.73	1.84	1.93	2.12	2.23	2.33	2.37
12/08/2023	2.34	2.32	2.21	2.14	2.02	1.98	1.95	1.97	1.97	1.97	1.99	1.98	1.95	1.89	1.81	1.77	1.77	1.83	1.90	2.01	2.13	2.24	2.37	2.43
13/08/2023	2.43	2.39	2.29	2.19	2.12	2.02	1.95	1.92	1.94	1.99	1.96	1.89	1.86	1.87	1.81	1.77	1.74	1.82	1.88	1.98	2.12	2.23	2.36	2.42

Least Square (dm)

T/J	00:00	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
30/07/2023	23.50	23.07	22.47	21.90	21.40	21.30	21.00	21.23	21.60	21.57	21.27	21.17	20.33	19.17	18.40	17.47	16.77	16.77	18.00	18.87	20.23	21.70	22.77	23.67
31/07/2023	24.10	23.70	23.03	22.47	21.80	21.37	21.13	20.90	21.03	21.07	20.77	20.33	19.83	19.30	18.60	17.53	16.70	16.67	18.10	19.00	20.30	21.93	23.23	24.40
01/08/2023	15.87	15.73	15.44	15.21	14.96	14.92	14.88	15.02	15.32	15.46	15.40	15.36	15.06	14.63	14.28	13.75	13.38	13.51	14.53	15.26	16.29	17.46	18.39	19.22
02/08/2023	25.13	25.73	25.73	25.10	24.23	23.70	22.73	22.23	21.27	21.10	20.57	20.13	19.10	18.60	18.33	18.00	17.63	16.70	16.90	17.23	18.37	19.97	21.30	22.37
03/08/2023	23.30	24.57	25.30	25.13	24.63	24.23	23.43	22.40	21.67	20.73	19.93	19.80	19.70	19.37	18.83	18.67	18.60	18.40	18.00	18.17	19.33	20.50	21.80	22.27
04/08/2023	23.20	24.67	25.50	25.50	24.90	24.03	23.53	22.77	21.60	20.53	19.57	18.93	18.47	18.53	17.67	17.27	17.23	17.80	17.47	17.60	17.90	19.23	20.93	22.13
05/08/2023	23.30	23.97	24.83	25.47	25.60	25.27	24.40	23.87	22.77	21.43	20.23	19.23	18.63	18.33	18.10	17.57	17.30	17.77	18.40	18.60	18.67	19.43	20.43	22.10
06/08/2023	23.20	23.63	24.27	24.90	25.50	25.30	24.73	24.17	23.50	22.57	21.17	19.80	18.50	18.17	18.13	17.73	17.77	17.50	18.50	18.87	19.40	20.23	20.83	21.77
07/08/2023	23.00	23.13	23.97	23.93	24.23	24.33	24.30	24.23	23.70	22.67	21.73	20.13	19.30	18.27	17.47	17.77	17.97	18.60	19.13	19.53	20.50	20.90	20.97	22.13
08/08/2023	22.73	22.90	22.97	23.13	23.77	23.57	23.43	23.63	23.30	22.73	21.87	20.57	19.73	18.47	18.00	17.50	17.57	18.10	18.90	19.83	21.00	21.87	22.03	22.57
09/08/2023	23.00	23.13	22.73	21.93	22.43	22.43	22.37	22.23	22.50	22.30	21.80	20.93	20.03	18.97	18.13	17.47	17.57	18.00	18.57	19.73	21.03	21.97	22.43	22.57
10/08/2023	22.90	22.40	21.87	21.27	20.77	20.67	21.17	21.13	21.67	21.30	20.97	20.33	19.50	18.87	18.03	17.77	18.00	18.27	19.07	20.27	21.67	22.83	23.07	23.20
11/08/2023	23.10	23.00	21.67	21.17	20.07	19.63	19.70	19.90	20.13	20.10	20.03	19.57	18.83	18.27	17.10	17.27	17.27	17.33	18.40	19.30	21.23	22.27	23.30	23.67
12/08/2023	23.37	23.20	22.07	21.43	20.20	19.77	19.50	19.67	19.67	19.70	19.90	19.80	19.53	18.87	18.10	17.67	17.67	18.30	19.03	20.13	21.30	22.40	23.70	24.27
13/08/2023	24.27	23.90	22.90	21.93	21.17	20.17	19.47	19.20	19.43	19.87	19.57	18.93	18.57	18.70	18.13	17.67	17.43	18.17	18.83	19.77	21.23	22.33	23.63	24.23

LEAST SQUARE		meter
Elevasi Muka Air		
Hingest Water Spring (HWS) =	34.6347	3.463
Mean High Water Spring(MHWS)=	24.8782	2.488
Mean High Water Level(MHWL)=	24.8706	2.487
Mean Sea Level (MSL) =	20.474	2.047
Mean Low Water Level (MLWL)=	16.5929	1.659
Mean Low Water Spring (MLWS)=	16.9249	1.692
Lowest Water Spring (LWS) =	9.483	0.948
Elevasi Muka Air Referensi LLWL		
Hingest Water Spring (HWS) =	25.1516	2.515
Mean High Water Spring(MHWS)=	15.3952	1.540
Mean High Water Level(MHWL)=	15.3876	1.539
Mean Sea Level (MSL) =	10.991	1.099
Mean Low Water Level (MLWL)=	7.1099	0.711
Mean Low Water Spring (MLWS)=	7.4419	0.744
Lowest Water Spring (LWS) =	0	0.000

Lokasi	Elevasi Muka Air	Least Square	
		Ref. Pel (m)	Ref. LLWL (m)
TANJUNG MAS	HHWL	3.46	2.52
	MHWS	2.49	1.54
	MHWL	2.49	1.54
	MSL	2.05	1.10
	MLWL	1.66	0.71
	MLWS	1.69	0.74
	LLWL	0.95	0.00
Tunggang Pasang Surut		2.52	
Amplitudo		Least Square	
S0		20.47	
M2		0.68	
S2		1.91	
N2		0.39	
K1		5.70	
O1		1.15	
M4		0.01	
MS4		0.03	
K2		1.39	
P1		3.18	
Bilangan Formzal		2.649	
F=(AO1+AK1)/(AM2+AS2)			

Source: Researcher Processing, 2024

The tidal data obtained are not only numbers but also graphs. Here is a graph of tidal data.

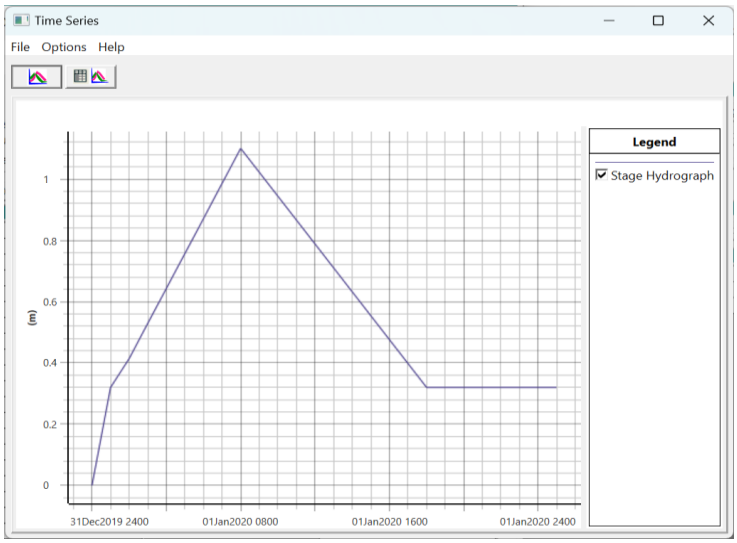

Figure 2. Tidal Data Graph

Source: Researcher Processing, 2024

Then, a diversion flow is made that can drain the current water discharge downstream of the Babon River. The following are some alternative schemes and parameters planned for the model. This modeling uses a two-year return period (Q2) for flood discharge to obtain an efficient design. This is because this building is not a permanent building but a temporary building used for two years of the project.

From the modeling that has been carried out for several parameters for each alternative, the following results were obtained:

Table 4. Hydraulic Model Result Matrix of Several Alternatives

Model	Elevation Downstream TMA	Dimensions Channel (m)	Amount Channel (bh)	Elevation Base	Information
Alternative 1	+4.180	2.4	10	0.700	Not Recommended
Alternative 2	+2.220	3	14	-0.700	Recommendation
Alternative 3	+2.800	4.58x3.05	4	-1.000	Not Recommended
Alternative 4	+1.500	4.58x3.05	6	-1.000	Recommendation

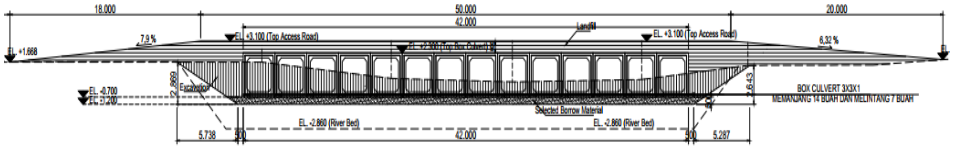

Figure 3. Alternative Culvert Construction 2

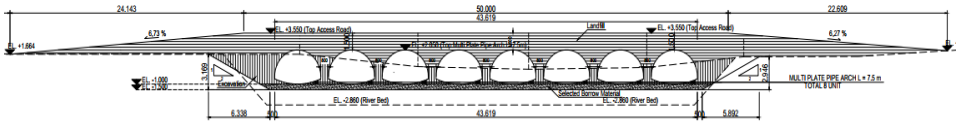

Figure 4. Alternative Culvert Construction 4

B. Cost Analysis

To get the most efficient cost from several alternative results obtained, it is necessary to calculate the cost for each alternative. To form a cost, a basic unit price is needed for labor wages, materials, tools, and their coefficients. The source of the basic unit price can be obtained from:

1. Local government provisions include provincial or district/city minimum wages, excluding taxes.
2. Central Bureau of Statistics
3. Survey data and other data that can be accounted for.

Meanwhile, the coefficient can be obtained from the Minister of PUPR Regulation No. 1 of 2022, concerning guidelines for preparing construction work cost estimates or using technical analysis.

The following are the basic unit prices and the coefficients obtained.

Table 5. Basic Price of Labor Wages

No	Uraian	Satuan	Harga Satuan (Rp.)	Ketrerangan
1	Pekerja	OH	126.000,00	
2	Tukang	OH	150.000,00	
3	Mandor	OH	150.000,00	
4	Operator	OH	265.000,00	
5	Pembantu Operator	OH	140.000,00	
6	Sopir / Driver	OH	210.000,00	
7	Pembantu Sopir / Driver	OH	145.000,00	
8	Mekanik	OH	230.000,00	
9	Pembantu Mekanik	OH	65.000,00	
10	Kepala Tukang	OH	160.000,00	
11	Juru Ukur	OH	185.000,00	
12	Pembantu Juru Ukur	OH	145.000,00	
13	Tukang Listrik	OH	155.000,00	

Table 6. Basic Price of Materials

No	Uraian	Satuan	Harga Satuan (Rp.)	Ketrerangan
1	Tanah Pilihan	m3	179.800,00	Quary ke Lokasi Pekerjaan
2	Tanah Padas	m3	201.200,00	Quary ke Lokasi Pekerjaan
3	Box Culvert Beton Bertulang	unit	25.419.600,00	Uk. 300 cm x 300 cm x 100 cm
4	Pipa Baja Bergelombang Type	m	24.225.000,00	Uk. 4580mm x Rs 3050 mm x 7 mm
	MPP (Aramco)			

Table 7. Basic Price of Equipment

No	Uraian	Satuan	Harga Satuan (Rp.)	Ketrerangan
1	Stamper	Jam	35.000,00	
2	Crane On Wheel (10-15) Ton	Jam	359.800,00	
3	Truck Crane 5 Ton	Jam	525.000,00	
4	Flat Bed Truck 3-4 m3	Jam	465.100,00	
5	Excavator 80□140 HP	Jam	668.200,00	
6	Vibro Roller 5-8 ton	Jam	392.200,00	
7	Bulldozer 100-150 HP	Jam	912.500,00	
8	Dump truk 6-8 m3	Jam	344.400,00	
9	Water Tank Truck 3000-4000 L	Jam	255.200,00	

Table 8. Manual Earth Embankment Engineering Analysis

No.	Uraian	Kode	Koefisien	Satuan	Keterangan
I.	**ASUMSI**				
1	Pekerjaan dilakukan secara manual tenaga manusia				
2	Lokasi pekerjaan : Suara Sungai Babon				
3	Kondisi Jalan : Tanah				
4	Jam kerja efektif per-hari	Tk	7,00	jam	
5	Faktor pengembangan bahan (padat ke asli)	Fv	1,20	-	
6	Tebal hamparan padat	t	0,20	m	
7	Berat volume bahan (lepas)	D	1,25	ton/ m3	
II.	**URUTAN KERJA**				
1	Excavator menggali dan memuat ke dalam dump truck				
2	Dump Truck mengangkut ke lapangan dengan jarak dari sumber galian ke lapangan	L	45,00	km	
3	Material diratakan dengan menggunakan Bulldozer				
4	Material dipadatkan menggunakan Vibro Roller				
5	Selama pemadatan sekelompok pekerja akan merapikan tepi hamparan dan level permukaan dengan menggunakan alat bantu				
III.	**PEMAKAIAN BAHAN, ALAT DAN TENAGA**				
1.	**BAHAN**				
1.a.	Bahan timbunan = 1 x Fv		1,20	m3	
2.	**ALAT**				
2.a.	STAMPER	(E25)			
	Kecepatan	v	1,00	km/ Jam	
	Efisiensi alat	Fa	0,83	-	
	Lebar pemadatan	Lb	0,50	m	
	Banyak lintasan	n	10	lintasan	
	Tebal lapis hamparan	tp	0,10	m	
	Panjang pemadatan	Pp	0,50	m	
	Kap. Prod. / Jam = $\frac{v \times 1000 \times Fa \times Lb \times tp}{n \times (E1\text{-}241)}$	Q1	1,73	m3/ Jam	
	Koefisien Alat / m' = 1 : Q1	(E25)	**0,5783**	**jam**	
2.b	ALAT BANTU				
	Diperlukan alat-alat bantu kecil				Lump Sump
	- Sekop = 3 buah				
3.	**TENAGA**				
	Produksi menentukan : STAMPER	Q1	1,73	m3/Jam	
	Produksi Timbunan / hari = Tk x Q1	Qt	12,10	m3	
	Kebutuhan tenaga :				
	- Pekerja	P	2,00	orang	
	- Mandor	M	1,00	orang	
	Koefisien tenaga / m3 :				
	- Pekerja = P : Qt		**0,1652**	OH	
	- Mandor = M : Qt		**0,0826**	OH	

Tabel 9. Analisa Teknik Aramco Type MPP Arch, Uk. Span 4580mm x Rs 3050 mm x 7 mm

No.	Uraian	Kode	Koefisien	Satuan	Keterangan
I.	**ASUMSI**				
1	Pekerjaan dilakukan secara mekanik/manual				
2	Lokasi pekerjaan : Muara Sungai Babon.				
3	Lebar gorong-gorong	B	4,58	m	
4	Tinggi gorong-gorong	T	3,05	m	
7	Jarak rata-rata Stock Pile ke lokasi pekerjaan	L	0,50	km	
8	Jam kerja efektif per-hari	Tk	7,00	jam	
II.	**URUTAN KERJA**				
1	Aramco di pesan dari Pabrik di letakkan ke stok pile area				
2	Flat Bed Truck mengangkut Box culvert dari stock pile ke lokasi pekerjaan				
3	Aramco di rakit di lokasi pekerjan				
4	Setelah selah Aramco di timbun tanah pilihan dan dipadatkan menggunakan Stamper				
5	Setelah Aramco dipasang bagian atasnya di timbun tanah padas dan dipadatkan menggunakan vibro roller				
6	Sekelompok pekerja akan melaksanakan pekerjaan dengan cara manual dengan menggunakan alat bantu				
II	**PEMAKAIAN BAHAN, ALAT DAN TENAGA**				
1.	**BAHAN**				
1.a	- Multi Plate Pipe Arch., Uk. Span 4.580mm x Rs 3050 mm x 5 mm		**1,00**	m	
2.	**ALAT**				
2.a.	**CRANE ON WHEEL 10 - 15 TON**	(E25)			
	Kecepatan	v	1,00	m	
	Efisiensi alat	Fa	0,83	-	
	Waktu sikhs				
	- Mengangkat dan memasang	T1	5,00	menit	
	- Lain-lain	T2	5,00	menit	
		Ts1	10,00	menit	
	Kap. Prod. / Jam = $\frac{v \times Fa \times 60}{Ts1}$	Q1	4,98	m/ jam	
	Koefisien Alat / m = 1 : Q1	(E25)	**0,2008**	**jam**	
2.b.	**TRUCK CRANE 5 TON**	(E11)			
	Kapasitas bak sekali muat	V	5,00	m	
	Faktor efisiensi alat	Fa	0,83		
	Kecepatan rata-rata bermuatan	v1	20,00	km/ jam	
	Kecepatan rata-rata kosong	v2	40,00	km/ jam	
	Waktu sikhs :	Ts			
	- Waktu tempuh isi = (L : v1) x 60	T1	1,50	menit	
	- Waktu tempuh kosong = (L : v2) x 60	T2	0,75	menit	
	- Muat, bongkar dan lain-lain	T3	3,00	menit	
		Ts	5,25	menit	
	Kapasitas Produksi / Jam = $\frac{V \times Fa \times 60}{Ts}$	Q2	47,4286	m/ Jam	
	Koefisien Alat / m = **1 : Q2**	(E11)	**0,0211**	**jam**	
2.c.	ALAT BANTU				
	Diperlukan alat-alat bantu kecil				Lump Sump
	- Sekop				
	- Pacul				
	- Alat-alat kecil lain.				
3.	**TENAGA**				
	Produksi menentukan : Flat Bed Truck	Q1	4,98	m/ jam	
	Produksi Gorong-gorong Kotak / hari = Tk x Q2	Qt	34,86	m	
	Kebutuhan tenaga :				
	- Pekerja	P	6,00	orang	
	- Tukang	T	4,00	orang	
	- Mandor	M	1,00	orang	
	Koefisien tenaga / m :				
	- Pekerja = (Tk x P) : Qt	(L01)	**0,1721**	**OH**	
	- Tukang = (Tk x T) : Qt	(L02)	**0,1147**	**OH**	
	- Mandor = (Tk x M) : Qt	(L03)	**0,0287**	**OH**	

Table 10. Technical Analysis of Reinforced Concrete Box Culvert, Size 300cm x 300cm x 100cm

No.	Uraian	Kode	Koefisien	Satuan	Keterangan
I.	**ASUMSI**				
1	Pekerjaan dilakukan secara mekanik/manual				
2	Lokasi pekerjaan : Muara Sungai Babon.				
3	Lebar gorong-gorong	B	2,00	m	
4	Tinggi gorong-gorong	T	2,00	m	
5	Tebal atas gorong-gorong	tag	20,00	cm	
6	Tebal dasar saluran dan dinding tegak gorong-gorong	tbg	20,00	cm	
7	Jarak rata-rata Stock Pile ke lokasi pekerjaan	L	1,00	km	
8	Jam kerja efektif per-hari	Tk	7,00	jam	
II	**PEMAKAIAN BAHAN, ALAT DAN TENAGA**				
1.	**BAHAN**				
1.a	- Box Culvert Beton Bertulang Precast, Uk. 200 x 200 cm		**1,00**	m	
2.	**ALAT**				
2.a.	CRANE ON WHEEL 10 - 15 TON (Di Lokasi Stock Pile)	(E25)			
	Kecepatan	v	1,00	m	
	Efisiensi alat	Fa	0,83	-	
	Waktu sikhs				
	- Mengangkat dan menurunkan	T1	5,00	menit	
	- Lain-lain	T2	5,00	menit	
		Ts1	10,00	menit	
	Kap. Prod. / Jam = $\frac{v \times Fa \times 60}{Ts1}$	Q1A	4,98	m/jam	
	Koefisien Alat / m = 1 : Q1	(E25)	**0,2008**	**jam**	
2.b.	CRANE ON WHEEL 10 - 15 TON (Di Lokasi Pekerjaan)	(E25)			
	Kecepatan	v	1,00	m	
	Efisiensi alat	Fa	0,83	-	
	Waktu sikhs				
	- Mengangkat dan memasang	T1	15,00	menit	
	- Lain-lain	T2	5,00	menit	
		Ts1	20,00	menit	
	Kap. Prod. / Jam = $\frac{v \times Fa \times 60}{Ts1}$	Q1B	2,49	m/Jam	
	Koefisien Alat / m = 1 : Q1	(E25)	**0,4016**	**jam**	
2.c.	FLAT BED TRUCK 3-4 M3	(E11)			
	Kapasitas bak sekali muat	V	7,00	m	
	Faktor efisiensi alat	Fa	0,83		
	Kecepatan rata-rata bermuatan	v1	20,00	km/ jam	
	Kecepatan rata-rata kosong	v2	40,00	km/ jam	
	Waktu sikhs :	Ts			
	- Waktu tempuh isi = (L : v1) x 60	T1	3,00	menit	
	- Waktu tempuh kosong = (L : v2) x 60	T2	1,50	menit	
	- Muat, bongkar dan lain-lain	T3	3,00	menit	
		Ts	7,50	menit	
	Kapasitas Produksi / Jam = $\frac{Vx Fax 60}{Ts}$	Q2	46,4800	m/Jam	
	Koefisien Alat / m = **1 : Q2**	(E11)	**0,0215**	**jam**	
2.d.	ALAT BANTU				
	Diperlukan alat-alat bantu kecil				Lump Sump
	- Sekop				
	- Pacul				
	- Alat-alat kecil lain.				
3.	**TENAGA**				
	Produksi menentukan : FLAT BED TRUCK 3-4 M3	Q2	46,48	m/jam	
	Produksi Gorong-gorong Kotak / hari = Tk x Q2	Qt	325,36	m	
	Kebutuhan tenaga :				
	- Pekerja	P	2,00	OH	
	- Tukang	T	1,00	OH	
	- Mandor	M	1,00	OH	
	Koefisien tenaga / m :				
	- Pekerja = (Tk x P) : Qt	(L01)	**0,0061**	hari	
	- Tukang = (Tk x T) : Qt	(L02)	**0,0031**	hari	
	- Mandor = (Tk x M) : Qt	(L03)	**0,0031**	hari	

Table 11. Mechanical Soil Excavation Technique Analysis

No.	Uraian	Kode	Koefisien	Satuan	Keterangan
I.	**ASUMSI**				
1	Menggunakan alat berat (cara mekanik)				
2	Lokasi pekerjaan : Muara Sungai Babon				
3	Kondisi Jalan : Tanah				
4	Jam kerja efektif per-hari	Tk	7,00	Jam	
5	Faktor pengembangan bahan	Fk	1,20	-	
II.	**URUTAN KERJA**				
1	Tanah yang digali berada di atas jalan akses				
2	Penggalian dilakukan dengan menggunakan Excavator				
3	Selanjutnya Excavator meruangkan material hasil galian kedalam Dump Truck				
4	Dump Truck membuang material hasil galian keluar lokasi jalan sejauh	L	1,00	Km	
II	**PEMAKAIAN BAHAN, ALAT DAN TENAGA**				
1.	**BAHAN**				
	Tidak ada bahan yang diperlukan				
2.	**ALAT**				
2.a.	EXCAVATOR PC 200				
	Kapasitas Bucket	V	0,93	m3	
	Faktor Bucket	Fb	1,20	-	
	Faktor Efisiensi alat	Fa	0,83		
	Faktor konversi , kedalaman 40 %-75 %, Mudah	Fv	0,80		
	Waktu siklus	Ts1		menit	
	- Menggali , memuat (swing 180°)	T1	1,000	menit	
	- Lain lain	T2	0,600	menit	
	Waktu siklus = T1 + T2	Ts1	1,600	menit	
	Kap. Prod. / jam = $\frac{V \times Fb \times Fa \times 60 \times Fk}{Ts1 \times Fv}$	Q1	52,10	m3/ jam	
	Koefisien Alat / m3 = 1 : Q1		**0,0192**	Jam	
2.b.	DUMP TRUCK 6- 8 M3				
	Kapasitas bak	V	8,00	m3	
	Faktor efisiensi alat	Fa	0,85	-	
	Kecepatan rata-rata bermuatan	v1	25,00	km/ Jam	
	Kecepatan rata-rata kosong	v2	40,00	km/ Jam	
	Waktu siklus	Ts2		menit	
	- Muat = (V/Q1) x 60	T1	9,21	menit	
	- Waktu tempuh isi = (L : v1) x 60	T2	2,40	menit	
	- Waktu tempuh kosong = (L : v2) x 60	T3	1,50	menit	
	- Lain-lain	T4	1,82	menit	
		Ts2	14,93	menit	
	Kapasitas Produksi / Jam = $\frac{V \times Fa \times 60}{Fk \times Ts2}$	Q2	22,77	m3/ Jam	
	Koefisien Alat / m3 = 1 : Q2		**0,0439**	Jam	
2.d.	ALAT BANTU				
	Diperlukan alat-alat bantu kecil				Lump Sump
	- Sekop				
	- Keranjang				
3.	**TENAGA**				
	Produksi menentukan : EXCAVATOR	Q1	52,10	M3/Jam	
	Produksi Galian/ hari = Tk x Q1	Qt	364,72	M3	
	Kebutuhan tenaga :				
	- Pekerja	P	5,00	orang	
	- Mandor	M	1,00	orang	
	Koefisien tenaga / m3 :				
	- **Pekerja** = P : Qt	(L01)	**0,0137**	Hari	
	- **Mandor** = M : Qt	(L03)	**0,0027**	Hari	

Table 12. Mechanical Earth Embankment Engineering Analysis

No.	Uraian			Kode	Koefisien	Satuan	Keterangan
I.	**ASUMSI**						
1	Pekerjaan dilaksakan secara mekanis						
2	Lokasi pekerjaan : Sungai Babon						
3	Kondisi Jalan : Tanah						
4	Jam kerja efektif per-hari			Tk	7,00	jam	
5	Faktor pengembangan bahan (padat ke asli)			Fv	1,20	-	
6	Tebal hamparan padat			t	0,20	m	
7	Berat volume bahan (lepas)			D	1,25	ton/ m3	
II.	**URUTAN KERJA**						
1	Excavator menggali dan memuat ke dalam dump truck						
2	Dump Truck mengangkut ke lapangan dengan jarak dari sumber galian ke lapangan			L	45,00	km	
3	Material diratakan dengan menggunakan Bulldozer						
4	Material dipadatkan menggunakan Vibro Roller						
5	Selama pemadatan, sekelompok pekerja akan merapikan tepi hamparan dan level permukaan dengan menggunakan alat bantu						
III.	**PEMAKAIAN BAHAN, ALAT DAN TENAGA**						
I.	**BAHAN**						
1.a.	Bahan timbunan	= 1 x Fv			1,20	m3	
2.	**ALAT**						
2.a.	BULLDOZER 100 - 150 HP						
	Kapasitas pisau			q	2,30	m3	
	Faktor pisau (blade), agak sukar			Fb	0,70	-	
	Faktor efisiensi kerja			Fa	0,75	-	
	Kecepatan mengupas			Vf	2,00	km/ Jam	
	Kecepatan mundur			Vr	4,00	km/ Jam	
	Faktor kemiringan (grade)			Fm	1,00		
	Jarak pengupasan			L2	70	m3	
	Waktu Siklus						
	- Waktu gusur	= (L2 x 60) : Vf		T1	2,10	menit	
	- Waktu kembali	= (L2 x 60) : Vr		T2	1,05	menit	
	- Waktu pasti (Direct Drive)			T3	0,20	menit	
				Ts	3,35	menit	
	Kapasitas Produksi / Jam =		q x Fb x Fm x Fa x 60 / Ts x 0,3	Q1	72,09	m3	
	Koefisien Alat / m3	= 1 : Q1			**0,0139**	Jam	
2.b	VIBRO ROLLER 5-8 TON						
	Kecepatan rata-rata alat			v	5,00	km/ Jam	
	Lebar Area Pemadatan			w	3,50	m	
	Lebar efektif pemadatan			b	1,68	m	
	Jumlah lintasan			n	8,00	lintasan	
	Lebar Overlap			bo	0,10	m	
	Lajur lintasan		= w / (b - bo)	N	3,00		
	Faktor efisiensi alat			Fa	0,85	-	
	Kapasitas Produksi / Jam =		(v x 1000) x (N(b-bo)+bo) xt xFa / n	Q2	514,25	m3	
	Koefisien Alat / m2	= 1 : Q2			**0,0019**	Jam	
2.c	WATER TANK TRUCK						
	Volume tangki air			V	5,00	m3	
	Kebutuhan air/M3 material padat			Wt	0,07	m3	
	Kapasitas pompa air			pa	200,00	liter/menit	
	Faktor efisiensi alat			Fa	0,85		
	Kapasitas Prod./Jam =		pa x Fa x 60 / 1000 x Wt	Q3	145,71	m3	
	Koefisien Alat / m3	= 1 : Q5			**0,0069**	jam	
2.d.	ALAT BANTU						
	Diperlukan alat-alat bantu kecil						Lump Sump
	- Sekop = 3 buah						
3.	**TENAGA**						
	Produksi/ m ditentukan : BULLDOZER			Q1	72,09	m3/Jam	
	Produksi Timbunan / hari = Tk x Q1			Qt	504,63	m3	
	Kebutuhan tenaga :						
		- Pekerja		P	6,00	orang	
		- Mandor		M	1,00	orang	
	Koefisien tenaga / M3 :						
		- Pekerja	= P : Qt	(L01)	**0,0119**	OH	
		- Mandor	= M : Qt	(L03)	**0,0020**	OH	

Source: Researcher Processing, 2024

C. Alternative Cost 2

Alternative culvert 2 used Cast Concrete Box Culvert material with dimensions of 300 mm x 300 mm x 100 mm, as many as 98 pieces. With the analysis of the unit price of the work item, as follows:

1. Reinforced Concrete Box Culvert Work with Unit m1

No	Komponen	Satuan	Koefisien	Harga Satuan (Rp.)	Harga Satuan (Rp.)
A.	**Tenaga**				
1.	Pekerja	OH	0,0061	126.000,00	774,53
2.	Tukang	OH	0,0031	150.000,00	461,03
3	Mandor	OH	0,0031	150.000,00	461,03
	Jumlah Harga Tenaga				**1.696,58**
B.	**Bahan**				
1	Box Culvert Beton Bertulang Precast, BC□, Uk. 300cm x 300cm	m	1,0000	25.419.600,00	25.419.600,00
	Jumlah Harga Bahan				**25.419.600,00**
C.	**Alat**				
1	Crane On Wheel (10-15) Ton	jam	0,6024	359.800,00	216.746,99
2	Flat Bed Truck	jam	0,0215	465.100,00	10.006,45
	Jumlah Harga Alat				**226.753,44**
D.	**Jumlah Harga Tenaga, Bahan, dan Alat (A + B + C)**				**25.648.050,02**
E.	**Overhead dan Keuntungan**		**15,0 % x D**		**3.847.207,50**
F.	**Harga Satuan Pekerjaan (D + E)**				**29.495.257,52**

2. Mechanical Earth Excavation Work with m3 units

No	Komponen	Satuan	Koefisien	Harga Satuan (Rp.)	Harga Satuan (Rp.)
A.	**Tenaga**				
1.	Pekerja	OH	0,0137	126.000,00	1.727,34
2.	Mandor	OH	0,0027	150.000,00	411,27
	Jumlah Harga Tenaga				**2.138,61**
B.	**Bahan**				
	-				
	Jumlah Harga Bahan				-
C.	**Alat**				
1	Excavator 80□140 HP	jam	0,0192	668.200,00	12.824,54
2	Dump truk 6-8 m3	jam	0,0439	344.400,00	15.127,38
	Jumlah Harga Alat				**27.951,91**
D.	**Jumlah Harga Tenaga, Bahan, dan Alat (A + B + C)**				**30.090,52**
E.	**Overhead dan Keuntungan**		**15,0 % x D**		**4.513,58**
F.	**Harga Satuan Pekerjaan (D + E)**				**34.604,10**

3. Mechanical Earth Filling Work with m3 units

No	Komponen	Satuan	Koefisien	Harga Satuan (Rp.)	Harga Satuan (Rp.)
A.	Tenaga				
1.	Pekerja	OH	0,0119	126.000,00	1.498,14
2.	Mandor	OH	0,0020	150.000,00	297,25
				Jumlah Harga Tenaga	1.795,39
B.	Bahan				
1	Tanah Padas	m3	1,2000	201.200,00	241.440,00
				Jumlah Harga Bahan	241.440,00
C.	Alat				
1	Bulldozer 100-150 HP	jam	0,0139	912.500,00	12.657,87
2	Vibro Roller 5-8 Ton	jam	0,0019	392.200,00	762,66
3	Water Tank Truck 3000 - 4000 L	jam	0,0069	255.200,00	1.751,37
				Jumlah Harga Alat	15.171,90
D.	Jumlah Harga Tenaga, Bahan, dan Alat (A + B + C)				258.407,29
E.	Overhead dan Keuntungan		15,0 % x D		38.761,09
F.	Harga Satuan Pekerjaan (D + E)				297.168,38

4. Manual Earthworks with m3 units

No	Komponen	Satuan	Koefisien	Harga Satuan (Rp.)	Harga Satuan (Rp.)
A.	Tenaga				
1.	Pekerja	OH	0,1652	126.000,00	20.819,28
2.	Mandor	OH	0,0826	150.000,00	12.392,43
				Jumlah Harga Tenaga	33.211,70
B.	Bahan				
1	Tanah Pilihan	m3	1,2000	179.800,00	215.760,00
				Jumlah Harga Bahan	215.760,00
C.	Alat				
1	Stamper	jam	0,5783	35.000,00	20.240,96
				Jumlah Harga Alat	20.240,96
D.	Jumlah Harga Tenaga, Bahan, dan Alat (A + B + C)				269.212,67
E.	Overhead dan Keuntungan		15,0 % x D		40.381,90
F.	Harga Satuan Pekerjaan (D + E)				309.594,56

From the analysis of the unit price of the work above, the price for the Alternative 2 culvert work is obtained as follows:

Table 13. Price of Culvert Work Using Alternative 2

No	Item Pekerjaan	Satuan	Volume	Harga Satuan (Rp)	Jumlah Harga (Rp)
1	Box Culvert Beton Bertulang, Uk. 300cm x 300cm x 100cm	ml	98,00	29.495.257,52	2.890.535.236,96
2	Galian Tanah dengan Alat Berat	m3	1.009,03	34.604,10	34.916.459,03
3	Timbunan Tanah dengan Alat Berat	m3	710,91	297.168,38	211.258.858,64
4	Timbunan Tanah Manual	m3	176,00	309.594,56	54.488.642,56
	TOTAL HARGA				3.191.199.197,19

1. Alternative Cost 4

Alternative culvert 4 used Aramco Type MPP Arch material with span size 4580mm x rise 3050mm x thickness 7mm, as many as 6 pieces with 1 piece length of 7.6 m. With the analysis of the unit price of the work item, as follows:

1. Aramco Type MPP Arch work with m1 units.

No	Komponen	Satuan	Koefisien	Harga Satuan (Rp.)	Harga Satuan (Rp.)
A.	**Tenaga**				
1.	Pekerja	OH	0,1721	126.000,00	21.686,75
2.	Tukang	OH	0,1147	150.000,00	17.211,70
3	Mandor	OH	0,0287	150.000,00	4.302,93
	Jumlah Harga Tenaga				**43.201,38**
B.	**Bahan**				
1	Pipa Baja Bergelombang Type Multi Plate Pipe Arch Uk. Span 4580mm x Rs 3050 mm x 5 mm	m	1,0000	18.500.000,00	18.500.000,00
	Jumlah Harga Bahan				**18.500.000,00**
C.	**Alat**				
1	Crane On Wheel (10-15) Ton	jam	0,2008	359.800,00	72.249,00
2	Truck Crane 5 Ton	jam	0,0211	465.100,00	9.806,33
	Jumlah Harga Alat				**82.055,32**
D.	**Jumlah Harga Tenaga, Bahan, dan Alat (A + B + C)**				**18.625.256,70**
E.	**Overhead dan Keuntungan**		**15,0 % x D**		**2.793.788,50**
F.	**Harga Satuan Pekerjaan (D + E)**				**21.419.045,20**

2. Mechanical Earth Excavation Work with m3 units

No	Komponen	Satuan	Koefisien	Harga Satuan (Rp.)	Harga Satuan (Rp.)
A.	**Tenaga**				
1.	Pekerja	OH	0,0137	126.000,00	1.727,34
2.	Mandor	OH	0,0027	150.000,00	411,27
	Jumlah Harga Tenaga				**2.138,61**
B.	**Bahan**				
	-				
	Jumlah Harga Bahan				-
C.	**Alat**				
1	Excavator 80□40 HP	jam	0,0192	668.200,00	12.824,54
2	Dump truk 6-8 m3	jam	0,0439	344.400,00	15.127,38
	Jumlah Harga Alat				**27.951,91**
D.	**Jumlah Harga Tenaga, Bahan, dan Alat (A + B + C)**				**30.090,52**
E.	**Overhead dan Keuntungan**		**15,0 % x D**		**4.513,58**
F.	**Harga Satuan Pekerjaan (D + E)**				**34.604,10**

3. Mechanical Earth Filling Work with m3 units

No	Komponen	Satuan	Koefisien	Harga Satuan (Rp.)	Harga Satuan (Rp.)
A.	Tenaga				
1.	Pekerja	OH	0,0119	126.000,00	1.498,14
2.	Mandor	OH	0,0020	150.000,00	297,25
				Jumlah Harga Tenaga	1.795,39
B.	Bahan				
1	Tanah Padas	m3	1,2000	201.200,00	241.440,00
				Jumlah Harga Bahan	241.440,00
C.	Alat				
1	Bulldozer 100-150 HP	jam	0,0139	912.500,00	12.657,87
2	Vibro Roller 5-8 Ton	jam	0,0019	392.200,00	762,66
3	Water Tank Truck 3000 - 4000 L	jam	0,0069	255.200,00	1.751,37
				Jumlah Harga Alat	15.171,90
D.	Jumlah Harga Tenaga, Bahan, dan Alat (A + B + C)				258.407,29
E.	Overhead dan Keuntungan		15,0 % x D		38.761,09
F.	Harga Satuan Pekerjaan (D + E)				297.168,38

4. Manual Earthworks with m3 units

No	Komponen	Satuan	Koefisien	Harga Satuan (Rp.)	Harga Satuan (Rp.)
A.	Tenaga				
1.	Pekerja	OH	0,1652	126.000,00	20.819,28
2.	Mandor	OH	0,0826	150.000,00	12.392,43
				Jumlah Harga Tenaga	33.211,70
B.	Bahan				
1	Tanah Pilihan	m3	1,2000	179.800,00	215.760,00
				Jumlah Harga Bahan	215.760,00
C.	Alat				
1	Stamper	jam	0,5783	35.000,00	20.240,96
				Jumlah Harga Alat	20.240,96
D.	Jumlah Harga Tenaga, Bahan, dan Alat (A + B + C)				269.212,67
E.	Overhead dan Keuntungan		15,0 % x D		40.381,90
F.	Harga Satuan Pekerjaan (D + E)				309.594,56

From the analysis of the unit price of the work above, the price for the Alternative 4 culvert work is obtained as follows:

Table 14 Price of Culvert Work Using Alternative 4

No	Item Pekerjaan	Satuan	Volume	Harga Satuan (Rp)	Jumlah Harga (Rp)
1	Aramco Type MPP Arch, Uk. Span 4580mm x Rs 3050mm x 5mm	ml	60,80	28.002.795,20	1.702.569.948,16
2	Galian Tanah dengan Alat Berat	m3	1.715,28	34.604,10	59.355.735,32
3	Timbunan Tanah dengan Alat Berat	m3	1.431,41	297.168,38	425.368.750,73
4	Timbunan Tanah Manual	m3	182,48	309.594,56	56.493.576,93
	TOTAL HARGA				**2.243.788.011,14**

Research result

Based on the results of the analysis and discussion of this research, the following results were obtained:

The solution used to drain water at the Babon River estuary during the construction period is to use culverts with 2 alternatives, namely:

A. Alternative 2

1. The culvert uses a Reinforced Concrete Box Culvert with 300mm x 300mm x 100mm dimensions.
2. The number of speedboats along the road is 14, and across the road is 7. So the total requirement is 98.
3. The channel base is placed at an elevation of -0.700 and installed in flat elevation conditions.
4. Requires a dam height of approximately 0.9 m for the Babon River along 700 m upstream due to *backwater*.

B. Alternative 4

1. Culverts using Armco *Type Multi Plate Pipe (MPP) Arch* with a span size of 4580mm x rise 3050mm x thickness 7mm
2. The total requirement is 1 piece of road lengthwise, 7.6 m long, and 8 pieces across the road. So, the total requirement is 6 pieces, each 7.6 m long.
3. The channel base is placed at -1,000 and installed in flat elevation conditions.
4. From these results, MAB's elevation is below the Babon River's banks.

The cost analysis results showed that alternative 4, namely a culvert using Aramco's Type Multi Plate Pipe (MPP) Arch, was the most efficient in terms of cost.

CONCLUSION

This study concludes that the most effective construction method for managing water flow at the Babon River estuary during the Semarang–Demak 1C Toll Road project is the use of Armco Type Multi Plate Pipe (MPP) Arch culverts, with specifications of a 4,580 mm span, 3,050 mm rise, and 7 mm thickness. This option was selected due to its superior cost efficiency, ease of installation, quick construction time, and simple logistics for transportation and assembly. Given its advantages, this method is well-suited for temporary drainage infrastructure in flood-prone construction zones. For future research, it is recommended to explore the long-term hydraulic performance and environmental impact of MPP culverts and conduct comparative studies on other culvert materials and configurations under varying topographic and climatic conditions to expand the applicability of such designs in broader infrastructure contexts.

REFERENCES

Alam, M. S., Sasaki, N., & Datta, A. (2017). Waterlogging, crop damage and adaptation interventions in the coastal region of Bangladesh: A perception analysis of local people. In *Environmental Development* (Vol. 23). https://doi.org/10.1016/j.envdev.2017.02.009

Alfarobi, M. R., & Tujni, B. (2023). Sistem Informasi Operasional dan Pemeliharaan Bangunan Sungai Berbasis Web. *Jurnal Nasional Ilmu Komputer*, *4*(4). https://doi.org/10.47747/jurnalnik.v4i4.1406

Amanatillah, D., & Anggraini, L. (2020). Potensi Pengembangan Sukuk Berbasis Wakaf Untuk Pembangunan Infrastruktur di Indonesia. *SHIBGHAH: Journal of Muslim Societies*, *2*(2).

Cahyono, B. K., Aditya, T., & Istarno. (2022). The Determination of Priority Areas for the Restoration of Degraded Tropical Peatland Using Hydrological, Topographical, and Remote Sensing Approaches. *Land*, *11*(7). https://doi.org/10.3390/land11071094

Deng, X., Friedman, S., Ryan, I., Zhang, W., Dong, G., Rodriguez, H., Yu, F., Huang, W., Nair, A., Luo, G., & Lin, S. (2022). The independent and synergistic impacts of power outages and floods on hospital admissions for multiple diseases. *Science of the Total Environment*, *828*. https://doi.org/10.1016/j.scitotenv.2022.154305

Latif, A., Irwan, Rusdi, M., Mustanir, A., & Sutrisno, M. (2019). Partisipasi Masyarakat Dalam Pembangunan Infrastruktur Di Desa Timoreng Panua Kecamatan Panca Rijang Kabupaten Sidenreng Rappang. *Jurnal MODERAT*, *5*(1).

Latif, A., Rusdi, M., Mustanir, A., & Sutrisno, M. (2019). Partisipasi Masyarakat Dalam Pembangunan Infrastruktur Di Desa Timoreng Panua Kecamatan Panca Rijang Kabupaten Sidenreng Rappang Dosen Ilmu Pemerintahan Stisip Muhammadiyah Rappang Dosen Ilmu Administrasi Negara Stisip Muhammadiyah Rappang 5). *Jurnal MODERAT*, *5*(1).

Masthura, L., Wignyosukarto, B. S., Fahriana, N., & Ardhyan, M. Z. (2023). Keterpaduan Lintas Sektoral Dalam Pengembangan Kebijakan Integrated Water Resources Management (IWRM) pada Wilayah Sungai Aceh Meureudu Provinsi Aceh. *Jurnal Daur Lingkungan*, *6*(1). https://doi.org/10.33087/daurling.v6i1.199

Posumah, F. (2015). Pengaruh Pembangunan Infrastruktur Terhadap Investasi di Kabupaten Minahasa Tenggara. *Jurnal Berkala Ilmiah Efisiensi*, *15*(2).

Riskayanti. (2022). Partisipasi Masyarakat Dalam Pembangunan Infrastruktur Di Desa Romanglasa Kecamatan Bontonompo Kabupaten Gowa. *Kimap: Kajian Ilmiah Mahasiswa Administrasi Publik*, *3*(3).

Santos, M. L., Silva, C. M., Ferreira, F., & Matos, J. S. (2023). Hydrological Analysis of Green Roofs Performance under a Mediterranean Climate: A Case Study in Lisbon, Portugal. *Sustainability (Switzerland)* , *15*(2). https://doi.org/10.3390/su15021064

Terzaghi, K., & Peck, R. B. (1948). *Soil Mechanics in Engineering Practice*. John Wiley & Sons, Inc.

Wahyudi, S., & Adi, H. P. (2016). *Polder System Drainage*. EF Press Digimedia.

Xie, T., Wei, F., Yang, H., Gardner, J. S., & Xie, X. (2017). A design method for a debris flow water-sediment separation structure. *Engineering Geology*, *220*. https://doi.org/10.1016/j.enggeo.2017.01.025

Zakaria, Z. (2009). Analysis of Land Slope Stability. *Journal of Geotechnical Laboratory, Faculty of Geology, Padjadjaran University*.